Residential Energy Code
Combustion Air and Make-Up Air

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CCLD /DOLI
History of the Energy Code
History

• First Energy Code Became effective on January 30, 1976
History

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• Chapter 7670 – June 16, 1994
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• Model Energy Code Phase
  – 1982-1992
• Chapter 7670
  – June 16, 1994
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• Chapter 7672
  – April 15, 2000
• Mn. Rule 1322
  – June 1 2009
Minnesota’s Residential Energy Code What’s Changing
Minnesota Rules Chapter 1322

The New Residential Energy Code,

Incorporates Provisions for Radon Control however we are not discussing them today
N1101.1 Scope

This chapter regulates the energy efficiency for the design and construction of buildings regulated by the International Residential Code (IRC) as adopted and amended by the State of Minnesota.
Single Family Dwellings
• Two Family Dwellings
Townhouses
N1101.1 Scope

This chapter shall also be used to meet the energy efficiency for the design and construction of new multi-family residential buildings regulated by the International Building Code (IBC) as adopted and amended by the State of Minnesota, that:
Scope

(1) are not more than three stories in height;
These would be under the Residential Energy Code
This Building would be built to the Commercial Energy Code
Scope

(1) are not more than three stories in height;

(2) contain no conditioned common space that is shared between dwellings;
This Building *would* Meet the Scoping Provisions
This Building **would not** Meet the Scoping Provisions

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td><strong>Conditioned common space</strong></td>
<td></td>
</tr>
</tbody>
</table>
Scope

(1) are not more than three stories in height;

(2) contain no conditioned common space that is shared between dwellings;

(3) each dwelling unit contains a separate means of egress.
Scope

The intent of these criteria is to provide a means for furnishing
Scope

The intent of these criteria is to provide a means for furnishing

1. quality indoor air
Scope

The intent of these criteria is to provide a means for furnishing

1. quality indoor air
2. assuring building durability
What is meant by durable buildings?
What is meant by durable buildings?

- Insurance company point of view
What is meant by durable buildings?

• Insurance company point of view

• Mortgage company point of view
What is meant by durable buildings?

- Insurance company point of view
- Mortgage company point of view
- Contractor point of view
What is meant by durable buildings?

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• Code/Building Inspector point of view
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- Code/Building Inspector point of view
- Owner/occupant point of view
- Other points of view
Why and where do the codes address durability?

- Energy code
Why and where do the codes address durability

• Energy code
  – Required by the legislature to address it.
Why and where do the codes address durability

• Energy code
  – Required by the legislature to address it.
  – Should it be only a BTU code?
Vapor Retarders/Wall Durability
Vapor Retarders/Wall Durability

• Durability and moisture control are directly related
Vapor Retarders/Wall Durability

- Durability and moisture control are directly related
- Controlling moisture means controlling wetting and drying
Vapor Retarders/Wall Durability

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• Controlling moisture means controlling wetting and drying
• Wetting is primarily controlled by air barriers, flashing and drainage plane improvements
Vapor Retarders/Wall Durability

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• Controlling moisture means controlling wetting and drying
• Wetting is primarily controlled by air barriers, flashing and drainage plane improvements
• Drying is primarily controlled by air barriers and vapor retarders
Vapor Retarders/Wall Durability

• Durability and moisture control are directly related
• Controlling moisture means controlling wetting and drying
• Wetting is primarily controlled by air barriers, flashing and drainage plane improvements
• Drying is primarily controlled by air barriers and vapor retarders
• This is true on both the cold and warm sides of the wall
Why and where do the codes address durability

- What about the building codes
Why and where do the codes address durability

- What about the building codes
  - Flashings
Why and where do the codes address durability

• What about the building codes
  – Flashings
  – Weather resistive barriers
Why and where do the codes address durability

- What about the building codes
  - Flashings
  - Weather resistive barriers
  - Drainage – (above and below grade)
Why and where do the codes address durability

• What about the building codes
  – Flashings
  – Weather resistant barriers
  – Drainage—(above and below grade)
  – Ventilation
Why and where do the codes address durability

• What about the building codes
  – Flashings
  – Weather resistive barriers
  – Drainage
  – Ventilation
  – Others?
Water/Moisture/Bulk/Diffusion
Water/Moisture/Bulk/Diffusion

• When the rate of wetting exceeds the rate of drying accumulation occurs
Water/Moisture/Bulk/Diffusion

- When the rate of wetting exceeds the rate of drying accumulation occurs
- The drying potential of an assembly decreases with the thickness of the insulation and increases with the rate of air flow
Water/Moisture/Bulk/Diffusion

- When the rate of wetting exceeds the rate of drying accumulation occurs.
- The drying potential of an assembly decreases with the thickness of the insulation and increases with the rate of air flow.
- Energy conservation increases the thickness of the insulation and decreases the air flow.
Water/Moisture/Bulk/Diffusion

• When the rate of wetting exceeds the rate of drying accumulation occurs
• The drying potential of an assembly decreases with the thickness of the insulation and increases with the rate of air flow
• Energy conservation increases the thickness of the insulation and decreases the air flow
• Energy conservation has a potential to increase moisture wall problems
Moisture Balances Occurring In the Exterior Wall

A typical house can have 10,000 pounds of studs and sheathing. 10% moisture is 1,000 pounds or 125 gallons of water capacity.
National Experts have stated that moldy buildings today likely make up 5-10% of all housing. Before 1990 the failure rate was less than 0.1%
Moisture Balance in Walls

Bar chart showing wetting, accumulation, and drying over three time periods: 1950, 2006, and Future.
The intent of these criteria is to provide a means for furnishing

1. quality indoor air
2. assuring building durability
3. permitting energy efficient operation
Scope

Exceptions: There are several exceptions to the scoping provisions of this document and have been placed there by the committee to clarify its intent for construction and enforcement.
Scope

- Portions of the building envelope that do not enclose conditioned space, including garages.
Scope

- Insulation R-values, air barrier and vapor retarder requirements are not required for existing foundations, crawl space walls, and basements in existing dwellings or existing dwelling units whose alterations or repair require a permit, if the original dwelling’s permit was issued prior to the effective date of this chapter.
• Additions to existing dwellings or dwelling units may be made without making the entire dwelling or dwelling unit comply, provided that the addition complies with all the requirements of this chapter.
Scope

• Alterations and repairs to existing dwellings or dwelling units may be made without making the entire dwelling or dwelling unit comply.
Scope

- Buildings that have been specifically designated as historically significant by the state or local governing body or, listed or, determined to be eligible for listing in the National Register of Historical Places.
Scope

• If a building houses more than one occupancy, each portion of the building must conform to the requirements for the occupancy housed in that portion.
Scope

- This chapter does not cover buildings, structures, or portions of such buildings whose peak design energy rate usage is less than 3.4 Btu per hour per square foot or 1.0 Watt per square foot of floor area for all purposes.
Compliance Climate Zones

Climate zones from Table N1101.2 or Figure 1101.2 shall be used in determining the applicable requirements from this chapter.

Please note: These are different than what is in the national document. We are adopting the state map for frost and snow load but it is not consistent with the wind load chart that the structural committee adopted.
Climate Zones

Northern Zone

ABOVE LINE  5' - 0"

BELOW LINE  3' - 6"

Southern Zone
Identification/Insulation Mark

• Materials, systems and equipment shall be identified in a manner that will allow a determination of compliance with the applicable provisions of this chapter.
Plans & Specs

- Plans and specifications shall show in sufficient detail, pertinent data and features, of the building, the equipment, and the systems as herein governed, including, but not limited to:
Building Thermal Insulation.

- All thermal insulation must conform to Minnesota Rules Chapter 7640, "Minnesota Thermal Insulation Standards" adopted by the Department of Commerce.
- For Foam Insulation we need to know and use the aged R-value.
Building Thermal Insulation.

• Insulation shall be manufactured for its intended use, and installed according to the manufacturer's specifications.

• Insulation materials used on the exterior for the purpose of insulating foundation walls shall be a water resistant material and shall comply with ASTM C578, C612 or other approved standards.
Attic thickness markers.

- The thickness of blown or sprayed roof and/or ceiling insulation shall be written in inches on markers that are installed at least one for every 100 ft$^2$ (9.3 m$^2$) throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness, with numbers a minimum of 1 inch (25 mm) in height. Each marker shall face the attic access opening.
Attic insulation card.

- A signed and dated insulation receipt attic card must be attached to the framing near the access opening, in a clearly visible place and posted with the certificate required by N1101.8. The attic card must identify the type of insulation installed, the manufacturer, the installer, the R-value per inch, the designed settled thickness, the square footage of attic coverage area, and the number of bags installed.
<table>
<thead>
<tr>
<th>Component</th>
<th>Certificate requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date certificate is installed</td>
<td>Posted date</td>
</tr>
<tr>
<td>Dwelling or dwelling unit location</td>
<td>Mailing address and city</td>
</tr>
<tr>
<td>Residential Contractor</td>
<td>Name of licensed residential contractor</td>
</tr>
<tr>
<td>Insulation installed in or on ceiling/roof, walls, slab-on-grade and floor</td>
<td>Type and installed R-value</td>
</tr>
<tr>
<td>Rim joist and foundation wall insulation</td>
<td>Installed R-value, type and whether the insulation is exterior, integral or interior</td>
</tr>
<tr>
<td>Fenestration</td>
<td>Average U-factor and SHGC (solar heat gain coefficient)</td>
</tr>
<tr>
<td>Ducts outside conditioned spaces</td>
<td>Installed R-value</td>
</tr>
<tr>
<td>Mechanical ventilation system</td>
<td>Type, location and design continuous &amp; total ventilation rates</td>
</tr>
<tr>
<td>Make-up air &amp; combustion air systems (if installed)</td>
<td>Type, location and size</td>
</tr>
<tr>
<td>Heating system</td>
<td>Type, input rating, AFUE or HSPF, manufacturer, model and the structures calculated heat loss</td>
</tr>
<tr>
<td>Domestic water heater</td>
<td>Type, size, manufacturer and model</td>
</tr>
<tr>
<td>Cooling system (if installed)</td>
<td>Type, output rating, SEER, manufacturer, model, the structures calculated cooling load and heat gain</td>
</tr>
<tr>
<td>Radon Control System</td>
<td>Passive or active</td>
</tr>
</tbody>
</table>
Fenestration Products

- Fenestration product rating. U-factors of fenestration products (windows, doors and skylights) shall be determined in accordance with NFRC 100, and air leakage by NFRC 400, by an accredited, independent laboratory, and labeled and certified by the manufacturer. Products lacking such a labeled U-factor, shall be assigned a default U-factor from Table N1101.6.
# Default Glazed Fenestration U-Factor Table

<table>
<thead>
<tr>
<th>Frame Type</th>
<th>Single Pane</th>
<th>Double Pane</th>
<th>Skylight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single pane</td>
<td>Double pane</td>
<td></td>
</tr>
<tr>
<td>Metal</td>
<td>1.20</td>
<td>0.80</td>
<td>1.60</td>
</tr>
<tr>
<td>Metal w/thermal break</td>
<td>1.10</td>
<td>0.65</td>
<td>1.90</td>
</tr>
<tr>
<td>Non-Metal or metal clad</td>
<td>0.95</td>
<td>0.55</td>
<td>1.25</td>
</tr>
<tr>
<td>Glazed Block</td>
<td></td>
<td></td>
<td>0.60</td>
</tr>
<tr>
<td>Non-Metal or metal clad</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glazed Block</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table N1101.5(2)

Default Door U-Factors

<table>
<thead>
<tr>
<th>Material</th>
<th>U-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uninsulated metal</td>
<td>1.2</td>
</tr>
<tr>
<td>Insulated Metal</td>
<td>0.6</td>
</tr>
<tr>
<td>Wood</td>
<td>0.5</td>
</tr>
<tr>
<td>Insulated non-metal edge, Max 45% glazing, Any glazing</td>
<td>0.35</td>
</tr>
<tr>
<td>double pane</td>
<td></td>
</tr>
</tbody>
</table>
Installation of Materials

• **Installation.** All materials, systems and equipment shall be installed in accordance with the manufacturer’s installation instructions and the conditions of any listing or required certifications.
Building Certificate

• A certificate shall be posted in a permanently visible location inside the building. The certificate shall list information and the values of components listed in Table 1101.8.
<table>
<thead>
<tr>
<th>Component</th>
<th>Certificate requirements</th>
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</thead>
<tbody>
<tr>
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<td>Insulation installed in or on ceiling/roof, walls, slab-on-grade and floor</td>
<td>Type and installed R-value</td>
</tr>
<tr>
<td>Rim joist and foundation wall insulation</td>
<td>Installed R-value, type and whether the insulation is exterior, integral or interior</td>
</tr>
<tr>
<td>Fenestration</td>
<td>Average U-factor and SHGC (solar heat gain coefficient)</td>
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</tr>
<tr>
<td>Radon Control System</td>
<td>Passive or active</td>
</tr>
</tbody>
</table>
Building Thermal Envelope Requirements

