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Chapter SPS 322

Introduction

This chapter of the UDC sets minimum standards for energy conservation for new one- and two-family dwellings. It sets requirements for insulation and moisture protection of the building envelope and capacity and efficiency requirements for heating, ventilating and air conditioning systems.

The standards attempt to satisfy the human comfort needs of proper temperature, air movement and humidity as well as economical and building-preserving construction and operation. To assist you in better understanding these standards, we've included the following energy basics section. Following that is the code section-by-section commentary.

Note that the effective date of the original energy conservation standards was December 1, 1978, differing from the June 1, 1980, effective date of the other chapters of the UDC.

Special electrically heated dwelling standards were removed by March 2008 Legislative action.

Some Energy Basics

The following information is offered as background material to the intent and proper application of the Ch. SPS 322 requirements.

Chapter SPS 322 requirements can be put into the four categories of heat loss control, moisture control, ventilation design, and heating equipment requirements with some overlap between the four.

I. Heat Loss

The heat loss control requirements of Ch. SPS 322 are meant to limit heat transfer. Heat transfer is the tendency of heat or energy to move from a warmer space to a cooler space until both spaces are the same temperature. Obviously, the greater the difference in temperatures, the greater will be the heat flow. There are three types of heat transfer:

- Radiation - transfer of heat through space. An example is your body heat radiating out a closed window on a winter night. The glass is cold so there is no radiation to you and it is a poor reflector of your own heat back to you. Another example is sunshine coming in through a window.

- Conduction - transfer of heat through a material. An example is your warm hand held against the inside surface of a cold exterior wall. You will note that the code has a lower allowable R-value for what are called mass walls, versus frame walls. This reflects that capacity for such walls to maintain a certain temperature relatively longer because of its heat capacity.

- Convection - transfer of heat by moving masses of air. An example is heated air leaking out through door and window openings.

The code does not say much about radiative heat losses. It does say a lot about conductive and convective heat losses. Let's discuss these further.

A. Heat Loss By Conduction

1. C-Values and k-Values

   A measure of a material's ability to Conduct heat is its "C"-value which is expressed in BTUs per (hour)(^{o}F). A BTU is a British Thermal Unit which is the heat required to raise one pound (about a pint) of water by one degree Fahrenheit and is roughly equal to the heat given off by the burning of one kitchen match. A human body gives off about 400 BTUs per hour. Since a C-value is a flow rate of heat, it needs a per time unit similar to other rate measures such as speed, "55 miles per hour." An hourly rate is also used in the C-value. Finally, as you recall, heat flow is greater as the temperature difference increases. So the C-value needs to be expressed in terms of what the difference is. For simplicity, it is taken at 1 degree Fahrenheit difference.

   Another term to be familiar with is a "k"-value which is merely the C-value for one inch of material.

   Typically, building components such as walls or ceilings consist of a "series" or layers of different materials as you follow the heat flow path out. However, you cannot add C-values together because if you were to take two insulating materials with a C-value of .5 each and were to add them together, you get the result of a total C-value of 1.0. This would mean that the heat flow rate has increased with the addition of more insulating material. Obviously then you cannot add C-values to find the "series" value.

2. R-Values

   Therefore, we now have to bring in the perhaps more familiar "R"-value which is a measure of a material's Resistance to heat flow and is the inverse or reciprocal of the material's C-value (R=1/C).

   So if a material has a C-value of 0.5, it has an R-value of 2 (as 2 = 1/0.5). If you have to add two materials in series or layers, say each with a C-value of 0.5, you take the inverse of both to get an R-value for each of 2. These can be added together to get a total R-value of 4. Usually materials are labeled or tables are written so that the material's R-value is given [see SPS 322.20(5)(a)], which relieves you of finding the inverse of the material's C-value.

3. U-Values

For thermal heat loss calculations, we normally use "U"-values (U for Unrestrained heat flow or transmittance) which is a material's C-value but also includes the insulating effect of the air films on either side of the material. So it is, therefore, a smaller number (less heat flow).

A U-value can also refer to thermal transmittance of a series of materials in layers. To obtain a U-value for such an assembly, you add the individual R-values of the layers and the air films on either side of the assembly. Then you take the reciprocal of the total R-value to get the total U-value of the assembly (U = 1/R). (As with C-values discussed above, you can not add U-values for series calculations.)

4. Heat Loss Calculations

The purpose of these C-, k-, R- and U-values is to be able to calculate heat loss through a building component (wall, ceiling, floor). The basic equation is U x A x TD = Heat Loss or

U x Area (ft^2) x Temperature Difference (^oF) = Conduction Heat Loss (BTU/hr)

So to find the heat loss per hour through a building section of wall, you:

- determine its U-value by finding the inverse of the sum of individual R-values for each layer of material;
- decide on the inside and outside temperatures (in the case of the UDC, the winter design temperatures are mandated – see SPS 322.40(c) and the UDC Appendix A 323.02(1));
- measure the surface area of the building section;
- multiply these numbers together and get a result in BTUs per hour.

If you did this for every different building section (solid wall, window, ceiling, etc.), you could obtain the total heat loss through the envelope at design temperatures, which is the worst case situation. Normally this maximum figure along with the heat loss by infiltration (see discussion later) is used to size the furnace or other heating source. It is referred to as the heating load.

If you wanted to know the total envelope loss for a heating season, you do a degree-day calculation. A degree-day is the difference between 65°F and the average temperature for a day if it was below 65°F. If this calculation is done for each day of the heating season, you can find the total heating degree-days for the year. This can be plugged into a modified version of the heat loss calculation as follows:

U x Surface Area x Degree-days x 24 hours/day = Season Heat Loss

5. U-Overall

   One more term to know is U-overall or U_o which refers to the overall U-value of a building component such as a wall or ceiling. For example, a wall will have different individual U-values for the windows, stud cavities and stud locations. The UDC sets a minimum U_o for each overall component surface. If a designer has a large window area, more insulation will need to be placed in the wall cavities or sheathing areas so that the overall or "average" wall surface U-value is acceptable.

   The U-overall value is calculated by taking the weighted average of the U-values (not R-values) of the different parallel paths through the same component (wall, ceiling or other) that you're dealing with.

6. System Design

   As an alternative, the system design method can be used so that more insulation is put in the ceiling to make up for the extra windows. However, it is not a one-for-one tradeoff because of the thermal transfer properties and mathematics of reciprocals involved. Let's say you have an R-10 (U = 0.1) wall and R-10 (U = 0.1) ceiling of equal area. If you transfer half of the wall insulation, to the ceiling, the wall becomes R-5 (U = 0.2) and the ceiling becomes R-15 (U = 0.07). However, you can see that the wall U-value increased by 0.1 and the ceiling U-value only decreased by 0.03. (Remember U-values are used to calculate heat losses.)

B. Heat Loss By Convection

As mentioned, the other mechanism of heat loss addressed by the UDC is convection, or heat loss by air movement. In homes, this is principally heat loss by exfiltration and infiltration. Exfiltration is the loss of heated air through building cracks and other openings. Infiltration is the introduction of outside cold air into the building. This air movement also causes discomfort (drafts) to occupants in addition to the heat loss itself.

The driving force for this exchange of air is the difference between indoor and outdoor air pressures. Air pressure differences are principally caused by wind pressures and the "stack" effect of warm inside air that tends to rise. Mechanically induced air pressure differences can also occur due to such things as exhaust fans and furnace venting.

