

Vapor Control in Walls With Continuous Insulation

The **International Residential Code** is supposed to provide clarity into how builders construct homes. In the IRC's own words, "The IRC was created to serve as a complete, comprehensive code regulating the construction of single-family houses, two-family houses (duplexes) and buildings consisting of three or more town-house units." Usually, the codes give us clear options on how we should build homes with the occupant's safety and health as our No. 1 priority. Codes also address energy efficiency and building durability. Sometimes though, the codes can be quite confusing. How we handle vapor retarders when using continuous insulation is one of those areas.

Let's begin with the energy code's required insulation values for walls in Table N1102.1.3 (R402.1.3), "Insulation Minimum R-values and Fenestration Requirements by Component," in Chapter 11 of the 2021 IRC. Here's a simplified version of this table, focusing on insulation requirements for wood-framed walls in all climate zones:

INSULATION MINIMUM R-VALUE	
Climate Zone	Wood-Framed Wall R-Value
0, 1, 2	13 or 0 & 10ci
3	20 or 13 & 10ci or 0 & 15ci
4 through 8 (including marine)	30 or 20 & 5ci or 13 & 10ci or 0 & 15ci

Climate zones 0 through 2 (0 is a new climate zone that does not exist in the continental U.S.; note, the IRC is an "international" building code) allow two options:

- R-13 cavity insulation only (2x4 wall insulated with R-13 batt insulation).
- R-10 continuous insulation (ci) only. For this option, the place for cavity insulation is set at "0."

Climate zone 3 offers three options:

- R-20 cavity insulation only (2x6 wall with R-20 batts).
- Cavity insulation and continuous insulation (2x4 wall with R-13 batts and R-10 ci).
- R-15 continuous insulation only.

Climate zones 4 through 8 (including marine zone 4) now all require one of four options:

- R-30 cavity insulation only. This could be a 2x6 wall insulated with spray foam or a 2x8 wall insulated with Rockwool or high-density fiberglass batts.
- Cavity insulation and continuous insulation (2x4 wall with R-13 batts and R-10 ci).
- Cavity insulation and continuous insulation (2x6 wall with R-20 batts and R-5 ci).
- R-15 continuous insulation only—something like Joe Lstiburek's "perfect wall."

Along with the insulation requirements above is also a reference in Chapter 11 to vapor retarders, in Section N1102.1.1 (R402.1.1), which reads: "Wall assemblies in the building thermal envelope shall comply with the vapor retarder requirements of section R702.7."

This sends us to Chapter 7, Wall Coverings, where we find information in Section 702.7 that defines the different classes of vapor retarders, explains where they are required, and provides details on how you can change the vapor retarder class when modifying the wall design to include continuous insulation and/or vented rainscreens. This is where confusion for some builders sets in. Before delving into that, however, we need a little more background on code definitions for vapor retarders.

What materials are used as vapor retarders? To answer this question, we first need to understand how vapor retarders are classified based on the ability of water vapor to move through the material. A "perm," or the "permeability" of a material, refers to the passage of one grain of water vapor through 1 square foot of material in 1 hour with a pressure differential between the cold and warm sides of the material at 1 inch of mercury. The higher the number, the more easily water vapor can diffuse through the material. Almost no water vapor moves through metal, whereas fibrous insulation is vapor open, and water vapor easily passes through it. A test used to verify a material's permeance is ASTM E96.

Table R702.7(1) (not shown in this article) classifies materials based on their permeability. It boils down to the following classifications:

- A Class I material has a perm rating of *less than or equal to 0.1*. Glass and metal are in this class, along with polyethylene sheeting.
- A Class II material has a perm rating *between 0.1 and 1*. Kraft-faced insulation, vapor-retarding paints, and most smart (responsive or variable) vapor retarders fall in this classification.

■ A Class III material has a perm rating *between 1.0 and 10.0*. Latex- or enamel-painted drywall is a Class III vapor retarder.