• Based on the climate zone specified in Table N1101.2, the building thermal envelope shall meet the requirements of Table N1102.1(1) or Table N1102.1(2).
<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Fenestration (b) U-Factor</th>
<th>Skylight U-Factor</th>
<th>Glazed Fenestration SHGC</th>
<th>Ceiling R-Value</th>
<th>Wood Frame Wall R-Value</th>
<th>Mass Wall R-Value (f)</th>
<th>Floor over unconditioned space R-Value</th>
<th>Basement (d) Wall R-Value</th>
<th>Slab (c) R-Value &amp; Depth</th>
<th>Crawl Space Wall R-Value</th>
<th>Rim Joist R-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Southern</strong></td>
<td>0.35</td>
<td>0.60</td>
<td>NR</td>
<td>38</td>
<td>19 or 13+5 (e)</td>
<td>15</td>
<td>30 (d)</td>
<td>5/10</td>
<td>10, 3.5 ft</td>
<td>10</td>
<td>- 10</td>
</tr>
<tr>
<td><strong>Northern</strong></td>
<td>0.35</td>
<td>0.60</td>
<td>NR</td>
<td>44</td>
<td>19</td>
<td>15</td>
<td>30 (d)</td>
<td>10</td>
<td>10, 5 ft</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

(a) R-values are minimums. U-factors are maximums. R-19 shall be permitted to be compressed into a 2x6 cavity.
(b) The fenestration U-factor column excludes skylights.
(c) R-5 shall be added to the required slab edge R-values for heated slabs.
(d) Or insulation sufficient to fill the framing cavity, R-19 minimum.
(e) “13+5” means R-13 cavity insulation plus R-5 insulated sheathing. If structural sheathing covers 25% or less of the exterior, R-5 sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25% of exterior, structural sheathing shall be supplemented with insulated sheathing of at least R-2.
(f) When using Log Type construction for Thermal Mass Walls the following shall apply:
   1. A minimum of a 7 inch diameter log shall be used
   2. The U-value of fenestration products shall be 0.31 overall on average or better.
Table 1102.1(2)  
Equivalent U-Factors\(^{(a)}\)

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Fenestration U-Factor</th>
<th>Skylight U-Factor</th>
<th>Ceiling Wall U-Factor</th>
<th>Frame Wall U-Factor</th>
<th>Mass Wall U-Factor</th>
<th>Floor U-Factor</th>
<th>Basement Wall U-Factor</th>
<th>Crawl Space Wall U-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>South</td>
<td>0.35</td>
<td>0.60</td>
<td>0.026</td>
<td>0.060</td>
<td>0.077</td>
<td>0.033</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>North</td>
<td>0.35</td>
<td>0.60</td>
<td>0.023</td>
<td>0.060</td>
<td>0.077</td>
<td>0.033</td>
<td>0.10</td>
<td>0.10</td>
</tr>
</tbody>
</table>

\(^{(a)}\) Non-fenestration U-factors shall be obtained from measurement, calculation or an approved source.
Mass walls.

- Concrete block, concrete, insulated concrete form (ICF), masonry cavity, brick (other than brick veneer), earth (adobe, compressed earth block, rammed earth), and solid timber/logs.

- Mass walls shall comply with Section N1102.1.
## Table 1102.1(1) Insulation and Fenestration Requirements by Component

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Fenestration U-factor</th>
<th>Skylight U-Factor</th>
<th>- Glazed Fenestration SHGC</th>
<th>Ceiling R-Value</th>
<th>Wood Frame Wall R-Value</th>
<th>Mass Wall R-Value</th>
<th>Floor over unconditioned space R-Value</th>
<th>Basement Wall R-Value</th>
<th>Slab R-Value &amp; Depth</th>
<th>Crawl Space Wall R-Value</th>
<th>Rim Joist R-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern</td>
<td>0.35</td>
<td>0.60</td>
<td>NR</td>
<td>38</td>
<td>19 or 13+5(e)</td>
<td>15</td>
<td>30(d)</td>
<td>5/10</td>
<td>10 10, 3.5 ft</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td>19</td>
<td>15</td>
<td>30(d)</td>
<td>10</td>
<td>10, 5 ft</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

(a) R-values are minimums. U-factors are maximums. R-19 shall be permitted to be compressed into a 2x6 cavity.

(b) The fenestration U-factor column excludes skylights.

(c) R-5 shall be added to the required slab edge R-values for heated slabs.

(d) Or insulation sufficient to fill the framing cavity, R-19 minimum.

(e) “13+5” means R-13 cavity insulation plus R-5 insulated sheathing. If structural sheathing covers 25% or less of the exterior, R-5 sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25% of exterior, structural sheathing shall be supplemented with insulated sheathing of at least R-2.

(f) When using Log Type construction for Thermal Mass Walls the following shall apply:

1. A minimum of a 7-inch diameter log shall be used
2. The U-value of fenestration products shall be 0.31 overall on average or better
Steel-frame ceilings, walls and floors

• Shall meet the insulation requirements of Table N1102.2.3 or shall meet the U-factor requirements in Table N1102.1(2).

• The calculation of the U-factor for a steel-frame wall shall use a series-parallel path calculation method.
Table 1102.2.3 Steel frame Ceiling, Wall and Floor Insulation (R-value)

<table>
<thead>
<tr>
<th>Wood Frame R-Value Requirement</th>
<th>Cold-Formed Steel Equivalent R-Value&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Steel Truss Ceilings&lt;sup&gt;2&lt;/sup&gt;</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>R-38</td>
<td>R-49 or R-38+3</td>
</tr>
<tr>
<td>R-44</td>
<td>R-38+5</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Steel Joist Ceilings&lt;sup&gt;2&lt;/sup&gt;</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>R-30</td>
<td>R-21 + R-6 in 2 x 6, R-21 + R-12 in 2 x 8 or 2 x 10</td>
</tr>
<tr>
<td>R-38</td>
<td>R-49 in 2x4 or 2x6 or 2x8 or 2x10</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Steel Framed Wall</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>R-19</td>
<td>R-13+9 or R-19+8 or R-25+7</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Steel Joist Floor</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>R-30</td>
<td>R-21+R-6 in 2x6</td>
</tr>
<tr>
<td></td>
<td>R-21+R-12 in 2x8 or 2x10</td>
</tr>
</tbody>
</table>

Footnotes:
1. Cavity insulation R-value is listed first, followed by a “+” and the continuous insulation R-value, if applicable.
2. Insulation exceeding the height of the framing shall cover the framing.
Foundations
Decision Tree for foundation Insulation in the Residential Energy Code

Proposed home Foundation Reqmt’s Depending on Foundation Type

- Integrally insulated Foundation Mandatory items
- Exterior insulated Foundation Mandatory items
- Interior insulated Foundation Mandatory items

Type of insulation Used and its Reqmt’s for use

Type of insulation Used and its Reqmt’s for use

Reqmt’s specific to insulation type (several types)

Note: This is not a complicated process. It is very prescriptive. The builder shall decide where they want to insulate the foundation and what product they are going to use and follow the code, including code sections, ASTM Standards etc…
Foundation Wall Performance
Prescriptive Option

• **Foundation insulation** Foundation insulation of basement and crawl space walls and the perimeter of slab-on grade floors must comply with this section. Insulation materials shall be installed according to manufacturer’s installation specifications and any additional requirements of sections N1102.2.6.1 through N1102.2.6.11. Adding additional insulation to increase R-values or adding an additional vapor retarder to foundation wall assemblies, other than those required in this section, is prohibited.
Interior design = 70 degrees F with 30% RH
(warm air = Positive pressure)

Ext. design temp = -20 Degrees F
(Cold air = Negative pressure)

Total R Value = 10  Delta T = 90  See Dew Point Calculations Below

R-8 (Foam insulation) Divided by 10 (Total R Value) Multiplied by 90 (Delta T) = Temperature change from one side of foam to other side of foam. Ex. \((8/10 \times 90 = 72\) Degrees temperature Change) The temperature between the foam insulation and the 2 x 10 rim is now at 52 Degrees. \((-20 + 72 = 52)\)

The dew point temperature for a building with a interior temp of 70 degrees F and a interior RH of 30% is 37.5 degrees. (see Psychrometric Chart) This is the condensation point in this assembly. If moisture condenses there how will it get out or dry out. Remember it will condensate to the first plane or surface to the cold side. Heat and moisture always flow from warm to cold.
Exceptions:

• 1. Foundation walls enclosing unconditioned spaces shall meet this requirement unless the floor overhead is insulated in accordance with Section N1102.1.

• 2. Permanent wood foundations shall meet the requirements of R401.1.

• 3. Frost protected shallow foundations shall meet the requirements of R403.3

• 4. Insulating concrete form materials shall meet the requirements of Section R611.
Basement foundation and crawl space walls.

- Basement foundation and crawl space walls shall be insulated from the top of the foundation wall down to the top of the footing or from the top edge of the interior wall to the top of the slab if insulation is on the interior.
Slab-on-grade and basement walkout foundation walls.
Slab-on-grade and basement walkout foundation walls.

- Insulation shall extend to the design frost line or top of footing whichever is less.
Slab-on-grade and basement walkout foundation walls.

- Insulation shall extend to the design frost line or top of footing whichever is less.
- The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45-degree angle away from the exterior wall.
Slab-on-grade and basement walkout foundation walls.

- Insulation shall extend to the design frost line or top of footing whichever is less.
- The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45-degree angle away from the exterior wall.
- Slab-edge insulation is not required in jurisdictions designated by the code official as having termite infestation.
Foundation wall and rim joist area thermal insulation requirements.

- The foundation wall system and rim joist area shall have an insulating layer with minimum thermal properties as required in this section. The insulation layer must be a minimum R-10 in accordance with Table N1102.1.
Exception

- The foundation wall system and rim joist area shall have an insulating layer with minimum thermal properties as required in this section. The insulation layer must be a minimum R-10 in accordance with Table N1102.1.

In the Southern Zone, the foundation and rim joist area insulation may be reduced to a minimum of an R-5 if
Exception

• The foundation wall system and rim joist area shall have an insulating layer with minimum thermal properties as required in this section. The insulation layer must be a minimum R-10 in accordance with Table N1102.1.

In the Southern Zone, the foundation and rim joist area insulation may be reduced to a minimum of an R-5 if

• 1. The insulation is located on the exterior or is integral to the foundation wall; and
Exception

• The foundation wall system and rim joist area shall have an insulating layer with minimum thermal properties as required in this section. The insulation layer must be a minimum R-10 in accordance with Table N1102.1.

In the Southern Zone, the foundation and rim joist area insulation may be reduced to a minimum of an R-5 if
• 1. The insulation is located on the exterior or is integral to the foundation wall; and
• 2. An additional R-5 insulation is added to the minimum attic R-value level; and
Exception

• The foundation wall system and rim joist area shall have an insulating layer with minimum thermal properties as required in this section. The insulation layer must be a minimum R-10 in accordance with Table N1102.1.

In the Southern Zone, the foundation and rim joist area insulation may be reduced to a minimum of an R-5 if

• 1. The insulation is located on the exterior or is integral to the foundation wall; and
• 2. An additional R-5 insulation is added to the minimum attic R-value level; and.
• 3. The heating system meets the minimum efficiency ratings in Table N1102.2.6.4; and
<table>
<thead>
<tr>
<th>Heating System Type</th>
<th>Minimum Efficiency Rating</th>
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<tr>
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<td>AFUE</td>
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Table 1102.2.5 HVAC System Minimum Efficiency Requirement to Qualify for R-5 Exterior Insulation in the Southern Zone
Exception

• The foundation wall system and rim joist area shall have an insulating layer with minimum thermal properties as required in this section. The insulation layer must be a minimum R-10 in accordance with Table N1102.1.