To calculate the heat loss by convection, we go back to the general heat loss calculation and modify it to:

$$\text{Heat Loss} = \text{Air's Heat Capacity} \times \frac{\text{Air Volume Exchanged}}{\text{Hour}} \times \text{Temp. Difference}$$

The volume exchanged can be determined by measuring or judging how many air changes that a house goes through in an hour. To do this, you calculate the volume of the heated space and multiply by an air change rate. For a UDC home, you can assume a rate between 0.2 and 0.5 air changes per hour [see SPS 322.30(2)], usually with a lower rate for basements with little outside air exposure, and higher rates for living areas or exposed basements. If you have a 1500 square foot house on a crawl space with 8-foot ceilings, the calculation of the volume exchanged can be:

$$1500 \text{ sq. ft.} \times 8 \text{ ft.} \times 0.5 \text{ Air Changes/hr} = 6{,}000 \text{ cu. ft./hr}$$

The heat capacity of air is a physical constant and is 0.018 BTU per (°F)(cu. ft.). The temperature difference, which varies by site location, used is the same as for heat loss by conduction. So the whole equation for this example is:

$$\frac{0.018 \text{ BTU}}{(^{o}\text{F})(\text{cu. ft.})} \times 6{,}000 \text{ cu. ft./hr.} \times 90^{o} = 9{,}720 \text{ BTUs/hr}$$

This figure is the design or maximum heat loss by convection. If you wanted to figure the total seasonal infiltration heat loss, you would perform a degree day calculation as for the seasonal conduction heat loss calculation. You substitute the seasonal degree days and the 24-hour multiplier for the temperature difference figure in the infiltration heat loss equation above.

Another method of determining heat loss by convection is the crack method. For this method you obtain the air leakage rates in cubic feet per minute for the doors and windows from their manufacturers and multiply by the lineal feet of sash crack or square feet of door area. (A more exact analysis would multiply the door infiltration rates by 1 or 2 due to open/close cycles and add 0.07 cfm per lineal feet of foundation sill crack.) This gives an air change rate per minute. This has to be converted to an hourly rate by multiplying by 60. Then you substitute this figure for the air change rate in the infiltration heat loss equation above.

C. Total Dwelling Heat Loss

If you add the heat losses by conduction and convection, you arrive at the total dwelling heat loss for purposes of the UDC. Of course this figure is approximate and ignores other means of heat loss. However, it also ignores the major heat gain from secondary sources such as electric lights, human bodies, cooking, etc. So the figure tends to overstate the heat loss but this ensures an adequately sized heating plant.

II. Moisture Control

The second area of concern addressed by the UDC is control of moisture. The occupancy of a dwelling produces a large amount of water vapor. As you may recall from weather forecasts, warmer air can hold more moisture than cold air. In the winter, the inside air is warmer than the outside, so if moisture moving outside by convection or dispersion (similar to conduction) reaches too cold of air, it will "condense out." This occurs at the dew point for that water vapor/air mixture. This condensation can be damaging to the building if it happens inside part of the wall or ceiling construction. It can promote structural member decay and lessening of the insulation's effective R-value.

There are three methods of reducing the possibility of condensation--vapor retarders and cold-side venting.

A. Vapor Retarders and Air Barriers

A vapor retarder (sometimes called a vapor barrier) acts to resist the movement of moisture through a section of the building envelope by water vapor diffusion and bulk movement of moist air. A vapor retarder's efficiency at reducing moisture movement by water vaper diffusion is measured by its permeability in "perms." A perm is one grain of water per (hour) (square foot) (inch of mercury vapor). The lower the number, the more resistant is the material to moisture flowing through it.

The required continuity of the vapor retarder over the warm-in-Winter surface provides the required barrier to bulk movement of moist air through the assembly. This means the retarder also needs to be continuous with seams and holes lapped or sealed. This bypass effect can be much greater than the movement of water vapor by diffusion. Note that the code also requires sealing of the building envelope against air infiltration from the exterior – typically the vapor retarder will satisfy the requirement for this "air barrier".

Vapor condenses when it comes in contact with material that is at a temperature lower than its dew point. This temperature typically occurs within the wall cavity and thus would condense out water vapor before it can escape from the dwelling. This moisture can cause decay of building materials and a reduction in insulating value.

Additional areas where condensation occurs are generally at corners of rooms at the exterior walls. This area is subject to condensation for a number of reasons. The temperature at the corners is generally cooler due to the fact that it is difficult to insulate at this location due to the method of construction. The insulation may be further reduced due to the roof system allowing less insulation to be placed above the corner. Condensation also occurs in areas with poor air circulation such as closets.

B. Cold-Side Venting

The other means of controlling moisture is cold-side venting. This is usually employed in attics and unheated crawlspaces. The venting removes excess moisture that bypassed the ceiling vapor retarders or comes out of the earth in the crawl space. This venting is usually done by natural means through the use of grills or louvers from the space to the outside. However, for that to work, there must be high and low venting in the case of the attic or cross ventilation in the case of the crawl space.

Cold-side attic venting also keeps the roof cooler so that there is less melting of snow and contributes to less creation of ice dams at the eaves in the winter. It also helps dissipate summertime attic heat, which increases comfort and reduces cooling costs.

C. Impervious Insulations

Thus use of closed-cell foam plastic insulation or similar non-absorbent insulating materials that are unaffected by moisture condensation is another effective method used for some designs of dwellings to deal with this issue.

D. Moisture Control During Construction

Unless proper construction techniques are utilized during construction, serious problems can occur as a result of water vapor that is trapped inside and then causes deterioration of gypsum wallboard.

Over the years we have seen many improvements in both materials and methods in home construction. Often times the use of a new material required the change in a technique or method of construction previously unheard of. Most building codes are only a reflection of our latest achievements in technology and engineering. The vapor retarder requirements in the Uniform Dwelling Code are a reflection of state of the art insulation techniques. Simply stated, the purpose of the vapor retarder is to prevent (as much as possible) water vapor from penetrating into the insulation and thereby reducing the effectiveness of the insulation. The problem is that builders who are not familiar with the use of vapor retarders, particularly during winter construction months, can inadvertently create problems for the homeowner if precautionary measures are not taken during construction. We offer the following suggestions to incorporate in construction procedures, especially during winter months:

1. Do not allow gypsum board to pick up excess moisture prior to installation.
2. Make sure attics are insulated prior to putting heat into the home for gypsum board taping and finishing. Many builders neglect to do this and create condensation problems when the water vapor condenses upon hitting the cold, attic air above the gypsum board. Gypsum board ceilings should be hung and insulated prior to putting heat into the home.
3. Make sure all heating appliances, i.e., furnaces, temporary heaters, salamanders, etc., are vented to the outside of the home. Builders who do not follow this warning are adding additional water vapor created by combustion of heating fuels.
4. Make sure all required attic ventilation is installed and operable to remove any water vapor trapped in the attic.
5. Provide a means for the water vapor in the home to escape; such as periodic opening of windows, doors, etc. Perhaps the installation of a humidistatically controlled exhaust fan is necessary, particularly where electric baseboard heat or heat pump systems are utilized.
6. Do not overload gypsum board ceilings with insulation beyond their capacity. See s. SPS 321.02 (1)(a) of this commentary.