Any material more than 10 perms is considered vapor open. The classification of perm ratings needs to be understood before we can discuss the next table.

Where to use vapor retarders. Section R702.7 states that a vapor retarder is required on the interior side of all exterior wood-framed walls in climate zones 4 through 8, including marine 4. There are a few exceptions, however: Vapor retarders are not required on any below-grade or basement walls or in an assembly that is not damaged by moisture or frozen moisture. Some spray foam applications also satisfy the vapor-retarder requirement.

Table R702.7(2) (not shown here) describes where you can and cannot use a specific class of vapor retarder in a wall assembly. Class I and II vapor retarders should not be used in climate zones 1 and 2 (at least, not on the interior side of the wall). The reasoning has to do with vapor drive. The direction vapor moves in areas with higher outdoor heat (and humidity) is inward, toward the cooler and less-humid interior of the building. A low-permeance vapor retarder on the interior (this even includes some wallpaper) will trap this inward drive of moisture inside the wall, which may cause moisture-related problems.

A Class I vapor retarder should not be used in climate zones 3 and 4 (excluding marine 4). These areas can use a Class II or Class III vapor retarder. The remaining climate zones can use Class I or II vapor retarders, or a Class III in certain instances.

There are footnotes in Table R702.7(2) that pertain to Class I and II vapor retarders. The first of these (footnote a) states:

“Class I and II vapor retarders with vapor permeance greater than 1 perm when measured by ASTM E96 water method (Procedure B) shall be allowed on the interior side of any framed wall in all climate zones.”

This footnote is certainly confusing to a lot of builders: We just learned in Section 702.7(1) that Class I and II vapor retarders will be less than 1 perm, but footnote a tells us we are allowed to use a Class I or II vapor retarder that's more than 1 perm. This contradicts the definition. As it turns out, it comes down to the procedure for the ASTM E96 test, for which there are two different methods. Procedure A is the dry-cup test, which is the standard test for determining the permeability of vapor-retarder materials. Procedure B is the wet-cup test. A material tested under Procedure A can test under 1 perm, and that same material tested under Procedure B can test over 1 perm. These materials that can have two different perm ratings are the smart

(responsive or variable) vapor retarders. Why the code has chosen to describe these products by listing them as ASTM E96 Procedure A or B, which most builders are not familiar with, is beyond me. Maybe this will be changed in future code editions.

There are a couple of other footnotes to Table R702.7(2). We are permitted to use Class I and II vapor retarders in the climate zones marine 4 through 8, with a couple of qualifiers. If you are using a Class I interior vapor retarder in conjunction with a continuous exterior insulation product that is also considered a Class I vapor retarder, you'll need to provide the code officials with some sort

CONTINUOUS INSULATION WITH CLASS III VAPOR RETARDERS

Climate Zone	Class III Vapor Retarders Permitted for:
Marine 4	Continuous insulation with R-value > 2.5 over 2x4 wall
	Continuous insulation with R-value > 3.75 over 2x6 wall
5	Continuous insulation with R-value > 5 over 2x4 wall
	Continuous insulation with R-value > 7.5 over 2x6 wall
6	Continuous insulation with R-value > 7.5 over 2x4 wall
	Continuous insulation with R-value > 11.25 over 2x6 wall
7	Continuous insulation with R-value > 10 over 2x4 wall
	Continuous insulation with R-value > 15 over 2x6 wall
8	Continuous insulation with R-value > 12.5 over 2x4 wall
	Continuous insulation with R-value > 20 over 2x6 wall

Adapted with permission from Table R702.7(3) of the IRC. This table shows the requirements for insulation used to control moisture when using a Class III vapor retarder, such as poly, on the interior side of the wall. According to a footnote in the original table, the insulation materials used to satisfy this option (a Class III vapor retarder) contribute to but do not supersede the thermal envelope requirements of Chapter 11.

of engineering or analysis showing the design will not trap moisture between the two vapor retarders. In other words, you'll need approval (footnote b).