In the Southern Zone, the foundation and rim joist area insulation may be reduced to a minimum of an R-5 if

• 1. The insulation is located on the exterior or is integral to the foundation wall; and

• 2. An additional R-5 insulation is added to the minimum attic R-value level; and

• 3. The heating system meets the minimum efficiency ratings in Table N1102.2.6.4; and

• 4. A minimum of a 6 inch energy heel is used for the roof framing and/or truss system.
Requirements for Integral foundation insulation systems

• An insulation assembly installed integral to the foundation walls shall be manufactured for its intended use and installed according to the manufacturer's specifications.
Decision Tree for foundation Insulation in the Residential Energy Code

Proposed home Foundation Reqmt’s Depending on Foundation Type

- Integrally insulated Foundation Mandatory items
- Exterior insulated Foundation Mandatory items
- Interior insulated Foundation Mandatory items

Type of insulation Used and its Reqmt’s for use

Type of insulation Used and its Reqmt’s for use

Reqmt’s specific to insulation type (several types)

Note: This is not a complicated process. It is very prescriptive. The builder shall decide where they want to insulate the foundation and what product they are going to use and follow the code, including code sections, ASTM Standards etc…
Foam Insulation that meets the requirements for R-Value and Perm rating

Exterior concrete meets the requirement for protection of the foam to a point 6 inches below grade

Interior concrete meets the requirement for thermal barrier and the additional concrete on the warm in winter side can be used as additional R-value

Waterproofing or Damproofing
Required in accordance with Chapter 4 of the IRC

Footing
Requirements for Exterior foundation insulation requirements
Note: This is not a complicated process. It is very prescriptive. The builder shall decide where they want to insulate the foundation and what product they are going to use and follow the code, including code sections, ASTM Standards etc…
1. Shall be of water resistant materials manufactured for its intended use;
• 1. Shall be of water resistant materials manufactured for its intended use;
• 2. Installed according to the manufacturer's specifications;
• 1. Shall be of water resistant materials manufactured for its intended use;
• 2. Installed according to the manufacturer's specifications;
• 3. Shall comply with either ASTM C578, C612 or C1029 as applicable and;
Exterior foundation insulation

- 1. Shall be of water resistant materials manufactured for its intended use;
- 2. Installed according to the manufacturer's specifications;
- 3. Shall comply with either ASTM C578, C612 or C1029 as applicable and;
- 4. Shall have a rigid, opaque and weather-resistant protective covering to prevent the degradation of the insulation’s thermal performance. The protective covering shall cover the exposed exterior insulation and extend a minimum of 6 inches (152 mm) below grade. The insulation and protective covering system shall be flashed in accordance with the IRC Section R703.8.
Exterior Foundation Insulation

- Foam Insulation that meets the requirements for R-Value and is approved for exterior use
- Exterior covering meeting the requirement for protection of the foam to a point 6 inches below grade
- Concrete wall meets the requirement for thermal barrier
- Waterproofing or Damp proofing: Required in accordance with Chapter 4 of the IRC
- Footing
Decision Tree for foundation Insulation in the Residential Energy Code

Proposed home Foundation Reqmt’s Depending on Foundation Type

- Integrally insulated Foundation Mandatory items
- Exterior insulated Foundation Mandatory items
- Interior insulated Foundation Mandatory items
  - Type of insulation Used and its Reqmt’s for use
  - Type of insulation Used and its Reqmt’s for use
  - Reqmt’s specific to insulation type (several types)

Note: This is not a complicated process. It is very prescriptive. The builder shall decide where they want to insulate the foundation and what product they are going to use and follow the code, including code sections, ASTM Standards etc…
Requirements for Interior foundation insulation
Decision Tree for foundation Insulation in the Residential Energy Code

Proposed home Foundation Reqmt’s Depending on Foundation Type

- Integrally insulated Foundation Mandatory items
- Exterior insulated Foundation Mandatory items
- Interior insulated Foundation Mandatory items

Type of insulation Used and its Reqmt’s for use

Type of insulation Used and its Reqmt’s for use

Reqmt’s specific to insulation type (several types)

Note: This is not a complicated process. It is very prescriptive. The builder shall decide where they want to insulate the foundation and what product they are going to use and follow the code, including code sections, ASTM Standards etc…
Interior foundation insulation

• 1. Masonry foundation walls shall be drained through the masonry block cores to an approved interior drainage system.
Masonry foundation walls shall be drained through the masonry block cores to an approved interior drainage system.
Interior foundation insulation

• 1. Masonry foundation walls shall be drained through the masonry block cores to an approved interior drainage system.

• 2. If a frame wall is installed it shall not be in direct contact with the foundation wall, unless that interior side of the foundation wall has been waterproofed.
If a frame wall is installed it shall not be in direct contact with the foundation wall, unless that interior side of the foundation wall has been waterproofed.

Masonry foundation walls shall be drained through the masonry block cores to an approved interior drainage system.
Interior foundation insulation

• 1. Masonry foundation walls shall be drained through the masonry block cores to an approved interior drainage system.
• 2. If a frame wall is installed it shall not be in direct contact with the foundation wall, unless that interior side of the foundation wall has been waterproofed.
• 3. Comply with the interior air barrier requirements in N1102.4.1
Interior Foundation Insulation

If a frame wall is installed it shall not be in direct contact with the foundation wall, unless that interior side of the foundation wall has been waterproofed.

Masonry foundation walls shall be drained through the masonry block cores to an approved interior drainage system.

Warm Side Vapor and Air barrier
Interior Foundation Insulation

- Insulation that meets the requirements for R-Value
- Warm Side vapor and Air barrier
- If a frame wall is installed it shall not be in direct contact with the foundation wall, unless that interior side of the foundation wall has been waterproofed.

Masonry foundation walls shall be drained through the masonry block cores to an approved interior drainage system.

Waterproofing or Damproofing Required in accordance with Chapter 4 of the IRC

Footing
Interior foundation insulation requirements

• 1. Masonry foundation walls shall be drained through the masonry block cores to an approved interior drainage system.

• 2. If a frame wall is installed it shall not be in direct contact with the foundation wall, unless that interior side of the foundation wall has been waterproofed.

• 3. Comply with the interior air barrier requirements in N1102.4.1

• 4. Comply with section N1102.2.6.8, N1104.2.2.6.9, N1102.2.6.10, or N1102.2.6.11.
Note: This is not a complicated process. It is very prescriptive. The builder shall decide where they want to insulate the foundation and what product they are going to use and follow the code, including code sections, ASTM Standards etc…
Rigid interior insulation
N1102.2.6.8

• 1. Either ASTM C 578 or ASTM C 1289.
Rigid interior insulation
N1102.2.6.8

• 1. Either ASTM C 578 or ASTM C 1289.

• 2. Dampproofing, waterproofing, or a water repellant shall be applied to the exposed above grade foundation walls or a layer of dampproofing or waterproofing shall be installed on the entire inside surface of the foundation wall. Water repellant materials shall comply with ASTM E 514 with 90% or greater reduction in water permeance when compared to an untreated sample.
Rigid Interior Foundation
Insulation N1102.2.6.8

Damproofing, waterproofing or water repellent above grade

Grade level

waterproofing or damproofing with parging
Rigid Interior Foundation Insulation N1102.2.6.8

Installation requirements

a. Must be in contact with the foundation wall surface

b. Vertical edges shall be sealed with acoustic sealant

c. All interior joints, edges, and penetrations shall be sealed against air and water vapor penetration.

d. Horizontally continuous acoustic sealant between the foundation wall and the insulation at the top of the foundation wall.

e. Horizontally continuous acoustic sealant between the basement floor and the bottom insulation edge.

Dampproofing, waterproofing or water repelent above grade

Grade level
Rigid Interior Foundation
Insulation N1102.2.6.8

Installation requirements

The insulation shall not be penetrated by the placement of utilities or by fasteners or connectors used to install a frame wall.

Damproofing, waterproofing or water repellent above grade

Grade level
Note: This is not a complicated process. It is very prescriptive. The builder shall decide where they want to insulate the foundation and what product they are going to use and follow the code, including code sections, ASTM Standards etc…
Spray applied interior insulation
N1102.2.6.9

• 1. Closed cell polyurethane
Spray applied interior insulation

N1102.2.6.9

1. Closed cell polyurethane
   a. ASTM C 1029 compliant with a permeance not greater than 1 in accordance with ASTM E 96 procedure A.
Spray applied interior insulation

N1102.2.6.9

• 1. Closed cell polyurethane
• a. ASTM C 1029 compliant with a permeance not greater than 1 in accordance with ASTM E 96 procedure A.
• b. Sprayed directly onto the foundation wall surface. There must be a 1” minimum gap between the foundation wall surface and any framing.
Interior Spray applied interior insulation N1102.2.6.9

Insulation that meets the requirements for R-Value

Foam may become the Warm Side vapor and Air barrier

If a frame wall is installed it shall not be in direct contact with the foundation wall
Interior Spray applied interior insulation N1102.2.6.9

Insulation that meets the requirements for R-Value

Foam *may* become the Warm Side vapor and Air barrier

If a frame wall is installed it shall not be in direct contact with the foundation wall

The insulation shall not be penetrated by the placement of utilities.

Through penetrations shall be sealed
Spray applied interior insulation
N1102.2.6.9

- 2. $\frac{1}{2}$ pound free rise open cell foam
Spray applied interior insulation

N1102.2.6.9

• 2. ½ pound free rise open cell foam

• a. Sprayed directly onto the foundation wall surface. There must be a 1” minimum gap between the foundation wall surface and any framing.
Interior Spray applied interior insulation N1102.2.6.9

- Insulation that meets the requirements for R-Value
- Foam may become the Warm Side Air barrier
- If a frame wall is installed it shall not be in direct contact with the foundation wall
Interior Spray applied interior insulation N1102.2.6.9

- Insulation that meets the requirements for R-Value

- Foam may become the Warm Side vapor and Air barrier

- If a frame wall is installed it shall not be in direct contact with the foundation wall

- The insulation shall not be penetrated by the placement of utilities.

- Through penetrations shall be sealed
Semi-rigid interior insulation
N1102.2.6.10
Note: This is not a complicated process. It is very prescriptive. The builder shall decide where they want to insulate the foundation and what product they are going to use and follow the code, including code sections, ASTM Standards etc…
Semi-rigid interior insulation

N1102.2.6.10

• 1. ASTM C1621 with a maximum permeance of 1.1 per inch.
Semi-rigid interior insulation

N1102.2.6.10

• 1. ASTM C1621 with a maximum permeance of 1.1 per inch.
• 2. Must have a minimum density of 1.3 pcf and have a fungal resistance per ASTM C1338.
Semi-Rigid Interior Foundation Insulation N1102.2.6.8

Installation requirements

a. Must be in contact with the foundation wall surface

b. Vertical edges shall be sealed with acoustic sealant

c. All interior joints, edges, and penetrations shall be sealed against air and water vapor penetration.

d. Horizontally continuous acoustic sealant between the foundation wall and the insulation at the top of the foundation wall.

e. Horizontally continuous acoustic sealant between the basement floor and the bottom insulation edge.
Unfaced fiberglass batt interior insulation
Decision Tree for foundation Insulation in the Residential Energy Code

Proposed home Foundation Reqmt’s Depending on Foundation Type

- Integrally insulated Foundation Mandatory items
- Exterior insulated Foundation Mandatory items
- Interior insulated Foundation Mandatory items

Type of insulation Used and its Reqmt,s for use

Type of insulation Used and its Reqmt’s for use

Reqmt’s specific to insulation type (several types)

Note: This is not a complicated process. It is very prescriptive. The builder shall decide where they want to insulate the foundation and what product they are going to use and follow the code, including code sections, ASTM Standards etc…
Unfaced fiberglass batt interior insulation

• 1. Waterproofing shall be applied to the entire inside surface of the foundation wall.
Unfaced fiberglass Interior Foundation Insulation N1102.2.6.8

- Damproofing, waterproofing or water repellent above grade
- Grade level
- Waterproofing **shall** be applied to the entire inside surface of the foundation wall
Unfaced fiberglass batt interior insulation

1. Waterproofing shall be applied to the entire inside surface of the foundation wall.

2. The top and bottom plates must be air sealed to the foundation wall surface and the basement floor.
Unfaced fiberglass Foundation Insulation N1102.2.6.8

The top and bottom plates must be air sealed to the foundation wall surface and the basement floor.
Unfaced fiberglass Foundation Insulation N1102.2.6.8

In addition an air barrier material and vapor retarder material with a minimum a permeance of at least 1 in accordance with ASTM E 96 procedure A.

a. Air sealed to the framing with construction adhesive or equivalent at the top and bottom plates and where the adjacent wall is insulated, and

b. Air sealed utility boxes and other penetrations, and

c. All seams shall be overlapped at least 6 inches and sealed with compatible sealing tape or equivalent.

Waterproofing shall be applied to the entire inside surface of the foundation wall.

The top and bottom plates must be air sealed to the foundation wall surface and the basement floor.
Unfaced fiberglass batt interior insulation

• 1. Waterproofing shall be applied to the entire inside surface of the foundation wall.
• 2. The top and bottom plates must be air sealed to the foundation wall surface and the basement floor.
• 3. In addition an air barrier material and vapor retarder material with a minimum a permeance of at least 1 in accordance with ASTM E 96 procedure A.
  • a. Air sealed to the framing with construction adhesive or equivalent at the top and bottom plates and where the adjacent wall is insulated, and
  • b. Air sealed utility boxes and other penetrations, and
  • c. All seams shall be overlapped at least 6 inches and sealed with compatible sealing tape or equivalent.
• d. Up to R-13 batts are allowed.
Foundation Wall Insulation Performance Option
Decision Tree for foundation Insulation in the Residential Energy Code

Proposed home Foundation Reqmt’s Depending on Foundation Type

- Integrally insulated Foundation Mandatory items
- Exterior insulated Foundation Mandatory items
- Interior insulated Foundation Mandatory items

Type of insulation Used and its Reqmt’s for use

Reqmt’s specific to insulation type (several types)

Note: This is not a complicated process, for the builder. However for someone else it may be
Foundation Wall Insulation Performance Option

• Insulated foundation systems designed and installed under the performance option shall meet the requirements of this section.
Water separation plane

• The foundation shall be designed and built to have a continuous water separation plane between the interior and exterior. The interior side of the water separation plane must:
1. Have a stable annual wetting/drying cycle whereby foundation wall system water (solid, liquid and vapor) transport processes produce no net accumulation of ice or water over a full calendar year and the foundation wall system is free of adsorbed water for at least 4 months over a full calendar year;
Water separation plane

1. Have a stable annual wetting/drying cycle whereby foundation wall system water (solid, liquid and vapor) transport processes produce no net accumulation of ice or water over a full calendar year and the foundation wall system is free of adsorbed water for at least 4 months over a full calendar year;

2. Prevent conditions of moisture and temperature to prevail for a time period favorable to mold growth for the materials used; and
Water separation plane

1. Have a stable annual wetting/drying cycle whereby foundation wall system water (solid, liquid and vapor) transport processes produce no net accumulation of ice or water over a full calendar year and the foundation wall system is free of adsorbed water for at least 4 months over a full calendar year;

2. Prevent conditions of moisture and temperature to prevail for a time period favorable to mold growth for the materials used; and

3. Prevent liquid water from the foundation wall system reaching the foundation floor system at any time during a full calendar year.
The foundation insulation system designer shall provide documentation certified by a professional engineer registered in Minnesota demonstrating how the requirements of this section are fulfilled. The foundation insulation system designer shall also specify the design conditions for the wall and the design conditions for the interior space for which the water separation plane will meet the requirements of this section. The foundation insulation system designer shall provide a label disclosing these design conditions and the label shall be posted in accordance with N1101.8.
Installation

• The *water separation plane* shall be designed and installed to prevent external liquid or capillary water flow across it after the foundation is backfilled.
Foundation air barrier.