Incorporation of these techniques will avoid major problems with condensation. These methods are not new and have been proven successful by many hundreds of builders operating in climates such as ours.

E. Post-Construction" Moisture Control Problems

As discussed in the basics section of this commentary chapter, moisture must be dealt with in all homes. The following is a general discussion of typical symptoms, causes and prevention techniques regarding moisture problems in homes. It is intended as background information to help explain some UDC requirements. Additional recommendations above and beyond the UDC minimums are included for homeowners who may experience more severe moisture problems.

1.How can you determine if a home has a moisture problem?

You can get a good idea of whether your home has an excess moisture problem that may lead to damage by checking for the following symptoms.

- Extensive condensation on windows during the heating season. Some condensation is normal. Condensation that streams off the window and puddles on the frame and sill when outside temperatures are 10°F or above and inside temperatures are above 65°F indicates humidity levels are probably too high.
  - If condensation is limited to the inside surface of storm windows, then your primary windows may be allowing moist interior air to leak by them. Because of the "stack" pressure effect, this problem may be worse on second floor windows.
  - If condensation is limited to the inside surface of the primary windows, then your storm windows may be allowing cold air to leak by them which then cools the primary window.
- Staining and mold on window frames.
- Mold or water spots in numerous locations on the inside surface of outside walls. Common trouble spots include closets on outside walls; corners between two outside walls or between an outside wall and ceiling; and outside walls behind furniture; or other areas where air circulation is limited.
- Soft or buckling interior wall surfaces. Gypsum board is a common interior surface. When dampened it may pull away from studs or ceiling rafters. Additional moisture may cause the gypsum board to crumble.
- Staining or warping of exterior siding.
- Paint peeling from exterior siding, especially extensive peeling of paint down to the primer.

If you have not experienced any of these symptoms, the home probably does not have a moisture problem. However, it may be a good idea to consider some of the measures in the following Section III to assure that future problems do not develop.

2. What are typical causes of moisture problems in homes?

Through breathing and normal daily activities, each member of a household produces about seven pounds of water vapor. Naturally this number varies greatly depending on living habits. This water vapor becomes part of the air. However, air can hold only a limited amount of water vapor. This amount depends on temperature. The higher the temperature the more moisture the air can hold. When more moisture is introduced into the air than it can hold, some of the moisture will condense on surfaces. If cold surfaces sufficiently cool the surrounding air, condensation will occur on that surface even though the remaining room air is not saturated with moisture. The frosted cold beverage glass in summer is an example.

In most older homes there is enough movement of air into and out of the house that moisture does not build up and only small amounts of condensation occurs. However, when air leaks into and out of a house it not only takes moisture but heat as well. In order to make homes more energy efficient, builders have been trying to seal cracks and cut air leaks.

These efforts to tighten homes have meant that more moisture remains in the home. Unless controlled ventilation is added, moisture accumulates, and condensation occurs near the ceiling on outside walls or on outside walls of closets. These areas generally have cooler surfaces. If condensation persists on these surfaces, molds and mildews may develop. In addition, fungal growth and possible deterioration of material may occur when temperatures are at or above 50°F and the material remains wet. Such fungal growth could damage wood members in extreme circumstances.

3. Besides the UDC requirements, what measures can help prevent moisture problems?
   - Reduce Moisture Production In The Home
     - One way to substantially reduce the chances that condensation will occur either on inside surfaces or within walls is to keep indoor moisture levels low. The first step is to reduce the amount of moisture produced in the home. Some major sources of moisture that can be controlled are listed below.
     - Prevent moisture from entering through basements. Many basements feel damp in the summer due to condensation of moisture from the air on cool basement surfaces. However, in some cases damp basements may be due to ground moisture entering the home through basement walls. Cracks or stains on basement walls and floors are signs of dampness entering through these surfaces.
       - You can check whether dampness is coming through walls by using a simple patch test. Tape a piece of plastic sheeting tightly against the basement wall where you suspect moisture penetration. After a couple of days pull the patch off and look for signs of moisture on the wall side of the patch. If you detect moisture, it means moisture is coming through the wall rather than condensing on the walls.
       - If you suspect a basement water problem, check the surface drainage around you home. Most basement water problems result from poor surface drainage. Make sure that the ground slopes away from the foundation. Consider installing gutters. If you have gutters, make sure they are clear of debris and functioning properly. Downspouts should direct water away from the foundation.

  - Do not store large amounts of firewood in the basement. Even seasoned wood can contain large amounts of moisture. It also may be a source for fungus.
  - Other ways you can reduce moisture generation:
    - Vent clothes dryers outdoors;
    - Don't line dry clothes indoors;
    - Limit the number of houseplants;
    - Cover kettles when cooking;
    - Limit the length of showers; and
    - Do not operate a humidifier in the wintertime unless your indoor relative humidity is below 25 percent.
    - Be sure any crawlspace floors have a vapor retarder covering.
  - If problems persist, you should also check for any blocked chimney flues that may be preventing moisture-laden flue gasses from exhausting out of the house.
  - Correct any plumbing and roof leaks. If ice dams are a problem, consider more attic ventilation and adding insulation.

- Add Mechanical Ventilation
  - A second way to reduce moisture levels is to add mechanical supply and exhaust ventilation. As an added benefit, ventilation will reduce concentrations of other possible air contaminants such as combustion by-products from heating, cooking and smoking.
  - A widely recommended ventilation rate for homes is one half air change per hour. In a 1,200-square-foot house with 8-foot high ceilings, there are about 9,600 cubic feet of air. To meet the ventilation standard, half of that amount or 4,800 cubic feet of air must be exchanged every hour. This roughly equals 100 cubic feet per minute (cfm) of air exchange. Even in a tight house some of this air exchange occurs naturally. A constantly running or humidstat-controlled bathroom fan would typically ensure adequate ventilation.
  - However, in a house that is experiencing severe moisture problems, it can be assumed you are getting less than one half air change per hour. A balanced ventilation system should be used to make up the remaining necessary air exchange. A balanced system is one that not only exhausts stale air but provides a source of fresh replacement air. Currently the UDC per SPS 323.02(3)(b)2. only mandates that 40% of exhaust ventilation be made up through another means. Without proper replacement air the home could have what is known as negative air pressure.
  - Negative pressure could cause exhaust gases from your furnace or water heater, which should be going up your chimney or out a vent, to be sucked into the living space.
  - Additional ventilation is needed only during the heating season. When you provide controlled ventilation for your home, the heat lost is relatively small. For a 1,200-square-foot home, the cost of this lost energy and the electricity to run the fan would amount to about a dollar a day assuming you heat with the most expensive heat source, electric baseboard. This cost should be much less if you heat with gas or other fuels. Also, some ventilation systems can reclaim a portion

of the heat (up to 80%) from the exhaust air by heat-recovery ventilators. This could help reduce energy costs.

- Stop Moisture At The Inside Wall Surface (In Addition To The Required Moisture Vapor Retarder)
  - In addition to reducing moisture levels of the interior air, carefully seal all openings in the inside surface of all exterior walls to prevent moist air penetration. This includes joints around window and door casings, baseboards, electrical outlets and switches and any other penetrations. Gaskets for electrical penetrations are now commonly available, be sure that they extend to the outside edge of the cover plate of electrical devices.