Another qualifier, footnote c, says, "where a Class II vapor retarder is used in combination with foam plastic insulation sheathing on the exterior side of framed walls, the continuous insulation shall comply with Table R702.7(4) and the Class II vapor retarder shall have a vapor permeance greater than 1 perm when measured by ASTM E96 water method (Procedure B)." Again, the ASTM E96 water method (Procedure B) refers to a "smart" vapor retarder. This footnote will eventually get us to Table R702.7(4), but first, let's look at Table R702.7(3), which covers Class III vapor retarders and when they can be used in marine zone 4 through zone 8.

Using Class III vapor retarders. A simplified version of Table R702.7(3) is shown on the opposite page. Here, we see when we can use continuous insulation to move from the required Class I or II vapor retarder to a Class III, painted drywall. (There are also options in the original table to add vented cladding, such as vinyl or brick veneer, to an assembly, but I am not going to cover vented cladding or vented rainscreens. In this article, we will just concentrate on continuous insulation.)

Table R702.7(3) in the IRC shows the conditions when a Class III vapor retarder is permitted. This table is creating more confusion by seeming to contradict the insulation requirements in Chapter 11 (Table R402.1.3). The table has lower continuous insulation R-value requirements than the table in Chapter 11 for climate zones marine 4 through 6. Why? It states this in a footnote: "The requirements in this table apply only to insulation used to control moisture in order to permit the use of Class III vapor retarders. The insulation materials used to satisfy this option also contribute to but do not supersede the thermal envelope requirements of Chapter 11."

As an example, in climate zone 5, you can use R-5 continuous insulation in a 2x4 framed wall to control moisture if you use a Class III vapor retarder, but per Chapter 11 (Table 402.1.3), R-10 is the minimum R-value of continuous insulation for a wall with R-13 cavity insulation. (The table also bounces back and forth between listing a 2x4 or 2x6 wall, then moving to R-13 and R-20 cavity insulation, causing more confusion.)

Using Class II vapor retarders. The last table in the vapor retarder section (Table R702.7(4), above right) is another table that does not line up with the insulation requirements of Chapter 11.

Table R702.7(2), which told us where we can use different vapor retarders, has already shown us we are allowed to use a Class I or II vapor retarder in climate zones marine 4 through 8, and a Class II retarder in

CONTINUOUS INSULATION WITH CLASS II VAPOR RETARDERS

Climate Zone	Class II Vapor Retarders Permitted for:
3	Continuous insulation with R-value > 2
4, 5, and 6	Continuous insulation with R-value > 3 over 2x4 wall Continuous insulation with R-value > 5 over 2x6 wall
7	Continuous insulation with R-value > 5 over 2x4 wall Continuous insulation with R-value > 7.5 over 2x6 wall
8	Continuous insulation with R-value > 7.5 over 2x4 wall Continuous insulation with R-value > 10 over 2x6 wall

Adapted with permission from IRC Table R702.7(4). This table shows the requirements for insulation used to control moisture when using a Class II vapor retarder. Once again, a footnote in the original table states that the insulation materials used to satisfy the option of a Class II vapor retarder contribute to but do not supersede the insulation requirements of Chapter 11.

zones 3 and 4. The table above now lets us know we can use less R-value in conjunction with a Class II vapor retarder, but according to the Chapter 11 insulation requirements, we are *not* allowed to use less R-value than Chapter 11 requires. There's probably some reasoning behind the contradictions of the previous two tables with the energy code R-value requirements, but why confuse most builders with this information? In the building code, insulation requirements trump condensation risk when it comes to continuous insulation. It would be simpler if the insulation requirements and vapor-retarder tables agreed with one another.

We will have to wait and see if the 2024 IRC simplifies vapor-retarder requirements with the energy code. Until then, I hope this article has helped you better understand how to navigate the insulation requirements and rules for using vapor retarders.

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