- The foundation insulation system shall be designed and installed to have a foundation air barrier system between the interior and the exterior.
Foundation air barrier.

• The foundation insulation system shall be designed and installed to have a foundation air barrier system between the interior and the exterior.
• The foundation air barrier system must be a material or combination of materials that is continuous with all joints sealed and is durable for the intended application.
Foundation air barrier.

• The foundation insulation system shall be designed and installed to have a foundation air barrier system between the interior and the exterior.
• The foundation air barrier system must be a material or combination of materials that is continuous with all joints sealed and is durable for the intended application.
• Material used for the foundation air barrier system must have an air permeability not to exceed 0.004 ft³/min.ft² under a pressure differential of 0.3 in. water (1.57 psf) (0.02 L/s.m² at 75 Pa) as determined by either commonly accepted engineering tables or by being labeled by the manufacturer as having these values when tested in accordance with ASTM E2178.
FENESTRATION.
Glazed fenestration exemption

• Up to 15 ft$^2$ of glazed fenestration per dwelling unit shall be permitted to be exempt from U-factor requirements in Section N1102.1.
Opaque door exemption

• One opaque door assembly is exempted from the U-factor requirements in Section N1102.1
Thermally isolated sunroom U-factor

- New windows and doors separating the sunroom from conditioned space shall meet the building thermal envelope requirements.
Replacement Fenestration

• Where some or all of an existing fenestration unit is replaced with a new fenestration product, including frame, sash, and glazing, the replacement fenestration unit shall meet the applicable requirements for U-factors found in Tables N1102.1, unless exempt under Section 1102.3.1.
Ventilation
Ventilation
Minnesota Rules, Chapter 1322, Residential Energy Code

1. Ventilation Overview
   - What is ventilation
   - Why ventilate
   - How much should we ventilate

2. Mechanical Ventilation Systems
   - Total and continuous ventilation rates
   - Ventilation System Requirements (3 types)
     - Exhaust only
     - Balanced
     - Other methods

3. Air distribution/circulation

4. Insulation, labeling, documentation
Ventilation Systems-Overview

• Goals of Mechanical Ventilation
  – To maintain good indoor air quality
  – To control indoor moisture
Ventilation Systems-Overview

– ASHRAE 62.1-2004

• “Acceptable indoor air quality: air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction.”
Ventilation Systems

• When to Ventilate?
  – Primarily when the home is occupied
  – May need to continue after or purge before
Ventilation Systems

• When to Ventilate?
  – Primarily when the home is occupied
  – May need to continue after or purge before

• Where to Ventilate?
  – Ideally where the pollutants are concentrated
  – Remove point source pollutants immediately
  – Use general ventilation for disperse pollutants
Overview - What is Ventilation?

“The process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space.”
Overview- Ventilation Systems

• **Why** Ventilate?
  – People pollutants
    • human respiration, body odors
    • water vapor
  – Building pollutants
    • VOCs, Combustion gases, radon
    • water vapor
  – Activity pollutants
    • VOCs, odors
    • water vapor
Overview-Ventilation Systems

• Types of Air Exchange in Houses
  – Infiltration/Exfiltration
  – Natural ventilation
  – Chimneys
  – Exhaust devices
  – Mechanical ventilation
Why Ventilate?

Athletic equipment

Smoke

Diapers

Mold

Bathroom exhaust

Pet odors

Cleaning supplies

Window condensation

Dust Mites
IAQ Solutions - HUMIDITY CONTROL

Why Manage Humidity?

- Moisture
- Source of Spores
- Organic Matter
- DIRT

Constant Temperature (40-100 F)

= Prerequisites for Microbial Growth
OVERVIEW - HUMIDITY CONTROL

Percent Relative Humidity, % RH

ASHRAE-recommended

Comfort Problems

Organic Growth
Overview- Ventilation Systems

• **How Much** to Ventilate, considering:
  – Moisture generation rates
    • people
    • building
  – Other pollutants
    • type of pollutant
    • source strength
  – Occupant sensitivity
  – Continuous ventilation
Overview-Ventilation Systems

• **How Much** to Ventilate?

• **Chapter 1322: Total ventilation rate:** “…shall provide sufficient outdoor air = total ventilation rate average, for each one hour period in accordance with Table N1104.2, or equation 11-1.

• **Equation 11-1**
  
  – Total ventilation rate (CFM) = (0.02 x square feet of conditioned space) + (15 x (number of bedrooms +1)).
  
  – Includes the basement but excludes conditioned crawl spaces.
Overview-Ventilation Systems

- **Equation 11-1**
  - Total ventilation rate (CFM) = (0.02 x square feet of conditioned space) + (15 x (number of bedrooms +1)).
- **Example 1:**
  - 2300 square feet of conditioned space house
    - Conditioned space = “An area, room or space being heated or cooled by any equipment or appliance.”
  - 3 bedrooms
  - .02 x square feet of conditioned space = .02 x 2300 = 46 CFM
  - Number of bedrooms (3) + 1 = 4
  - 15 x 4 = 60 CFM
  - Total ventilation rate (CFM) = 46 CFM + 60 CFM = 106 CFM
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¹ Assumes 100 square feet per bedroom.
² Assumes 300 square feet per bedroom.
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Overview-Ventilation Systems

• Continuous Ventilation:
  – N1104.2.1: “… a minimum of 50% of the total ventilation rate, but not less than 40 CFM, on a continuous rate average for each one hour period in accordance with Table N1104.2 or Equation 11-2.

  – **Equation 11-2**: Continuous ventilation (CFM) = total ventilation rate /2.
Table N1104.2 Total and continuous ventilation rates (in CFM)

<table>
<thead>
<tr>
<th>Conditioned space (in sq. ft.)</th>
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Overview-Ventilation Systems

- **Total Ventilation**: equation 11-1 total ventilation rate = 106 CFM and Table N1104.2 total ventilation rate = 110 CFM.

- **Continuous ventilation rate** = 53 CFM (if equation 11-2 is used) or 55 CFM = 55 CFM if table N1104.2 is used.
Supplemental Ventilation

• Kitchen Exhaust
• Bathroom Exhaust
• ETC.
Ventilation Systems
Required ventilation rate

Example 2

\[
(0.02 \times \text{square feet of conditioned space} + (15 \times (\text{number of bedrooms} + 1))) = \text{Total Ventilation Rate}
\]

Example: 4 bedroom, 2 bathroom, 2,000 sq.ft. house

\[
(4 \text{ Bedrooms} + 1) \times 15 \text{ (cfm)} + (0.02 \text{ (cfm)} \times 2000 \text{ sq.ft.}) + 40 = 115 \text{ cfm}
\]
Continuous Ventilation Rate

• 50% of Total Ventilation Rate

• Example:
  \[\frac{115 \text{ cfm}}{2} = 57.5 \text{ cfm} > 60 \text{ cfm}\]
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\(^1\) Total/Continuous \n\(^2\) Total/Continuous
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Ventilation Systems

Required ventilation rate

Example 3

\[(.02 \times \text{square feet of conditioned space}) + (15 \times (\text{number of bedrooms} + 1)) = \text{Total Ventilation Rate}\]

6 bedroom, 3 bathroom, 5,000 sq.ft. house

\[
(6 \text{ Bedrooms} + 1) \times 15 \text{ (cfm)} + (0.02 \times 5000 \text{ sq.ft.}) = 105 + 100 = 205
\]
Table N1104.2 Total and continuous ventilation rates (in CFM)

<table>
<thead>
<tr>
<th>Conditioned space (in sq. ft.)</th>
<th>Total/Continuous</th>
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Table N1104.2 Total and continuous ventilation rates (in CFM)

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² Excludes mechanical ventilation systems
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<th>Conditioned space^1 (in sq. ft.)</th>
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<td>210/105</td>
<td>225/113</td>
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</table>
Ventilation Systems
Required ventilation rate

Example 4

(.02 X square feet of conditioned space) + (15 x (number of bedrooms +1)) = Total Ventilation Rate

Example: 6 bedroom, 3 bathroom, 7,000 sq.ft. house

(6 Bedrooms + 1) X 15 (cfm) + (0.02 (cfm) X 7000 sq.ft.) = 7 X 15 =105 + 140 = 245 cfm
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<td>195/98</td>
<td>210/105</td>
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</tbody>
</table>
Sub-script 2 to the table

- If conditioned space exceeds 6000 sq. ft. or there are more than 6 bedrooms, use Equation 11-1 from section N1104.2 to calculate total ventilation rate.
Ventilation Systems

• Framework for Mechanical Ventilation
  – Quantity and location of exhaust (stale, moist) air
  – Quantity and location of supply (fresh, outdoor) air
  – Pressure imbalances (unbalanced exhaust & supply)
  – Internal distribution/circulation patterns
  – Controls
Overview-Ventilation Systems

N1104.3 Ventilation system requirements.
The mechanical ventilation system shall be one of 3 types:

1. Exhaust in accordance with N1104.2.1 (Continuous ventilation section).
2. Balanced, and HRV/ERV in accordance with N1104.3.2
3. Other method in accordance with N1104.3.3
Overview-Ventilation Systems

• N1104.3.1 Exhaust Systems. Fans used to comply with the continuous ventilation part of the mechanical ventilation system shall:
Overview-Ventilation Systems

• N1104.3.1 Exhaust Systems. Fans used to comply with the continuous ventilation part of the mechanical ventilation system shall:

1. Meet minimum continuous rate in N1104.2.1
Overview-Ventilation Systems

• N1104.3.1 Exhaust Systems. Fans used to comply with the continuous ventilation part of the mechanical ventilation system shall:
  1. Meet minimum continuous rate in N1104.2.1
  2. Designed and certified by equipment manufacturer as capable of continuous operation at rated CFM
Overview-Ventilation Systems

• N1104.3.1 Exhaust Systems. Fans used to comply with the continuous ventilation part of the mechanical ventilation system shall:
  1. Meet minimum continuous rate in N1104.2.1
  2. Designed and certified by equipment manufacturer as capable of continuous operation at rated CFM
  3. Have a 1.0 sone maximum per HVI Standard 915 for surface mounted fans
Overview-Ventilation Systems

N1104.3.1 Exhaust Systems. Fans used to comply with the continuous ventilation part of the mechanical ventilation system shall:

1. Meet minimum continuous rate in N1104.2.1
2. Designed and certified by equipment manufacturer as capable of continuous operation at rated CFM
3. Have a 1.0 sone maximum per HBI Standard 915 for surface mounted fans
4. Be permitted to use a required overcurrent protection device as a disconnect per the NEC.
Overview-Ventilation Systems

• **N1104.3.1 Exhaust Systems.** Fans used to comply with the **continuous ventilation part** of the mechanical ventilation system shall:

1. Meet minimum continuous rate in N1104.2.1
2. Designed and certified by equipment manufacturer as **capable of continuous operation at rated CFM**
3. Have a **1.0 sone maximum** per HBI Standard 915 for surface mounted fans
4. Be permitted to use a required overcurrent protection device as a disconnect per the NEC.
5. **Comply with the MN Mechanical Code 1346** which may require additional makeup air.
Ventilation System Requirements

• Exhaust Systems
  – Exhaust Fans operating @ the Continuous Ventilation Rate
  – Plus “supplemental/intermittent ventilation” system
  – Make up air into home?