Relative Humidity

In winter, the ideal relative humidity range for comfort is 30 percent - 45 percent. A lower humidity may cause excessive skin evaporation which in turn will cause an undesired cooling effect. For the sake of protecting the structure from damage due to excessive moisture, an ideal relative humidity range of less than 45 percent is recommended. Therefore, to provide comfort and still protect the building, a relative humidity range between 30 percent to 45 percent is recommended.

In summer, the ideal comfort range is 30 percent to 50 percent. Higher humidity won't allow adequate skin evaporation and the resulting desired cooling effect.

III. Mechanical Ventilation

As the code has mandated tighter home construction, the UDC has had to provide increase of mechanical ventilation as an alternative to infiltration to maintain indoor air quality so excessive humidity or other pollutant levels are checked. This has taken the form of required exhaust ventilation for rooms with a toilet, tub or shower and for kitchen exhaust.

A designer may decide to use an air-to-air heat exchanger to satisfy the exhaust requirement, while at the same time recovering heat from the exhausted air. This is done by moving the exhausted air past the intake air with a heat exchanging barrier between the two air streams.

IV. Equipment Efficiency Requirements

The final area that Ch. SPS 322 regulates is heating and cooling equipment efficiencies.

Subchapter I — Scope and Application

322.01(3) Scope

Dwellings that use renewable sources of energy, such as wood or solar, for heat generation, including for what is used by any heat pumps, are exempt from the building envelope insulation requirements. Non-renewable sources of energy may be used to distribute heat by fans or pumps without affecting the dwelling exemption. Although homes that are heated with renewable sources of fuel, such as wood, are exempt from the insulation requirements, they are still subject to the moisture control requirements for vapor retarders and ventilation. These are needed to protect framing and keep insulation dry and protected from degradation.

<u>322.02(2) Declaration of Method of Compliance</u>
As there are more than one method, submitters of plans & calculations should clearly communicate which method of compliance is being provided for the dwelling.

Subchapter III — Materials and Equipment.

<u>322.20(4) Material Installation</u>
This section requires all insulation, mechanical equipment and systems to be installed per the manufacturer's installation instructions which are to be available at job sites during inspection.

<u>322.20(6) Building Certification</u>
This section requires that a permanent certificate of insulation R-values and fenestration U-factors be provided on or immediately adjacent to the electrical distribution panel. If REScheck or REM/Rate software program was used, that certificate print-out shall be provided. Otherwise, a copy of the following form may be used.

2016 Wisconsin/2009 IECC Energy Efficiency Certificate (Post on or immediately adjacent to electrical distribution panel per SPS 322.20(6))

Insulation Rating	**R-Value**
Ceiling/roof	________
Wall	________
Floor/Foundation	________
Ductwork (unconditioned spaces)	________
Beneath Heated Slab	________
Perimeter of Heated Slab	________

Glass & Door Rating	**U-Factor**
Window	________
Skylight	________
Door	________

Name ____________________________ **Date** ______

Comments ______________________________

These Efficiency and Compliance Certificates may be used in lieu of the REScheck Certificates

2016 Wisconsin/2009 IECC UDC Compliance Certificate (Submit with building plans)

Owner/Agent _________________________ **Location** ___________________________________

Heating Appliance Type & Efficiency____________________ **Insulation Zone (SPS 322.31(1)(b)** ___

Building Component	Code Min. Insulation Value (Table 322.31-1)		Code Min. Insulation Value For Lower Efficiency Appliances[1] (Table 322.31-3)		Enter Actual Insulation Value & if Cavity or Continuous
	Zone 1	Zone 2	Zone 1	Zone 2	
Fenestration (U-Value)					
Window	0.35	0.35	0.30	0.30	
Door	0.35	0.35	0.30	0.30	
Skylight (U-Value)	0.60	0.60	0.60	0.60	
Ceiling					
Energy Heel	R-38	R-38	R-38	R-38	
Flat	R-49	R-49	R-49	R-49	
Wood Framed Wall	R-20 or R-13 cav + R-5 cont	R-21 cav	R-21 cav or R-19 cav + R-5 cont	R-21 cav or R-19 cav + R-5 cont	
Mass Wall	R-15/19	R-19/21	R-19	R-19	
Floor	R-30	R-38	R-30	R-30	
Basement	R-15 cav or R-19 cont	R-15 cav or R-19 cont	R-15 cav/ R-19 cont	R-15 cav or R-20 cont	
Crawl Space	R-10 cav or R-13 cont	R-10 cav or R-13 cont	R-15 cav/ R-19 cont	R-15 cav or R-20 cont	
Heated Slab	R-10 / R-15	R-10 / R-15	R-10 / R-20	R-10 / R-20	
Unheated Slab	R-10	R-10	R-15	R-15	

1. Includes less than 90% efficient natural gas and propane furnaces and hot water boilers, less than 83% efficient oil-fired furnaces and less than 84% oil-fired hot water heater boilers. (See Table 322.31-3)

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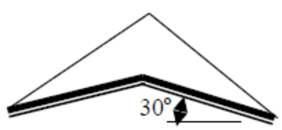
322.21(1)&(2) Protection of Insulation

This section requires blanket insulation to be held in place by a covering or mechanical fastening. SPS 322.21(2) requires cold-in-Winter side windwash protection of air-permeable insulation, thus also keeping insulation in place and maintaining the R-value of that insulation. Normally the exterior sheathing would do this, but where that is not present, some other vapor-permeable material, such as housewrap would be required.

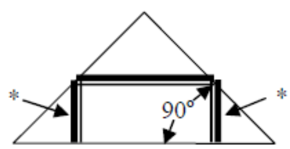
Question: If I have a sloped ceiling that is not a cathedral ceiling, such as that created by scissor trusses, that is insulated with an air-permeable insulation material, e.g. fiberglass or cellulose, do I need the wind wash protection required by this section?

Answer: No, if the ceiling is sloped less than 60 degrees from the horizontal and it is not a cathedral ceiling, wind wash protection is not required. A cathedral ceiling is a sloped ceiling, with closely-spaced, parallel ceiling and roof finishes. It is the intent of SPS 322.21(2)(a) to require the wind wash protection for walls or exposed vertical ends of air-permeable insulation at the perimeter of floor systems, open to attic space or other unconditioned space. The intent of incorporating the phrase “in a position other than horizontal” into this section is intended to exclude insulated ceilings, other than cathedral ceilings from the wind wash protection requirement. If that is the intent of that section, what is a wall? In model building codes and in Rescheck is the following guidance:



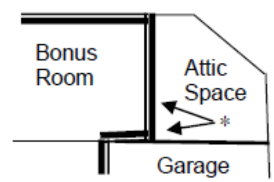
Bottom Chord Less Than 60° to Horizontal - Ceiling

* Wind Wash Protection Above Insulation Not Required.



Building Segment More Than 60° to Horizontal - Wall.

* Wind Wash Protection on Cold-in-Winter Side Required.



Building Segment More Than 60° to Horizontal - Wall.

* Wind Wash Protection on Cold-in-Winter Side Required, Including the End of the Floor Insulation.

In summary, a wall is defined as a building element that is sloped 60 degrees or more to the horizontal. Wind wash protection is not required for ceilings that are horizontal or tilted at less than 60 degrees to the horizontal.