• Note:
  – Surface mounted fan runs continuously at
    • 1 sone fan
  – In-line fan (outside conditioned space) and intermittent fans run continuously at
    • 2.5 sone fan
• Exhaust-only systems
  1. Decentralized fans in baths, kitchen, laundry, etc.
  2. Centralized exhaust system
     – with or without heat recovery
Decentralized Exhaust-Only
Point Source Approach
(Example using a single fan)
Decentralized Exhaust-Only Point Source Approach

Models 360/361 LoSone Ventilators
(See chart for specifications page 7)

- Blower wheel 5½" dia. x 3" - Use with Broan Model 57 Solid State Control
Decentralized Exhaust-Only Point Source Approach

- Flex Duct installations shall be stretched tight with no sags and excess duct cut off to allow for less static pressure loss and a more effective system.
Centralized Exhaust-Only Point Source Approach
(Example using a dedicated exhaust Unit)
Centralized Exhaust-Only

Point Source Approach
Ventilation Systems

• **Balanced systems**
  – integrated supply and exhaust system
    • HRV/ERV most common system
Ventilation Systems

• Balanced systems
  – integrated supply and exhaust system

  – separate supply and exhaust fans
• Mechanical ventilation is required:

  – “Balanced ventilation systems”
    • Energy Recovery Ventilator (ERV)
    • Heat Recovery Ventilator (HRV)
    • Fans
N1104.3.2 Balanced, and HRV/ERV Systems.
Shall meet either:
1. The requirements of HVI Standard 920, 72 hour minus 13 F cold weather test, or
2. Certified by a licensed professional engineer and installed per manufacturers installation instructions.
Balanced Ventilation

Volume Source Approach
Balanced Ventilation
Energy Recovery Ventilator
Balanced Ventilation
Heat Recovery Ventilator
Heat Recovery Ventilator
Heat Recovery Ventilator

- Supply Air
- Exhaust Air
- Outdoor Air
- Return Air
- Heat Exchanger
- Filters
Heat Recovery Ventilator

1. Transfers heat by conduction
HRV Defrost Operation

Recirculation damper opens

Supply damper closes

Heat Exchanger

Supply Air

Return Air
Energy Recovery Ventilator

1. Transfers heat by conduction
2. Transfers humidity using *hygroscopic* resin
Ventilation System Requirements
(Example)

• “Balanced Systems” (HRV or ERV)
  – Provides an “average” of 60 cfm
    • Provide (60 cfm X 60 min) = 3,600 cfh
Ventilation System Requirements

• Exhaust Systems

• “Balanced Systems” (ERV)
  – Provides an “average” of 60 cfm
    • Provide (60 cfm X 60 min) = 3,600 cfh
      – 120 cfm for 30 minutes  (120 X 30 = 3,600)
      – 180 cfm for 20 minutes  (180 X 20 = 3,600)
      – 240 cfm for 15 minutes  (240 X 15 = 3,600)
Proportional Timer

Turns unit on and off a percentage of each hour
Overview-Ventilation Systems

N1104.3.3 Other methods.

– Any mechanical ventilation system consisting of exhaust fans, supply fans or combination of both (that comply with N1104) shall be allowed.
Other Methods - complies with N1104

Separate Exhaust and Supply
Installation Requirements

• Installed in accordance with MN Rule 1346
Air distribution/circulation

4 conditions

• Outdoor air shall be delivered to each habitable space by:
  1. A forced air circulation system (Furnace)
Air distribution/circulation

4 conditions

• Outdoor air shall be delivered to each habitable space by:
  1. A forced air circulation system (Furnace)
  2. Separate duct system
Air distribution/circulation

4 conditions

- Outdoor air shall be delivered to each habitable space by:
  1. A forced air circulation system (Furnace)
  2. Separate duct system
  3. Individual inlets
“Not ducted” through Furnace
Air distribution/circulation

4 conditions

• Outdoor air shall be delivered to each habitable space by:
  1. A forced air circulation system (Furnace)
  2. Separate duct system
  3. Individual inlets
  4. Passive opening
Air distribution/circulation

**First condition**: using forced air circulation system

- Outdoor air shall be delivered to each habitable space by:
  1. **A forced air circulation system** (Furnace)
     - Outdoor air in **NOT** ducted to the forced air system
     - Outdoor air **IS** ducted to the forced air system
Air distribution/circulation

- Outdoor air shall be delivered to each habitable space by:
  1. A forced air circulation system (Furnace)
     - (a) When an outdoor air supply is not ducted to the forced air system, controls shall be installed to allow the forced air system to provide an average circulation flow rate each hour, of not less than 0.15 cfm/sq.ft. of the conditioned floor area.
“Not ducted” through Furnace
Air distribution/circulation

- Outdoor air shall be delivered to each habitable space by:
  1. A forced air circulation system (Furnace)
     - (b) When an outdoor air supply IS ducted to the forced air system, it shall be tempered so that the mixed air temperature shall be no less than 60 degrees Fahrenheit or the heating equipment manufacturers installation instruction, and controls shall be installed not less than 0.075 cfm / ft $^2$ of conditioned floor area.
Intake openings

- Exterior air intake openings shall be located in accordance Minnesota Rules Chapter 1346.
Filtration

• All mechanically supplied outdoor air shall have a filter with a designated minimum efficiency of MERV 4 (i.e. good furnace filter) The filter shall be located on the inlet of the appliance and shall be installed to be readily accessible and facilitate regular service.
Controls.

Mechanical ventilation system controls shall be provided in accordance with the following:

1. If required by the equipment (i.e. HRV or ERV) manufacturer’s installation instructions, controls shall be installed to ensure that the forced air circulation system is operating whenever the mechanical ventilation system is operating.
Controls.

Mechanical ventilation system controls (N1104.4.10) shall be provided in accordance with the following:

2. Controls shall be installed to ensure that whenever the mechanical ventilation system is operating, the forced air circulation system provides indirect circulation of 0.15 cfm per square foot of conditioned floor area or direct distribution of 0.075 cfm per square foot of conditioned floor area.
Controls.

Mechanical ventilation system controls (N1104.4.10) shall be provided in accordance with the following:

3. If the mechanical ventilation system is not designed to operate whenever the forced air circulation system is operating, the mechanical ventilation system shall incorporate an accessible backflow damper to prevent flow from the outside when the mechanical ventilation system is off.
Controls.

Mechanical ventilation system controls (N1104.4.10) shall be provided in accordance with the following:

4. Controls shall be compatible with the mechanical ventilation system.
Controls.

Mechanical ventilation system controls (N1104.4.10) shall be provided in accordance with the following:

5. Controls shall be installed to operate the mechanical ventilation system as designed.
Controls.

Mechanical ventilation system controls (N1104.4.10) shall be provided in accordance with the following:

6. Controls shall be readily accessible to occupants and shall be labeled to indicate their function.
Controls.

Mechanical ventilation system controls (N1104.4.10) shall be provided in accordance with the following:

7. If a switch is used to control the continuous ventilation system, it can be centrally or remotely located. If remotely located, it shall NOT be in a bath or toilet room. If centrally located, it shall be properly labeled and lighted when the system is on. If remotely located, there shall be a lighted status indicator in a central location that will be lighted when the system is on.
Push Button “Switch”
Labeling

• The outdoor air intake and exhaust air outlet shall include a permanent, weather resistant identification label stating:
  – "OUTDOOR AIR INTAKE” or
  – “EXHAUST AIR OUTLET”.

Labeling

• The outdoor air intake and exhaust air outlet shall include a permanent, weather resistant identification label stating:
  – Controls provided for continuous and intermittent ventilation shall be provided with a label stating “VENTILATION SYSTEM” or “VENTILATION FAN” or “INTERMITTENT FAN” or ventilation symbols, as appropriate.
Labeling

OUTDOOR AIR INTAKE

EXHAUST AIR Outlet
Documentation

• (ALL) Mechanical ventilation systems shall be provided with documentation that includes proper operation and maintenance instructions and a warning regarding potential problems if the system is not operated and maintained.
  – Bathroom fans
  – ERV’s & HRV’s
  – Furnaces
  – “Other equipment”
Documentation

• A permanent warning label shall be affixed to mechanical ventilation systems if it is readily accessible. If the mechanical ventilation system is not readily accessible, the documentation shall be in a conspicuous readily accessible location. (i.e. on the furnace or ERV)
## Changing Design Conditions

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</tr>
<tr>
<td>Minneapolis/St. Paul</td>
<td>89/73</td>
<td>88/72</td>
</tr>
<tr>
<td>Rochester</td>
<td>87/72</td>
<td>85/72</td>
</tr>
<tr>
<td>St. Cloud</td>
<td>88/72</td>
<td>86/71</td>
</tr>
<tr>
<td>Willmar</td>
<td>88/72</td>
<td>85/71</td>
</tr>
<tr>
<td>Winona</td>
<td>88/73</td>
<td>88/74</td>
</tr>
</tbody>
</table>
## Changing Design Conditions

<table>
<thead>
<tr>
<th>City</th>
<th>Summer Db/Wb °F</th>
<th>Winter Db °F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1999</td>
<td>2006</td>
</tr>
<tr>
<td>Aitkin</td>
<td>82/72</td>
<td></td>
</tr>
<tr>
<td>Cloquet</td>
<td>82/68</td>
<td></td>
</tr>
<tr>
<td>Crookston</td>
<td>84/70</td>
<td></td>
</tr>
<tr>
<td>Ely</td>
<td>82/68</td>
<td></td>
</tr>
<tr>
<td>Eveleth</td>
<td><strong>82/68</strong></td>
<td></td>
</tr>
<tr>
<td>Hibbing</td>
<td>82/68</td>
<td></td>
</tr>
<tr>
<td>Montevideo</td>
<td>86/72</td>
<td></td>
</tr>
<tr>
<td>Mora</td>
<td>84/70</td>
<td></td>
</tr>
<tr>
<td>Morris</td>
<td>84/72</td>
<td></td>
</tr>
<tr>
<td>New Ulm</td>
<td>87/73</td>
<td></td>
</tr>
<tr>
<td>Owatonna</td>
<td>86/73</td>
<td></td>
</tr>
<tr>
<td>Pequot Lake</td>
<td>84/68</td>
<td></td>
</tr>
<tr>
<td>Pipestone</td>
<td>85/73</td>
<td></td>
</tr>
<tr>
<td>Redwood Falls</td>
<td>89/73</td>
<td></td>
</tr>
<tr>
<td>Roseau</td>
<td>82/70</td>
<td></td>
</tr>
<tr>
<td>Thief River</td>
<td>82/68</td>
<td></td>
</tr>
<tr>
<td>Tofte</td>
<td>75/61</td>
<td></td>
</tr>
<tr>
<td>Warroad</td>
<td>83/67</td>
<td></td>
</tr>
<tr>
<td>Wheaton</td>
<td>84/71</td>
<td></td>
</tr>
<tr>
<td>Worthington</td>
<td>84/71</td>
<td></td>
</tr>
</tbody>
</table>
Residential Thermostats

• At least one thermostat shall be provided for each separate heating and cooling system
  – Does not require a programmable ‘stat!
Duct Insulation

• Ducts shall be insulated in accordance with Minnesota Rule Chapter 1346
## Residential Duct Insulation

### Minimum Required Duct Insulation

(see notes for explanations)

<table>
<thead>
<tr>
<th>Duct Location</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attics, garages, and ventilated crawl spaces</td>
<td>R-8 and V</td>
</tr>
<tr>
<td>Exterior of building</td>
<td>R-8, V and W</td>
</tr>
<tr>
<td>Inside of building and in unconditioned spaces TD less than or equal to 15°F</td>
<td>None required</td>
</tr>
<tr>
<td>TD greater than 15°F and less than or equal to 40°F</td>
<td>R-3.3 and V</td>
</tr>
<tr>
<td>TD greater than 40°F</td>
<td>R-5 and V</td>
</tr>
<tr>
<td>Within conditioned spaces, in basements with insulated walls, and in penums within conditioned spaces</td>
<td>None required</td>
</tr>
<tr>
<td>Intake and exhaust ducts within conditioned spaces*</td>
<td>R-3.3 and V</td>
</tr>
<tr>
<td>Within cement slab or within ground (also see IMC Section 603.7)</td>
<td>R-3.5</td>
</tr>
</tbody>
</table>

**Notes:**

* Insulation required for a distance of 3 feet (914 mm) from the exterior.

TD = Design temperature differential between the air in the duct and the ambient temperature outside of the duct.

V = Vapor retarder required in accordance with the IMC Section 604.11. When a vapor retarder is required, duct insulation required by this section shall be installed without respect to other building envelope insulation.

W = Approved weatherproof barrier.
# Duct Sealing

<table>
<thead>
<tr>
<th>Location</th>
<th>Design Static Pressure</th>
<th>Minimum Required Sealing</th>
</tr>
</thead>
<tbody>
<tr>
<td>All locations</td>
<td>Greater than 3.0 inches (750 Pa) water gauge</td>
<td>All transverse joints, longitudinal seams, and duct wall penetrations shall be sealed.</td>
</tr>
<tr>
<td>Portions of ducts not completely inside the vapor retarder/air barrier enclosing conditioned space</td>
<td>3.0 inches (750 Pa) water gauge and less</td>
<td>All transverse joints, longitudinal seams, and duct wall penetrations shall be sealed.</td>
</tr>
<tr>
<td>Portions of return air ducts in the same space as an atmospherically vented or fan-assisted appliance</td>
<td>3.0 inches (750 Pa) water gauge and less</td>
<td>All transverse joints, longitudinal seams, and duct wall penetrations shall be sealed.</td>
</tr>
<tr>
<td>All locations</td>
<td>Greater than 0.50 to 3.0 inches (125 to 750 Pa) water gauge</td>
<td>All transverse joints and duct wall penetrations shall be sealed.</td>
</tr>
<tr>
<td>All locations</td>
<td>0.50 inches (125 Pa) water gauge and less</td>
<td>All transverse joints, longitudinal seams, and duct wall penetrations shall have no visible gaps and shall be sufficiently airtight in accordance with Section 1.7 of the SMACNA HVAC Duct Construction Standards - Metal &amp; Flexible.</td>
</tr>
</tbody>
</table>
Supply Ducts

• Supply ducts shall be continuously ducted from the point of origin to the point of discharge . . . building framing cavities and building components shall not be used as supply ducts.
Domestic Water Piping Insulation

A. Cold Water: No insulation required.

Exception:
1. Piping within 6 inches of any heating pipes, . . .
and underground piping, . . . minimum of 1” insulation with . . . vapor jacket.
Domestic Water Piping
Insulation

B. **Hot Water**: No insulation required.

Exceptions:

1. All recirculating systems . . . 0.5” . . . on the entire loop with vapor jacket.

2. Underground piping, underground piping, . . . minimum of 1” insulation with . . . vapor jacket.
HVAC Piping Insulation

Hydronic, steam, and condensate piping . . . insulated in accordance with Minnesota Chapter Rule 1346 and shall have vapor appropriate jacket.
HVAC Piping Insulation

Hydronic, steam, and condensate piping . . .

Exceptions:
1. Piping installed within HVAC equipment; or
2. Piping installed in basements, crawl spaces, and cellars.
<table>
<thead>
<tr>
<th>Fluid Temperature Range °F</th>
<th>Runouts (See item C)</th>
<th>1 inch (25.4 mm and less)</th>
<th>1.25 to 2&quot; (31.7 to 50.8 mm)</th>
<th>2.5 to 4&quot; (63.5 to 101.6 mm)</th>
<th>5 to 6&quot; (127 to 152 mm)</th>
<th>8&quot; (203 mm) and Larger</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Piping System Type - Heating</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above 350</td>
<td>1.5</td>
<td>2.5</td>
<td>2.5</td>
<td>3.0</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>251-350</td>
<td>1.5</td>
<td>2.0</td>
<td>2.5</td>
<td>2.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>201-250</td>
<td>1.0</td>
<td>1.5</td>
<td>1.5</td>
<td>2.0</td>
<td>1.5</td>
<td>3.5</td>
</tr>
<tr>
<td>141-200</td>
<td>0.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>105-140</td>
<td>0.5</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Piping System Type - Cooling</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40-55</td>
<td>0.5</td>
<td>0.5</td>
<td>0.75</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Below 40 (see item D)</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

A. Insulation thickness in this section assumes a value of 0.27. If the k-value of a product is less than 0.22, then the thickness must be adjusted to have an equivalent R-value.

B. For piping exposed to outdoor air, insulation thickness must be 0.5 inch (12.7 mm) greater than required in the table.

C. This column applies only to runouts (branches) 2 inches (50.8 mm) in diameter and less, not exceeding 12 feet (3658 mm) in length, to individual terminal units. All other runouts shall meet the requirements given in other columns in the table, as appropriate.

D. For applications with fluid temperatures of 32°F (0°C) and below, a vapor retarder shall be installed in accordance with IMC Section 604.11.
Circulating hot water systems

Include controls that turn the circulating pump off when the system is not in use or when the circulating loop temperature is satisfied.
Equipment sizing

Heating and cooling equipment shall be sized per Minnesota Mechanical codes and an approved equivalent (method such as ACCA Manual J)
Minnesota Rules Chapter 1346

2006 International Mechanical Code
2006 International Fuel Gas Code
MN amendments
MN Mechanical Code (MN Rule 1346) 1346.0501 and 1346.5304

Agenda

1. Review Makeup Air Tables in the MN Mechanical Code as they apply to new and existing dwellings (See MN Rule 1309). Review examples.

2. Review Combustion Air requirements with an example.
Minnesota Mechanical Code

• *Residential Makeup Air/Combustion Air Software:*

  – **Makeup air** is determined according to amended IMC Section 501.3 (2006 IMC)

  – **Combustion air** is determined according to amended IFGC Section 304 (2006 IFGC)

  – **Ventilation air** is determined according to the Minnesota Energy Code
501.3.1: Makeup Air in new dwellings shall be determined by using table 501.3.1 and shall be supplied in accordance with IMC section 501.3.2
<table>
<thead>
<tr>
<th>Use the Appropriate Column to Estimate House Infiltration</th>
</tr>
</thead>
<tbody>
<tr>
<td>One or Multiple power vent or direct vent appliances or no combustion appliances&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
<tr>
<td>1 a) pressure factor (cfm/sf)</td>
</tr>
<tr>
<td>b) conditioned floor area (sf) (including unfinished basements)</td>
</tr>
<tr>
<td>Estimated House Infiltration (cfm): [1a x 1b]</td>
</tr>
<tr>
<td>2 Exhaust Capacity</td>
</tr>
<tr>
<td>a) continuous exhaust only ventilation system (not applicable to balanced ventilation systems such as HRV)</td>
</tr>
<tr>
<td>b) clothes dryer</td>
</tr>
<tr>
<td>c) 80% of largest exhaust rating (cfm): (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust)</td>
</tr>
<tr>
<td>d) 80% of next largest exhaust rating (cfm): (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust)</td>
</tr>
<tr>
<td>Total Exhaust Capacity (cfm): [2a+2b+2c+2d]</td>
</tr>
<tr>
<td>3 Makeup Air Requirement</td>
</tr>
<tr>
<td>a) Total Exhaust Capacity (from Above)</td>
</tr>
<tr>
<td>b) Estimated House Infiltration (from Above)</td>
</tr>
<tr>
<td>Makeup Air quantity (cfm): [3a - 3b] (if value is negative, no makeup air is needed)</td>
</tr>
<tr>
<td>4 For Makeup Air Opening Sizing, refer to Table 501.3.2</td>
</tr>
</tbody>
</table>

<sup>A</sup> Use this column if there are other than fan-assisted or atmospherically vented gas or oil appliances or if there are no combustion appliances.

<sup>B</sup> Use this column if there is one fan-assisted appliance per venting system. Other than atmospherically vented appliances may also be included.

<sup>C</sup> Use this column if there is one atmospherically vented (other than fan-assisted) gas or oil appliance per venting system or one solid fuel appliance.

<sup>D</sup> Use this column if there are multiple atmospherically vented gas or oil appliances using a common vent or if there are atmospherically vented gas or oil appliances or solid fuel appliances.
# Makeup Air Opening Sizing Table for New and Existing Dwellings

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(cfm)</td>
<td>(cfm)</td>
<td>(cfm)</td>
<td>(cfm)</td>
<td>(cfm)</td>
<td>(cfm)</td>
<td>(cfm)</td>
<td>(cfm)</td>
<td>(cfm)</td>
</tr>
<tr>
<td>Passive Opening</td>
<td>1 - 36</td>
<td>1 - 22</td>
<td>1 - 15</td>
<td>1 - 9</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive Opening</td>
<td>37 - 66</td>
<td>23 - 41</td>
<td>16 - 28</td>
<td>10 - 17</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive Opening</td>
<td>110 - 163</td>
<td>67 - 100</td>
<td>47 - 69</td>
<td>29 - 42</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive Opening</td>
<td>164 - 232</td>
<td>101 - 143</td>
<td>70 - 99</td>
<td>43 - 61</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive Opening</td>
<td>233 - 317</td>
<td>144 - 195</td>
<td>100 - 135</td>
<td>62 - 83</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive Opening</td>
<td>318 - 419</td>
<td>196 - 258</td>
<td>136 - 179</td>
<td>84 - 110</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive Opening</td>
<td>420 - 539</td>
<td>259 - 332</td>
<td>180 - 230</td>
<td>111 - 142</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive Opening with</td>
<td>540 - 679</td>
<td>333 - 419</td>
<td>231 - 290</td>
<td>143 - 179</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motorized Damper</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Powered Makeup Air^H</td>
<td>&gt; 679</td>
<td>&gt; 419</td>
<td>&gt; 290</td>
<td>&gt; 179</td>
<td>Not applicable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Notes:**

A. Use this column if there are other than fan-assisted or atmospherically vented gas or oil appliances or if there are no combustion appliances.

B. Use this column if there is one fan-assisted appliance per venting system. Other than atmospherically vented appliances may also be included.

C. Use this column if there is one atmospherically vented (other than fan-assisted) gas or oil appliance per venting system or one solid fuel appliance.

D. Use this column if there are multiple atmospherically vented gas or oil appliances using a common vent or if there are atmospherically vented gas or oil appliances and solid fuel appliance(s).

E. An equivalent length of 100 feet of round smooth metal duct is assumed. Subtract 40 feet for the exterior hood and ten feet for each 90-degree elbow to determine the remaining length of straight duct allowable.

F. If flexible duct is used, increase the duct diameter by one inch. Flexible duct shall be stretched with minimal sags.

G. Barometric dampers are prohibited in passive makeup air openings when any atmospherically vented appliance is installed.

H. Powered makeup air shall be electrically interlocked with the largest exhaust system.
Exhaust Systems
MN Mechanical Code 1346.0501

• That’s for new buildings but…..

• How about an existing building that’s altered?
  – Year built
  – Exhaust CFM
  – Solid fuel burning appliance
Exhaust Systems
MN Mechanical Code 1346.0501

• 501.3.3 Additions, alterations, or installations of mechanical systems in EXISTING dwellings. Makeup air shall be supplied to existing dwellings when any of the following conditions occur (6 conditions):

1. If a dwelling was constructed after 2003 using makeup air provisions of IMC Section 501.3.2, makeup air quantity shall be determined by using Table 501.3.1 and shall be supplied according to IMC Section 501.3.2 when any of the following conditions occur:
   – A vented combustion appliance is installed/replaced
   – An exhaust system is installed or replaced (exception)
501.3.3 Additions, alterations, or installations of mechanical systems in EXISTING dwellings. Makeup air shall be determined to existing dwellings when any of the following conditions occur (6 conditions):

2. **If a dwelling was constructed after 1999** using provisions of the Minnesota Energy Code (MN Rules 7672) makeup air shall be determined by using 501.3.1 supplied in accordance with IMC Section 501.3.2

3. **When a solid fuel burning appliance is installed in a dwelling constructed during or after 1994 under the MN Energy code (MN Rules 7670)** makeup air shall be determined by using 501.3.1 supplied in accordance with IMC Section 501.3.2
### Procedure to Determine Makeup Air Quantity for Exhaust Equipment in Dwellings
*Built after 1999 using Chapter 7672*

*Use the Appropriate Column to Estimate House Infiltration*

<table>
<thead>
<tr>
<th>One or Multiple power vent or direct vent appliances or no combustion appliances</th>
<th>One or multiple fan-assisted appliances and power vent or direct appliances</th>
<th>One atmospherically vented gas or oil appliance or one solid vent fuel appliance</th>
<th>Multiple atmospherically vented gas or oil appliance or solid vent fuel appliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a) pressure factor (cfm/sf)</td>
<td>0.15</td>
<td>0.09</td>
</tr>
<tr>
<td>b) conditioned floor area (sf) (including unfinished basements)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated House Infiltration (cfm):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Exhaust Capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) continuous exhaust only ventilation system (not applicable to balanced ventilation systems such as HRV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) clothes dryer</td>
<td>135</td>
<td>135</td>
<td>135</td>
</tr>
<tr>
<td>c) 80% of largest exhaust rating (cfm): (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) 80% of next largest exhaust rating (cfm): (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Exhaust Capacity (cfm):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Makeup Air Requirement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Total Exhaust Capacity (from Above)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Estimated House Infiltration (from Above)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Makeup Air quantity (cfm):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(if value is negative, no makeup air is needed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>For Makeup Air Opening Sizing, refer to Table</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Exhaust Systems
MN Mechanical Code 1346.0501

501.3.3 Additions, alterations, or installations of mechanical systems in EXISTING dwellings. Makeup air shall be determined to existing dwellings when any of the following conditions occur (6 conditions):

4. Dwelling constructed during or after 1994 and an exhaust system with a rated capacity > 300 CFM makeup air shall:
   - be determined by using IMC table 501.3.3(1)
   - supplied according to 501.3.2
<table>
<thead>
<tr>
<th>Procedure to Determine Makeup Air Quantity for Exhaust Equipment in Existing Dwellings Built Between 1994 and 1999 With an exhaust rate greater than 300 cfm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use the Appropriate Column to Estimate House Infiltration</td>
</tr>
</tbody>
</table>

| Use this column if there are other than fan-assisted or atmospherically vented gas or oil appliances or if there are no combustion appliances. |
| Use this column if there is one fan-assisted appliance per venting system. Other than atmospherically vented appliances may also be included. |
| Use this column if there is one atmospherically vented (other than fan-assisted) gas or oil appliance per venting system or one solid fuel appliance. |
| Use this column if there are multiple atmospherically vented gas or oil appliances using a common vent or if there are atmospherically vented gas or oil appliances and solid fuel appliances. |

<table>
<thead>
<tr>
<th>One or Multiple power vent or direct vent appliances or no combustion appliances</th>
<th>One or multiple fan-assisted appliances and power vent or direct appliances</th>
<th>One atmospherically vented gas or oil appliance or one solid vent fuel appliance</th>
<th>Multiple atmospherically vented gas or oil appliance or solid vent fuel appliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 a) pressure factor (cfm/sf)</td>
<td>0.15</td>
<td>0.09</td>
<td>0.06</td>
</tr>
<tr>
<td>1 b) conditioned floor area (sf)</td>
<td>1500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated House Infiltration (cfm): [1a x 1b]</td>
<td>225</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Exhaust Capacity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80% of largest exhaust rating (cfm): (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80% of next largest exhaust rating (cfm): (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Makeup Air Requirement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Total Exhaust Capacity (from Above)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Estimated House Infiltration (from Above)</td>
<td>225</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Makeup Air quantity (cfm): [3a - 3b] (if value is negative, no makeup air is needed)</td>
<td>225</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 For Makeup Air Opening Sizing, refer to Table 501.3.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Makeup air required</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
501.4.3 Additions, alterations, or installations of mechanical systems in EXISTING dwellings. Makeup air shall be determined to existing dwellings when any of the following conditions occur (6 conditions):