Subchapter IV — Dwelling Thermal Envelope

322.31 Envelope Compliance

Envelope compliance may be by prescriptive method of SPS 322.31(1) by either complying with Table 322.31-1 or Table 322.31-4 or alternatively, per SPS 322.31(2) by showing the overall envelope U-value multiplied by Area complies. The latter method may be done by hand calculation or more typically by the use of the free software program, Rescheck, available from the federal government at www.energycodes.gov . Rescheck version 4.3.0 or greater offers the required code of 2009 IECC. (Do **not** select "2009 Wisconsin".) Note that after selecting the 2009 IECC code, the previously available Loads tab in which to calculate your heating plant size will not be available. See SPS 323.02 of this commentary for methods of obtaining the heating load. See the last page of this chapter for an example of a Rescheck Compliance Report.

Note that if the permit applicant elects to install a heating appliance with efficiency lower than required by Table 322.31-3 and is therefore subject to the thermal envelope requirements of Table 322.31-4, Rescheck is **not** an acceptable method of showing code compliance.

The Rescheck program produces an inspection report based on the unamended 2009 IECC for use by builders and inspectors. Note that the following items in that report need to be modified per the amended Wisconsin adoption of the 2009 IECC:

- Duct tightness testing is only required per SPS 322.43 if any portion of the distribution system is outside the conditioned space.
- Thermostats are required per SPS 322.41 for all heating and cooling systems, but are not required to be programmable.
- The protective covering for exterior foundation insulation is only required to be installed **2"** below grade per SPS 322.21(3).
- All ducts located outside conditioned spaces shall be insulated to R-8 per SPS 322.42.
- Only ducts located outside the conditioned space shall be sealed per SPS 322.43.

Finally, compliance may be shown per SPS 322.51 by calculations or software that models the whole house energy usage. Remrate is a type of acceptable software for that purpose if its version is 14.6.2.1 or greater. Contact the Wisconsin Focus on Energy program for more information.

With any of the envelope compliance methods, any authorized party to the design or construction process may complete the necessary calculations or form completion.

322.32 (1) Ceilings With Attic Spaces.

This section permits the use of R-38 in the attic space in lieu of R-49 specified in Table 321.23-1 as long as the R-38 insulation covers the entire attic area including over the exterior wall top plates. This could be accomplished with the use of “energy heel” trusses. The height of the heel would depend on the type of insulation used to attain the R-38 insulation value.

322.33 Slab Floors

Shallow slabs less than 12" below grade must meet Table 322.31-1 or 322.31-4 for Unheated Slab R-value with perimeter insulation. Heated slabs of any depth with embedded, uninsulated heating ducts or pipes require slab insulation throughout, with additional insulation at the perimeter. Horizontal slab insulation that projects away from the building shall be protected by either pavement or a minimum of 10 inches of soil. See UDC Appendix drawings showing acceptable and unacceptable perimeter insulation in terms of ensuring the edge of the slab is properly insulated.

322.32(6) Discontinuities in Foundation Wall Insulation
See SPS 322.33(3)(c) for an exception that allows discontinuity in foundation insulation where interrupted by an intersecting foundation wall.

322.34 Crawl Spaces
This section requires a vapor retarder on the floor of a crawl space. Per Table 332.37, it shall be a Class I vapor retarder, which is defined by the IBC as having a perm rating of 0.1 or less. Note that requirement to run the vapor retarder 6" up the foundation wall is applicable when there is no floor present to maintain the vapor retarder in place.

322.35 Sunroom vs Screen Porch
This option for reduced insulation levels is only available to heated sunrooms with opaque walls and glazing. It is not available to heated screen rooms with only screens for a portion of the walls. Note that the requirement for a separate heating zone is not satisfied by dampers on the supply ducts.

322.36 Fenestration
Fenestration is an architectural term for windows and doors. The UDC generally requires them to be certified under the NFRC 100 standard for the values used, which is easily verified in the inspection of the window label on each unit. Where windows are not labeled, the conservative, default table values must be used for determining compliance. The code allows a single door and a single window to be exempt from door and window requirements which permits the installation of elements such as stained-glass windows

Different types of window operating hardware will produce different U-values for similar-sized windows. Therefore, a 3'-0" x 3'-0" double hung window would have a different U-value from a 3'-0" x 3'-0" fixed window sash. Similar size windows produced by two different manufacturers would most likely also have different U-values. Averaging of U-values is by area-weighting per SPS 322.36(1).

322.37 Air Leakage
Air leakage at fenestration and at other penetrations in the envelope are to be sealed properly per SPS 322.37(3), (4) & (6)(b) requirements or pass a blower door test per (6)(a).

SPS 322.37(4) provides specific guidance on recessed lighting installed at envelope areas, without leading to overheating fires.

322.37 Air Infiltration Barrier
The UDC does not define materials to be used as an infiltration barrier. It does require them to:

1. Be installed on the interior face, typically as part of the vapor retarder, or on the exterior face of the wall, typically as a house wrap or caulked building panels.
2. Form a continuous barrier over the walls of the building from the bearing points of the roof to the top of the foundation.
3. Have all seams, joints, tears, and punctures sealed.

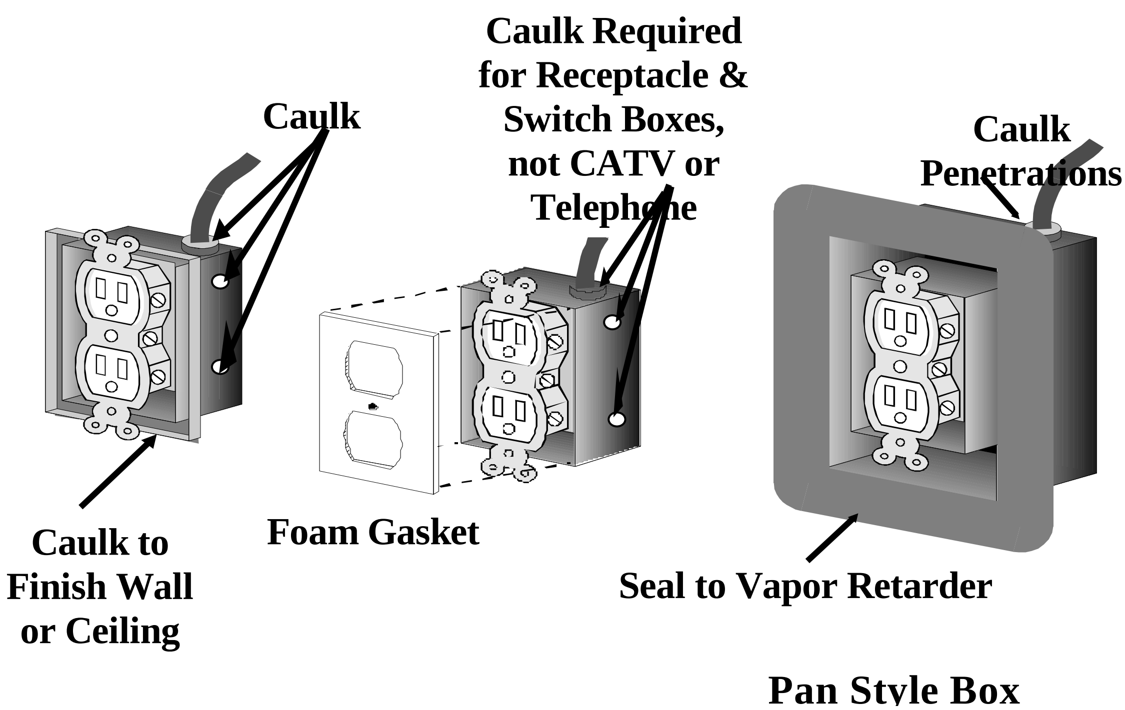
Additionally, the department has determined such infiltration barrier construction:

1. Be water vapor permeable to prevent moisture problems within the wall if installed on the cold side of the wall. The perm rating must be significantly higher than the interior vapor retarder. Alternatively, it is acceptable to have an exterior infiltration barrier that is vapor impermeable, but provides insulation to keep the dew point out of the wall.
2. Restrict infiltration to an appreciable extent.

These materials include:

- Spun bond polyolefin sheets, with taped joints.
- Micro-perforated polyethylene film sheets, with taped joints.
- Building panel sheets such as foam sheathing or plywood sheathing with taped joints, regardless if the panels have butt or tongue and groove edges

<u>322.37(3)(b) Air Sealing of Electrical Switch and Receptacle Boxes</u>



<u>322.37(6)(b) Air Barrier & Insulation Inspection Component Criteria Table</u>

Note that some of the items on this list need to be verified at the insulation inspection and others at the final inspection. Also the Table has several additional requirements that are not applicable if the Blower Door Test option is chosen. To highlight several items the list:

- Corners and headers of walls are required to be insulated.
- The reference to a Class I vapor retarder on the floor of a crawl space means a vapor retarder with a perm rating of 0.1 or less.
- Non-IC rated recessed ceiling light fixtures may be used in insulated ceilings if installed per SPS 322.37(4)(c)2., since this is a more specific treatment of the topic than the Table.
- The requirement to place insulation in the building envelope to the exterior of plumbing piping is based on SPS 382.40(8)(a)1. that requires piping to be protected against freezing.
- Common walls of duplexes require an air barrier, and exterior wall insulation, only if the two units are separately owned and therefore may not necessarily both be heated.

<u>322.38(1) Paint as a Vapor Retarder</u>
Certain paints have been tested per ASTM E-96 to provide a vapor retarder with a perm of 1 or lower or labeled as Class II (Class I would also be acceptable) when applied at specified rates and coats for certain surfaces. Regardless of the type of vapor retarder used, per SPS 322.38(1)(b), it shall be continuous. So in the case of vapor retarder paint, any discontinuities in the surface being painted, must caulked, gasketed or otherwise sealed.

In order to assure building officials and owners that vapor retarder paint has in fact been installed and the intent of SPS 322.38 met, a certificate of compliance (see following sample certificate) may be filled out and submitted to the building official with a copy to the owner. In addition to the certificate, the contractor should provide the inspection agency with the labels from the paint cans that were used by the applicator.

The following is the recommended procedure to be followed by building inspection agencies to assure compliance with the vapor retarder requirement:

1. At the time of plan submittal, the builder should state or have shown on the plans what type of vapor retarder is to be used in the dwelling.
2. At the time the plan is approved, the inspector should provide a blank Certificate of Application if one will be locally required.
3. At the time the insulation/rough energy inspection is made, the inspector will be able to determine where the standard vapor retarder was applied in the dwelling.
4. At the final inspection, the contractor should supply to the building inspector the completed certificate as well as the labels from the paint cans.
5. The inspector may then destroy the labels and the Certificate of Application can be filed with the building file.

VAPOR RETARDER PAINT
CERTIFICATE OF APPLICATION

THIS CERTIFIES THAT A VAPOR RETARDER PAINT HAVING A PERM RATING BELOW 1.0 WAS APPLIED TO THE FOLLOWING STRUCTURE:

____
____

PAINT MANUFACTURER: ____

SUPPLIER: ____

GALLONS USED: _________________________ LABELS SUBMITTED: ☐ YES ☐ NO

CEILINGS - TOTAL SQUARE FEET COVERED: ___________________________________

WALLS - TOTAL SQUARE FEET COVERED: _____________________________________

NUMBER OF GALLONS USED ON: 1st COAT ______________ 2nd COAT _____________

APPLICATION MADE BY NAME: ____

ADDRESS: ____

SIGNATURE: ____

<u>322.38(1)(b) Vapor Retarder Continuity</u>
Vapor retarder continuity is important for purposes of preventing bulk movement of warm, moist air into building assemblies, which is a more significant source of moisture than diffusion through the vapor retarder.

<u>322.38(2)(a) Vapor Retarders Not on In-Winter Warm Side</u>
Occasionally it occurs that a wall will have two materials or layers that may act as vapor retarders. It is important in this situation that the better vapor retarder (lower perm rating) be placed closer to the warm side. Also, extreme care should be taken to make the interior vapor retarder continuous with good joint and penetration sealing. This will help avoid condensation of moisture in the wall.

In some dwelling designs, double walls are constructed with insulation in both walls. Often this is to avoid making electrical box and other penetrations in the vapor retarder. A single vapor retarder is placed between the two walls. This conflicts with the requirements that vapor retarders be placed on the warm side of all insulation. However it may be acceptable depending on the distribution of the insulation between the two walls. If there is enough insulation on the exterior side of the vapor retarder, the air temperature in the insulation at the interior face of the vapor retarder may still be warm enough to prevent condensation.

> A DEW POINT CALCULATION estimates expected temperatures throughout the thickness of the wall. Interior temperature, exterior temperature, and wall component R-values must be known. Additionally, a "design" interior air relative humidity must be assumed. Since typical wintertime reported indoor humidities range from 40 percent to 60 percent, the department will accept 50 percent as an average indoor relative humidity (RH) design value for such a calculation.
>
> In order to do such a calculation, a person must have access to a psychrometric chart or table to determine dew points throughout the wall section given specific design temperatures, RH, and wall component R-values.
>
> Example: Fictional Wall
> R = 10, uniformly distributed across thickness of 4 inches
> RH = 50% (interior)
> Temp = 70°F interior and -10°F exterior
>
> This would result in condensation if interior air was lowered in temperature or exposed to a surface temperature of approximately 50°F. In this wall, the 50°F dew point occurs at 1 inch from the interior surface. Therefore, a recessed vapor retarder must be to the inside of this 1-inch limit.
>
> Detailed calculations shall be submitted for each specific project where a designer wishes to recess a vapor retarder into the wall cavity, other than as permitted by SPS 322.38(2)(c)4. for spray-applied foam insulation, that is relatively air impermeable. For air

permeable insulation such as fiberglass and cellulose, a rule of thumb is that no more than one-third of the insulation should be on the warm side of the vapor retarder.

322.38(2)(c)1. Exceptions to Vapor Retarder

If the exceptions in this section to a continuous vapor retarder at boxsills or over spray-applied foam are used, you are also required to stop air leakage at those locations that would have been otherwise provided by a continuous vapor retarder.

322.38(3) Omission of Taping of Vapor Retarder Joints Under Concrete Slabs

Similar to the exception in (1)(b) for taping of vapor retarder seams that are compressed between framing and finish materials, properly lapped seams that are under a poured floor are considered effectively sealed and will not require taping. Note that the negative impact from the small amount water vapor that may diffuse through any gaps into the dwelling is much less of a problem than gaps in wall and ceiling vapor retarders that allow bulk moisture laded-air from the interior into the building construction.