5. Dwelling constructed prior to 1994 with an exhaust > 300 CFM makeup air shall be;
   - determined by using IMC Table 501.3.3(2)
   - supplied according IMC Section 501.3.2
Use the Appropriate Column to Estimate House Infiltration

<table>
<thead>
<tr>
<th></th>
<th>One or Multiple power vent or direct vent appliances or no combustion appliances A</th>
<th>One or multiple fan-assisted appliances and power vent or direct appliances B</th>
<th>One atmospherically vented gas or oil appliance or one solid vent fuel appliance C</th>
<th>Multiple atmospherically vented gas or oil appliance or solid vent fuel appliance D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 a) pressure factor (cfm/sf)</td>
<td>0.25</td>
<td>0.15</td>
<td>0.10</td>
<td>0.05</td>
</tr>
<tr>
<td>b) conditioned floor area (sf) (including unfinished basements)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Estimated House Infiltration (cfm): 
\[1a \times 1b\]

or Alternate Calculation (by using blower door test) E

c) conversion factor

\[0.75 \times 0.45 \times 0.30 \times 0.15\]

d) CFM50 value

(from blower door test)

Estimated House Infiltration (cfm) \[1c \times 1d\]

2 Exhaust Capacity
80% of largest exhaust rating (cfm) = Exhaust capacity (cfm): (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust)

3 Makeup Air Requirement
a) Total Exhaust Capacity (from Above)

b) Estimated House Infiltration (from Above)

Makeup Air quantity (cfm): 
\[3a - 3b\]

(if value is negative, no makeup air is needed)

4 For Makeup Air Opening Sizing, refer to Table 501.3.2

A Use this column if there are other than fan-assisted or atmospherically vented gas or oil appliances or if there are no combustion appliances.
B Use this column if there is one fan-assisted appliance per venting system. Other than atmospherically vented appliances may also be included.
C Use this column if there is one atmospherically vented (other than fan-assisted) gas or oil appliance per venting system or one solid fuel appliance.
D Use this column if there are multiple atmospherically vented gas or oil appliances using a common vent or if there are atmospherically vented gas or oil appliances and solid fuel appliances.
E As an alternative, the Estimated House Infiltration may be calculated by performing a blower door test and multiplying the conversion factor by the CFM50 value.
501.4.3 Additions, alterations, or installations of mechanical systems in EXISTING dwellings. Makeup air shall be determined to existing dwellings when any of the following conditions occur (6 conditions):

6. Dwelling constructed prior to 1994 and a solid fuel appliance is installed makeup air shall be:
   - determined by IMC Table 501.3.3(3)
   - supplied according to IMC Section 501.3.2
### Procedure to Determine Makeup Air Quantity

**for Exhaust Equipment in Existing Dwellings Built Before 1994 With a Solid Fuel Burning Appliance**  
(Refer to Item 6 in section 501.4.3 to determine applicability of this table)

Use the Appropriate Column to Estimate House Infiltration

<table>
<thead>
<tr>
<th></th>
<th>One or Multiple power vent or direct vent appliances or no combustion appliances^</th>
<th>One or multiple fan-assisted appliances and power vent or direct appliances^</th>
<th>One atmospherically vented gas or oil appliance or one solid vent fuel appliance</th>
<th>Multiple atmospherically vented gas or oil appliance or solid vent fuel appliance^</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 a) pressure factor (cfm/sf)</td>
<td>0.25</td>
<td>0.15</td>
<td>0.10</td>
<td>0.05</td>
</tr>
<tr>
<td>b) conditioned floor area (sf) (including unfinished basements)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated House Infiltration (cfm):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>or Alternate Calculation (by using blower door test)^E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) conversion factor</td>
<td>0.75</td>
<td>0.45</td>
<td>0.3</td>
<td>0.15</td>
</tr>
<tr>
<td>d) CFM50 value (from blower door test)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated House Infiltration (cfm) 1c x1d</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Exhaust Capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) continuous exhaust only ventilation system (not applicable to balanced ventilation systems such as HRV)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) clothes dryer</td>
<td>135</td>
<td>135</td>
<td>135</td>
<td>135</td>
</tr>
<tr>
<td>c) 80% of largest exhaust rating (cfm): (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) 80% of next largest exhaust rating (cfm): (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust)</td>
<td></td>
<td></td>
<td></td>
<td>not applicable</td>
</tr>
<tr>
<td>Total Exhaust Capacity (cfm):</td>
<td>[2a+2b+2c+2d]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Makeup Air Requirement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Total Exhaust Capacity (from Above)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Estimated House Infiltration (from Above)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Examples of Footnotes

• A. Use this column if there are other than fan-assisted or atmospherically vented gas or oil appliances or if there are no combustion appliances.

• B. Use this column if there is one fan-assisted appliance per venting system. Other than atmospherically vented appliances may also be included.

• C. Use this column if there is one atmospherically vented (other than fan-assisted) gas or oil appliance per venting system or one solid fuel appliance.

• D. Use this column if there are multiple atmospherically vented gas or oil appliances using a common vent or if there are atmospherically vented gas or oil appliances and solid fuel appliance's).
MN Mechanical Code:

Determine Makeup Air Requirements for the following:

Size of new house: 2,000 sq. ft. (including basement)
Average ceiling height: 8 ft.
Number of bedrooms: 3
Ventilation type: Heat recovery ventilator (HRV)
Type of gas water heater: 40,000 Btu/hr power vent
Type of gas furnace: 60,000 Btu/hr direct vent
Type of gas fireplace: 30,000 Btu/hr direct vent
Kitchen exhaust fan: 250 cfm (exhausts to the outside)
Next largest exhaust fan: 70 cfm
Combustion air space: 10 ft. x 10 ft. x 8 ft.
Minnesota Mechanical Code

It’s NEW, so…. The makeup air shall be

• **Step 1**: Makeup Air Requirements shall be determined using *Table 501.3.1* and…

• **Step 2**: Supplied in accordance with *Table 501.3.2*
Minnesota Mechanical Code

Make up Air

Examples
MN Mechanical Code:

Determine Makeup Air Requirements for the following:

Size of new house: 2,000 sq. ft. (including basement)
Average ceiling height: 8 ft.
Number of bedrooms: 3
Ventilation type: Heat recovery ventilator (HRV)
Type of gas water heater: 40,000 Btu/hr power vent
Type of gas furnace: 60,000 Btu/hr direct vent
Type of gas fireplace: 30,000 Btu/hr direct vent
Kitchen exhaust fan: 250 cfm (exhausts to the outside)
Next largest exhaust fan: 70 cfm
Combustion air space: 10 ft. x 10 ft. x 8 ft.
### Procedure to Determine Makeup Air Quantity for Exhaust Equipment in Dwellings

<table>
<thead>
<tr>
<th>Scenario</th>
<th>One or multiple power vent or direct vent appliances or no combustion appliances</th>
<th>One or multiple fan-assisted appliances and power vent or direct vent appliances</th>
<th>One atmospherically vented gas or oil appliances</th>
<th>Multiple atmospherically vented gas or oil appliances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One</td>
<td>Multiple</td>
<td>One</td>
<td>Multiple</td>
</tr>
<tr>
<td>a) pressure factor (cfm/sf)</td>
<td>0.15</td>
<td>0.09</td>
<td>0.06</td>
<td>0.03</td>
</tr>
<tr>
<td>b) conditioned floor area (sf)</td>
<td>2,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(including unfinished basements)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Estimated House Infiltration (cfm):</strong></td>
<td>300</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 1. Use the Appropriate Column to Estimate House Infiltration

a) pressure factor (cfm/sf) | 0.15 | 0.09 | 0.06 | 0.03 |

b) conditioned floor area (sf) | 2,000 | | | |
| (including unfinished basements) | | | | |
| **Estimated House Infiltration (cfm):** | 300 | | | |

#### 2. Exhaust Capacity

a) continuous exhaust-only ventilation system (cfm) (not applicable to balanced ventilation systems such as HRV) | 0 | | | |

b) clothes dryer (cfm) | 135 | 135 | 135 | 135 |

c) 80% of largest exhaust rating (cfm) (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust) | 200 | | | |

d) 80% of next largest exhaust rating (cfm) (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust) | Not Applicable | | | |
| **Total Exhaust Capacity (cfm):** | 335 | | | |

#### 3. Makeup Air Requirement

a) Total Exhaust Capacity (from above) | 335 | | | |

b) Estimated House Infiltration (from above) | 300 | | | |

**Makeup Air Quantity (cfm):** | 35 | | | |
| (if value is negative, no makeup air is needed) | | | | |

#### 4. For Makeup Air Opening Sizing, refer to Table M501.3.2
## Makeup Air Opening Sizing Table for New and Existing Dwellings

<table>
<thead>
<tr>
<th>Type of opening or system</th>
<th>One or multiple power vent or direct vent appliances or no combustion appliances&lt;sup&gt;A&lt;/sup&gt;</th>
<th>One or multiple fan-assisted appliances and power vent or direct vent appliances&lt;sup&gt;B&lt;/sup&gt;</th>
<th>One atmospherically vented gas or oil appliance or one solid fuel appliance&lt;sup&gt;C&lt;/sup&gt;</th>
<th>Multiple atmospherically vented gas or oil appliances or solid fuel appliances&lt;sup&gt;D&lt;/sup&gt;</th>
<th>Passive makeup air opening duct diameter&lt;sup&gt;E,F,G&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Opening</td>
<td>1-36</td>
<td>1-22</td>
<td>1-15</td>
<td>1-9</td>
<td>3</td>
</tr>
<tr>
<td>Passive Opening</td>
<td>37-66</td>
<td>23-41</td>
<td>16-28</td>
<td>10-17</td>
<td>4</td>
</tr>
<tr>
<td>Passive Opening</td>
<td>110-163</td>
<td>67-100</td>
<td>47-69</td>
<td>29-42</td>
<td>6</td>
</tr>
<tr>
<td>Passive Opening</td>
<td>164-232</td>
<td>101-143</td>
<td>70-99</td>
<td>43-61</td>
<td>7</td>
</tr>
<tr>
<td>Passive Opening</td>
<td>233-317</td>
<td>144-195</td>
<td>100-135</td>
<td>62-83</td>
<td>8</td>
</tr>
<tr>
<td>Passive Opening with Motorized Damper</td>
<td>318-419</td>
<td>196-258</td>
<td>136-179</td>
<td>84-110</td>
<td>9</td>
</tr>
<tr>
<td>Passive Opening with Motorized Damper</td>
<td>420-539</td>
<td>259-332</td>
<td>180-230</td>
<td>111-142</td>
<td>10</td>
</tr>
<tr>
<td>Passive Opening with Motorized Damper</td>
<td>540-679</td>
<td>333-419</td>
<td>231-290</td>
<td>143-179</td>
<td>11</td>
</tr>
<tr>
<td>Powered Makeup Air&lt;sup&gt;H&lt;/sup&gt;</td>
<td>&gt;679</td>
<td>&gt;419</td>
<td>&gt;290</td>
<td>&gt;179</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

A. Use this column if there are other than fan-assisted or atmospherically vented gas or oil appliances or if there are no combustion appliances.

B. Use this column if there is one fan-assisted appliance per venting system. Other than atmospherically vented appliances may also be included.

C. Use this column if there is one atmospherically vented (other than fan-assisted) gas or oil appliance per venting system or one solid fuel appliance.

D. Use this column if there are multiple atmospherically vented gas or oil appliances using a common vent or if there are atmospherically vented gas or oil appliances and solid fuel appliance(s).

E. An equivalent length of 100 feet of round smooth metal duct is assumed. Subtract 40 feet for the exterior hood and 10 feet for each 90 degree elbow to determine the remaining length of straight duct allowable.

F. If flexible duct is used, increase the duct diameter by one inch. Flexible duct shall be stretched with minimal sags.

G. Barometric dampers are prohibited in passive makeup air openings when any atmospherically vented appliance is installed.

H. Powered makeup air shall be electrically interlocked with the largest exhaust system.
MN Mechanical Code:

Determine Makeup and Combustion Air Requirements for the following:

Size of new house (modified 2 story):
- basement: 1175 square feet
- first floor: 1194 square feet
- second floor: 760 square feet
TOTAL : 3129 square feet

average ceiling height: 8 ft.
Number of bedrooms: 3
Ventilation type: Heat recovery ventilator (HRV)
Type of gas water heater: 40,000 Btu/hr power vent
Type of gas furnace: 67,000 Btu/hr direct vent
Type of gas fireplace: none
Kitchen exhaust fan: none that exhausts outside
Next largest exhaust fan: 2 baths at 50 cfm, 1 bath at 70 cfm
Combustion air space: mechanical room area = open basement
Procedure to Determine Makeup Air Quantity for Exhaust Equipment in Dwellings

1. Use the Appropriate Column to Estimate House Infiltration

a) pressure factor (cfm/sf) 0.15 0.09 0.06 0.03
b) conditioned floor area (sf) 3129
   (including unfinished basements)

Estimated House Infiltration (cfm): [1a x 1b] 469

2. Exhaust Capacity

a) continuous exhaust-only ventilation system (cfm) 0
   (not applicable to balanced ventilation systems such as HRV)
b) clothes dryer (cfm) 135 135 135 135
c) 80% of largest exhaust rating (cfm) 56
   (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust)
d) 80% of next largest exhaust rating (cfm) Not Applicable
   (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust)

Total Exhaust Capacity (cfm): [2a + 2b + 2c + 2d] 191

3. Makeup Air Requirement

a) Total Exhaust Capacity (from above) 191
b) Estimated House Infiltration (from above) 469

Makeup Air Quantity (cfm): [3a - 3b] 0
(if value is negative, no makeup air is needed)

4. For Makeup Air Opening Sizing, refer to Table 501.3.2
MN Mechanical Code:

*Determine Makeup Air Requirements for the following:*

Size of new house (Rambler with full basement):
- basement: 1352 square feet
- first floor: 1496 square feet
- TOTAL: 2848 square feet

average ceiling height: 8 ft.
Number of bedrooms: 2
Ventilation type: Heat recovery ventilator (HRV)
Type of gas water heater: 2 @ 40,000 Btu/hr power vent
Type of gas furnace: 67,000 Btu/hr power vent
Type of gas fireplace: 2 power vent gas fireplaces and 1 solid fuel
Kitchen exhaust fan: none that exhausts outside
Next largest exhaust fan: 1 baths at 50 cfm, 1 bath at 70 cfm
Combustion air space: 5 x 12 x 8 = Mechanical room volume (480)
Procedure to Determine Makeup Air Quantity for Exhaust Equipment in Dwellings

1. Use the Appropriate Column to Estimate House Infiltration

   a) pressure factor (cfm/sf)  
      - One or multiple power vent or direct vent appliances or no combustion appliances: 0.15
      - One or multiple fan-assisted atmospherically or direct vent appliances: 0.09
      - One atmospherically vented gas or oil appliance or one solid fuel appliance: 0.06
      - Multiple atmospherically vented gas or oil appliances or solid fuel appliances: 0.03

   b) conditioned floor area (sf)  
      (including unfinished basements)  
      - Estimated House Infiltration (cfm): \[1a \times 1b\]  
        2848

2. Exhaust Capacity

   a) continuous exhaust-only ventilation system (cfm)  
      (not applicable to balanced ventilation systems such as HRV)  
      - Total Exhaust Capacity (cfm): \[2a + 2b + 2c + 2d\]  
        0

   b) clothes dryer (cfm)  
        135

   c) 80% of largest exhaust rating (cfm)  
      (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust)  
      - 80% of next largest exhaust rating (cfm)  
        Not Applicable
        40

   d) 80% of next largest exhaust rating (cfm)  
      (not applicable if recirculating system or if powered makeup air is electrically interlocked and matched to exhaust)  
      - Total Exhaust Capacity (cfm): \[2a + 2b + 2c + 2d\]  
        231

3. Makeup Air Requirement

   a) Total Exhaust Capacity (from above)  
      - Makeup Air Quantity (cfm): \[3a - 3b\]  
        231

   b) Estimated House Infiltration (from above)  
        171

   Makeup Air Quantity (cfm): \[3a - 3b\]  
   (if value is negative, no makeup air is needed)  
   60

4. For Makeup Air Opening Sizing, refer to Table 501.3.2
## Makeup Air Opening Sizing Table for New and Existing Dwellings

<table>
<thead>
<tr>
<th>Type of opening or system</th>
<th>One or multiple power vent or direct vent appliances or no combustion appliances&lt;sup&gt;A&lt;/sup&gt; (cfm)</th>
<th>One or multiple fan-assisted appliances and power vent or direct vent appliances&lt;sup&gt;B&lt;/sup&gt; (cfm)</th>
<th>One atmospherically vented gas or oil appliance or one solid fuel appliance&lt;sup&gt;C&lt;/sup&gt; (cfm)</th>
<th>Multiple atmospherically vented gas or oil appliances or solid fuel appliances&lt;sup&gt;D&lt;/sup&gt; (cfm)</th>
<th>Passive makeup air opening duct diameter&lt;sup&gt;E,F,G&lt;/sup&gt; (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Opening</td>
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<td>1-22</td>
<td>1-15</td>
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<td>3</td>
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</tbody>
</table>

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B. Use this column if there is one fan-assisted appliance per venting system. Other than atmospherically vented appliances may also be included.

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E. An equivalent length of 100 feet of round smooth metal duct is assumed. Subtract 40 feet for the exterior hood and 10 feet for each 90 degree elbow to determine the remaining length of straight duct allowable.

F. If flexible duct is used, increase the duct diameter by one inch. Flexible duct shall be stretched with minimal sags.

G. Barometric dampers are prohibited in passive makeup air openings when any atmospherically vented appliance is installed.

H. Powered makeup air shall be electrically interlocked with the largest exhaust system.
IFGC Section 304- Combustion, Ventilation, and Dilution Air

Air for combustion, ventilation, and dilution of flue gases shall be obtained by:

1. 304.2 “Indoor combustion air
2. 304.3 “Outdoor combustion air
3. 304.4 “Combination indoor and outdoor combustion air”
4. 304.5 “Engineered solutions” OR
5. 304.6 “Mechanical combustion air supply”
IFGC Section 304- Combustion, Ventilation, and Dilution Air

- Air for combustion, ventilation, and dilution of flue gases shall be obtained by 304.2 through 304.6 with exceptions:
  1. Direct vent appliances
  2. Type 1 clothes dryers that are provided with makeup air
  3. Replacement of fuel gas utilization equipment with 3 conditions:
     - < 30% original rating
     - Combustion air provisions meet original installation
     - Must be safe, nonhazardous, and not overloaded
IFGC Section 304- Combustion, Ventilation, and Dilution Air

- For Residential purposes:
  - Main Entry: residence
  - Pronunciation: \( \text{re-zə-den(t)s, re-zə-den(t)s, re-zə-den(t)s} \)
  - Function: noun
  - Date: 14th century
  - 1 a : the act or fact of dwelling in a place for some time b : the act or fact of living or regularly staying at or in some place for the discharge of a duty or the enjoyment of a benefit
  2 a (1) : the place where one actually lives as distinguished from one's domicile or a place of temporary sojourn (2) : domicile 2a b : the place where a corporation is actually or officially established c : the status of a legal resident
  3 a : a building used as a home : dwelling b : housing or a unit of housing provided for students
  4 a : the period or duration of abode in a place b : a period of active and especially full-time study, research, or teaching at a college or university
  - in residence : engaged to live and work at a particular place often for a specified time <poet in residence at a university>
  - See amended IRC 1309 for dwelling definition
IFGC Section 304- Combustion, Ventilation, and Dilution Air

– For Residential purposes:

– Appendix E: Worksheet E-1 and Table E-1
IFGC Appendix E, Worksheet E-1
Residential Combustion Air Calculation Method
(for Furnace, Boiler, and/or Water Heater in the Same Space)

Step 1: Complete vented combustion appliance information.
- Furnace/Boiler:
  - Draft Hood: __ Draft, __ Fan Assisted, __ Direct Vent
  - (Not fan assisted) & Power Vent: __ Blufhr
- Water Heater:
  - Draft Hood: __ Draft, __ Fan Assisted, __ Direct Vent
  - (Not fan assisted) & Power Vent: __ Blufhr

Step 2: Calculate the volume of the Combustion Appliance Space (CAS) containing combustion appliances.
The CAS includes all spaces connected to one another by code compliant openings. CAS volume: __ ft³

Step 3: Determine Air Changes per Hour (ACH)1
Default ACH values have been incorporated into Table E-1 for use with Method 4b (KAIR Method).
If the year of construction or ACH is not known, use method 4a (Standard Method).

Step 4: Determine Required Volume for Combustion Air.

4a. Standard Method
- Total Blufhr input of all combustion appliances (DO NOT COUNT DIRECT VENT APPLIANCES): __ Blufhr
- Use Standard Method column in Table E-1 to find Total Required Volume (TRV): __ ft³
- If CAS Volume (from Step 2) is greater than TRV then no outdoor openings are needed.
- If CAS Volume (from Step 2) is less than TRV then go to STEP 5.

4b. Known Air Infiltration Rate (KAIR) Method
- Total Blufhr input of all fan-assisted and power vent appliances (DO NOT COUNT DIRECT VENT APPLIANCES): __ Blufhr
- Use Fan-Assisted Appliances column in Table E-1 to find Required Volume Fan Assisted (RVFA): __ ft³
- Total Blufhr input of all non-fan-assisted appliances: __ Blufhr
- Use Non-Fan-Assisted Appliances column in Table E-1 to find Required Volume Non-Fan-Assisted (RVNFA): __ ft³
- Total Required Volume (TRV) = RVFA + RVNFA: __ ft³
- If CAS Volume (from Step 2) is greater than TRV then no outdoor openings are needed.
- If CAS Volume (from Step 2) is less than TRV then go to STEP 5.

Step 5: Calculate the ratio of available indoor volume to the total required volume.
Ratio = CAS Volume (from Step 2) divided by TRV (from Step 4a or Step 4b): __ / __ = __

Step 6: Calculate Reduction Factor (RF).
RF = 1 minus Ratio: __ = __

Step 7: Calculate single outdoor opening as if all combustion air is from outside.
- Total Blufhr input of all Combustion Appliances in the same CAS (EXCEPT DIRECT VENT): __ Blufhr
- Combustion Air Opening Area (CAOA): CAOA = __ ft³ / 3000 Blufhr per ft³ = __ in²
- Total Blufhr divided by 3000 Blufhr per in²: __ Blufhr

Step 8: Calculate Minimum CAOA.
- Minimum CAOA = CAOA multiplied by RF: Minimum CAOA = __ x __ = __ in²

Step 9: Calculate Combustion Air Opening Diameter (CAOD)
CAOD = 1.13 multiplied by the square root of Minimum CAOA: CAOD = 1.13 x √[Minimum CAOA] = __ in

1 If desired, ACH can be determined using ASHRAE calculation or blower door test. Follow procedures in Section G304.
Minnesota Mechanical Code

• Combustion Air Handout example.....
**Minnesota Mechanical Code**

- *Determine Makeup Air Requirements for the following:*

<table>
<thead>
<tr>
<th>Description</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of new house:</td>
<td>2,000 sq. ft. (including basement)</td>
</tr>
<tr>
<td>Average ceiling height:</td>
<td>8 ft.</td>
</tr>
<tr>
<td>Number of bedrooms:</td>
<td>3</td>
</tr>
<tr>
<td>Ventilation type:</td>
<td>Heat recovery ventilator (HRV)</td>
</tr>
<tr>
<td>Type of gas water heater:</td>
<td>40,000 Btu/hr power vent</td>
</tr>
<tr>
<td>Type of gas furnace:</td>
<td>60,000 Btu/hr direct vent</td>
</tr>
<tr>
<td>Type of gas fireplace:</td>
<td>30,000 Btu/hr direct vent</td>
</tr>
<tr>
<td>Kitchen exhaust fan:</td>
<td>250 cfm (exhausts to the outside)</td>
</tr>
<tr>
<td>Next largest exhaust fan:</td>
<td>70 cfm</td>
</tr>
<tr>
<td>Combustion air space:</td>
<td>10 ft. x 10 ft. x 8 ft.</td>
</tr>
</tbody>
</table>
Minnesota Mechanical Code

• Determine Combustion Air Requirements using Worksheet E-1 and Table E-1
• Step 1:  Furnace = Direct Vent 60,000 Btu/hr
• Water heater = Power Vent 40,000 Btu/hr
• Step 2:  Combustion Appliance Space (CAS) = 10 x 10 x 8 = 800 cu. ft.
• Step 3:  Determine Air Changes per Hour (ACH)
• New construction, so use Method 4b (KAIR Method)
• Step 4b:  From Table E-1, Required Volume Fan-Assisted (RVFA) = 3,000 cu. ft.
• Required Volume Non-Fan-Assisted (RVNFA) = 0 cu. ft.
• Total required volume (TRV) = 3,000 cu. ft.
• CAS is less than TRV, so go to step 5
• Step 5:  Ratio = CAS/TRV = 800/3,000 = 0.27
• Step 6:  Reduction Factor (RF) = 1-Ratio = 1-0.27 = 0.73
• Step 7:  Combustion Air Opening Area (CAOA) =
• Total Btu/hr / 3,000 Btu/hr per sq. inch = 40,000/3,000 = 13.3 sq. in.
• Step 8:  Minimum CAOA = CAOA x RF = 13.3 x 0.73 = 9.71 sq. in.
• Step 9:  Combustion Air Opening Diameter (CAOD) =
• 1.13 x square root of Minimum CAOA = 3.52 inch = 4 inch
Exhaust Systems
MN Mechanical Code 1346.0501

• Thank you!