322.38(4) Vapor Retarders Prohibited on Concrete or Masonry Walls

The code prohibits installing a non-rigid vapor retarder of a 0.1 perm or less rating, such as roll polyethylene sheeting ("Visqueen"), on or in front of masonry or concrete below grade foundation walls. This is avoiding the potential for moisture from adjoining earth being trapped between an interior vapor retarder and the wall and possibly causing degradation and mold.

322.39 Attic Ventilation

Attic ventilation is generally required where air-permeable insulation is installed. This means that attic ventilation is not required above closed-cell foam insulation. Note that insulation shall not block the ventilation route, so attic vent chutes may be required at the eaves.

The code requirements of these sections for venting areas are based on effective venting area. Louvers and screening greatly decrease the effective venting of attic vents. Usually the effective venting area of a vent is indicated on it. Otherwise the following is a guide:

Obstruction in Ventilator (Louvers and Screens)	To Determine Total Free Area of Ventilator Multiply Gross Area by:
1/4 inch mesh hardware cloth	1
1/8 inch mesh screen	0.8
No. 16 mesh insect screen (with or without plain metal louvers)	0.5
Wood louvers and 1/4 inch mesh hardware cloth	0.5
Wood louvers and 1/8 inch mesh screen	0.44
Wood louvers and No. 16 mesh insect screen	0.33

Regarding turbine vents, the effective area is equal to the bottom opening area.

Regarding power vents, manufacturer's requirements should be followed. Otherwise an installed mechanical ventilation capacity of 0.25 cfm per square foot of attic floor area is acceptable.

Additionally, adequate air intakes must be provided. Control of the fan must be provided by a humidistat or combination humidistat/thermostat. A humidistat setting of 90 percent is acceptable.

322.39(4) Cathedral Ceiling Venting Exception
A cathedral ceiling is a sloped ceiling, with closely-spaced, parallel ceiling and roof finishes.

Subchapter V — Systems

322.40 Outdoor Design Temperatures
The design of heating equipment to satisfy the heating load is regulated by ss. SPS 323.02 and 323.03. Those sections refer to the UDC Appendix table for determining outdoor design temperatures. See the commentary for SPS for SPS 323.02 for methods of calculating heating load now that the more recent versions of Rescheck do not offer that option anymore.

322.42 Ducts in Unconditioned Spaces
Ducts located outside conditioned space, including those in attics, unheated garages, and vented crawl spaces and under slabs, shall be insulated to at least R-8. Per SPS 322.10(3), conditioned is defined as being heated to 50 degrees or more at design conditions. Burying the ducts in attic insulation that provides the minimum R-8 value is acceptable, except if the ducts are used for cooling purposes. Per (1m) of this section, cooling supply ducts require at least R-8 duct insulation with an exterior vapor retarder to reduce surface condensation. Note that any ducts outside the conditioned space, which per SPS 322.37 includes the required air barrier, would generally trigger duct sealing and testing of the complete duct system per SPS 322.44.

Also note SPS 323.08(3) that requires exterior ducts that are susceptible to damage to be metal.

Ducts in underslab locations may be insulated per either of the following methods:

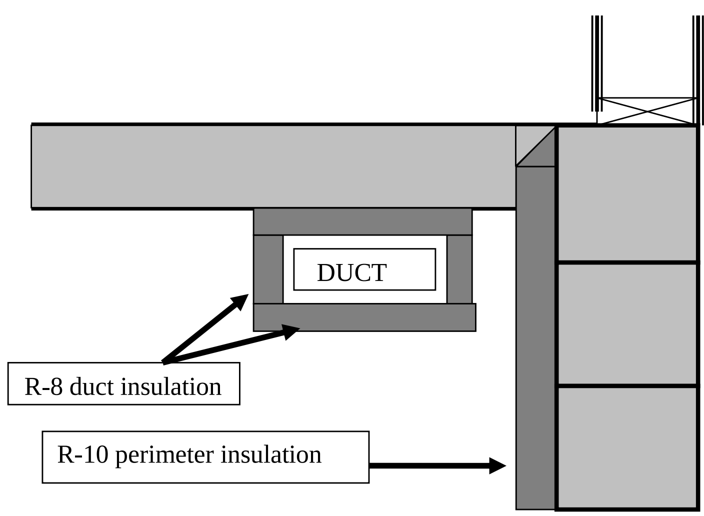


Fig. 1 - Acceptable design for insulated duct outside building thermal envelope of an unheated slab on grade design

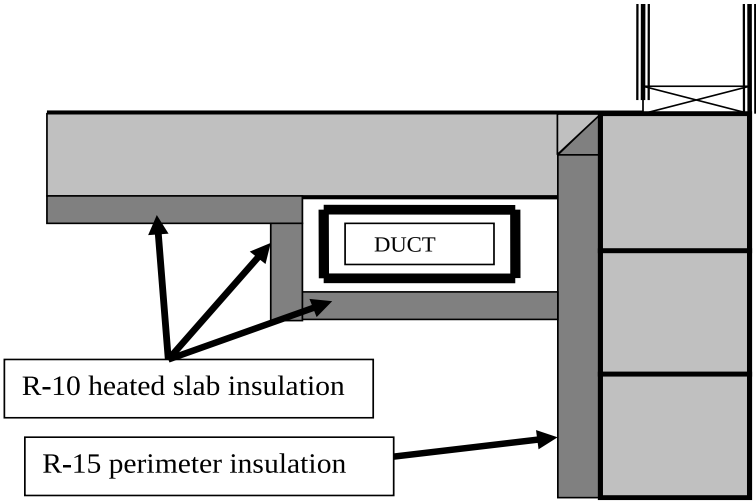


Fig. 2 - Acceptable design for heated slab-on-grade design as duct is within building thermal envelope

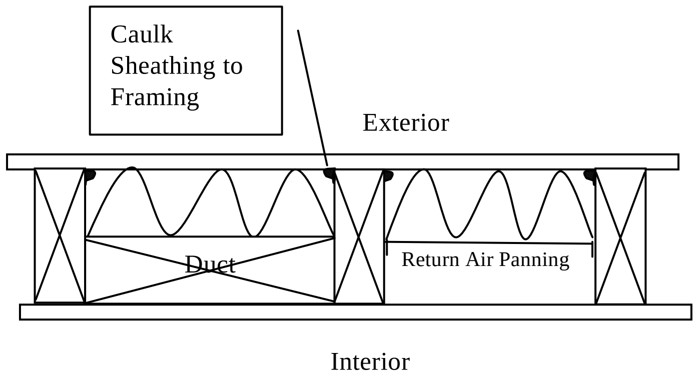
<u>322.43 Duct Sealing and Testing</u>

Any part of the supply and return duct system that is outside the conditioned space, including those in unconditioned attics, unheated garages, insulated floors, exterior stud spaces and vented crawl spaces and under slabs, shall be sealed per this section. Additionally, the whole duct system, including the air handler and both supply and return ducts, shall be tested for air tightness at either the rough-in or post-construction testing. Note that the post-construction test measures just the leakage to the outdoors, whereas the rough-in test measures the total system leakage, including leakage from the duct system to the conditioned space. The latter rough-in test would typically require that all of the ductwork of the dwelling be sealed in order to past the test.

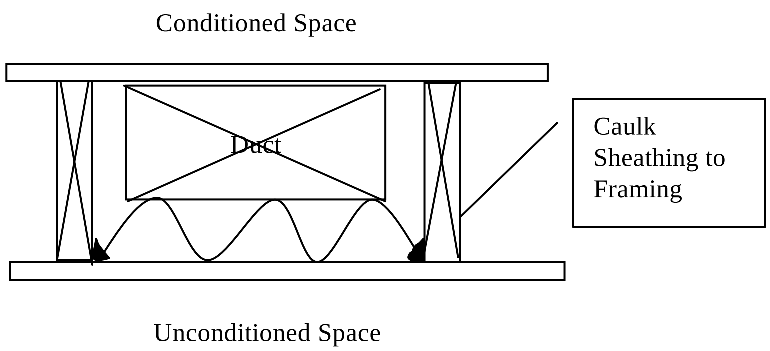
Duct tightness, especially relative to the outdoors, is important in that any air lost to the outdoors causes negative dwelling pressure as the result of the air handler drawing in outside air to replace the leaked duct air. Negative dwelling pressure potentially causes backdrafting of any open combustion appliances and infiltration of unconditioned air into the dwelling.

There are several exceptions to these general sealing and testing requirements:

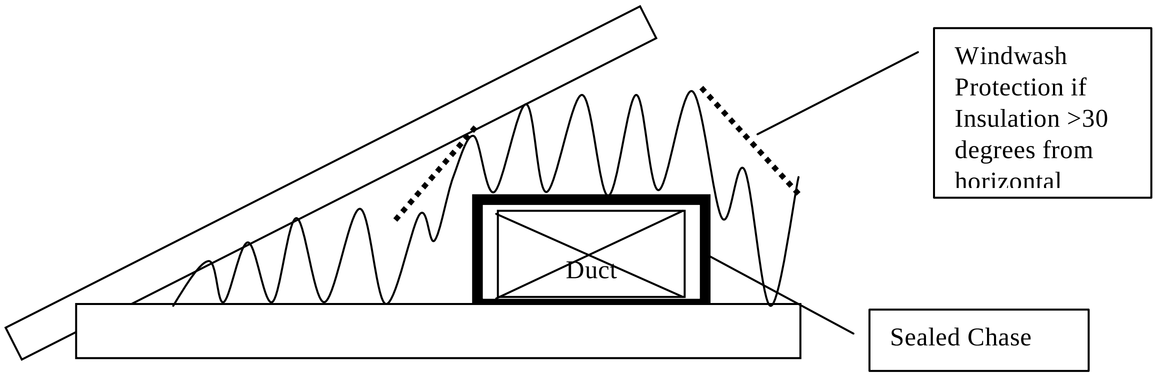
- Ducts that are in insulated ceilings, floors or walls that are insulated on the unconditioned side the same as the rest of the component (unless a different R-value of at least R-8 for the duct area has been entered into Rescheck) and there is a continuous air barrier separating the duct from the outdoors, are considered to be in the conditioned space and are exempt from the insulating, sealing and testing provisions. Additionally:
    - In exterior walls, this air barrier may be achieved with appropriate caulking and taping.



- An insulated floor, as below a bonus room over an unheated garage, would require sealing of the ceiling finish as well as the required windwash protection, per SPS 322.21(2), at any exposed, non-horizontal insulation.



- In attics, a sealed chase would be accepted as keeping the ducts within the conditioned space. If the sides of the chase are insulated with air permeable insulation exposed to the attic at more than 30 degrees from horizontal, then that insulation requires windwash protection per SPS 322.21(2).



- Just the ductwork in the unconditioned space may be tested at rough-in stage, meaning the remaining ductwork would not need to be sealed and tested. The "conditioned floor area" for calculation purposes would be the area served by the tested ducts.
- Ductwork located under a slab that is insulated per above Fig. 2 for underground ducts, will be considered within the conditioned space if the foam insulation joints are taped or otherwise sealed
- Ductwork located under a slab may be tested for leakage per the post-construction or rough-in methods required by the code, or alternatively, rigid plastic ductwork may be tested with a static air pressure of at least 5 psi, that holds for at least 15 minutes. Note that SPS 323.08(4) also requires underground duct to be moisture-proof.

If the rough-in testing option is chosen, then any stud or joist spaces used for return air purposes would need to be panned by the time of testing, rather than being panned with drywall at a later time.

322.44(1) Pipe Insulation

Subsection (1) requires hydronic heating pipes in **all** areas to have at least R-3 insulation and subsection (3) requires hydronic spaces in unheated spaces to have at least R-4 insulation. Generally basements are not considered unheated spaces, even without radiators installed.

The requirement for insulating circulating service hot water piping is applicable to systems mechanically circulated with pumps, not to thermosiphon systems that use convection to circulate the water.

322.46 Replacement Furnace & Boiler Efficiencies

Normally replacement equipment may meet the code at the time of their original installation per s. SPS 320.07(61) definition of repair, as opposed to alterations that need to meet the current code. (Note that the federal government has evolving minimum heating appliance efficiencies that apply to all residential installations, new or replacement.) However, this section requires that replacement furnaces also comply with specified duct sealing criteria and that replacement boilers comply with circulating motor limits. Alternatively, the replacement equipment may instead just comply with the more stringent Wisconsin heating equipment efficiency requirements of Table 322.31-3 (as for new construction that is permitted reduced thermal envelope insulation levels) without duct sealing or circulating motor limits.

Subchapter VI — Simulated Performance Alternative

322.51 Documentation of Simulated Performance Alternative

Compliance by SPS 322.52 is typically shown by REMrate software that models the whole house energy usage. REM/Rate software is proprietary to certain providers. The version 12.6.2.1 or greater is acceptable to show compliance with the current code.

REScheck Software Version 4.6.2

Compliance Certificate

Project North Meadows Development

Energy Code:	**2009 IECC**
Location:	**Abbotsford, Wisconsin**
Construction Type:	**Single-family**
Project Type:	**New Construction**
Conditioned Floor Area:	**2,000 ft2**
Glazing Area	**15%**
Climate Zone:	**6 (9125 HDD)**
Permit Date:	**3/17/00**
Permit Number:	

Construction Site: Owner/Agent: Designer/Contractor:

Compliance: Fails using UA trade-off

Compliance: **6.7% Worse Than Code** Maximum UA: **326** Your UA: **348**

The % Better or Worse Than Code Index reflects how close to compliance the house is based on code trade-off rules.
It DOES NOT provide an estimate of energy use or cost relative to a minimum-code home.

Envelope Assemblies

Assembly	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	U-Factor	UA
Ceiling 1: Flat Ceiling or Scissor Truss	729	38.0	0.0	0.030	22
Ceiling 2: Flat Ceiling or Scissor Truss	592	30.0	0.0	0.035	21
Wall 1: Wood Frame, 16" o.c.	1,647	13.0	6.0	0.053	71
Door 1: Glass	84			0.310	26
Window 1: Vinyl Frame, Double Pane with Low-E	204			0.320	65
Door 2: Solid	20			0.350	7
Wall 2: Wood Frame, 16" o.c.	276	13.0	0.0	0.082	21
Door 3: Solid	18			0.350	6
Floor 1: All-Wood Joist/Truss, Over Unconditioned Space	938	19.0	0.0	0.047	44
Floor 2: All-Wood Joist/Truss, Over Outside Air	32	30.0	0.0	0.033	1
Floor 3: Slab-On-Grade:Unheated Insulation depth: 2.0'	82		8.0	0.779	64

Project Notes:
Previously saved project information:
1010 Construction Ave.