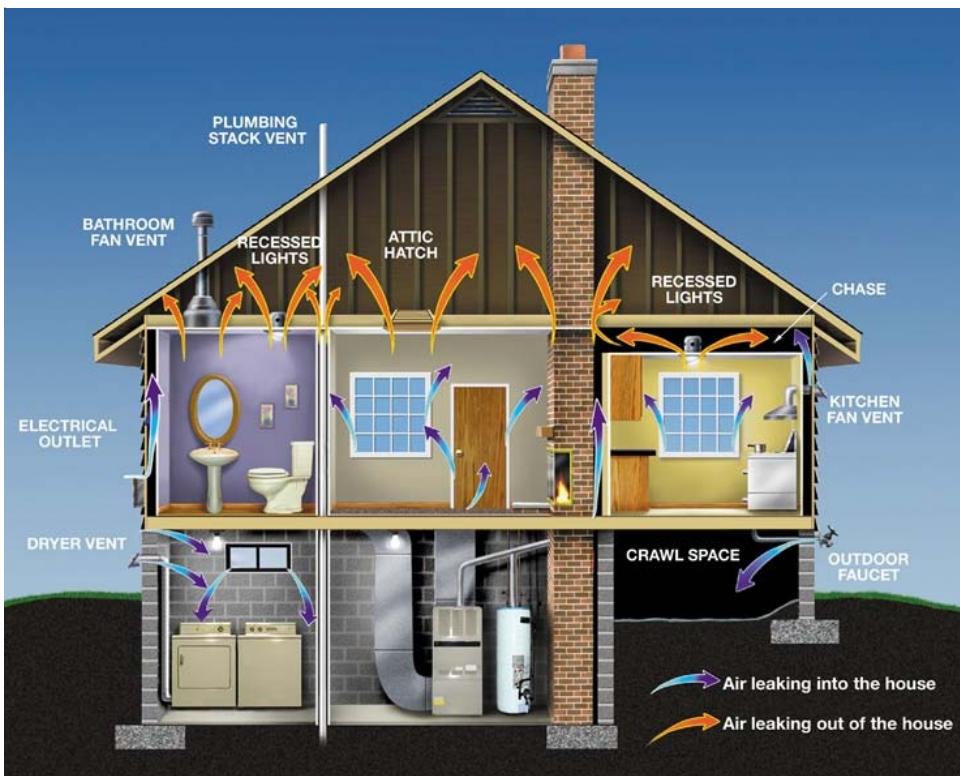


Determining Insulation and Air Infiltration Levels Using an Infrared Thermometer

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The cost of heating and air conditioning a home is increasing rapidly. In North Dakota, 50 percent of home energy consumption is from heating and cooling. The best ways to reduce heating costs are to add insulation to areas in the home that are below recommended levels, and control air leaks into and out of the home.

A simple way to determine if more insulation is needed is to compare the inside temperature of an exterior wall versus an interior wall in the same room using an infrared thermometer. If the difference is large, with several degrees Fahrenheit (°F) between the two, the wall probably has a low R-value (insulation amount) and more insulation would be recommended. The thermometer also can be used to detect air leaks.

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Why insulate or control air leaks?

Insulation reduces the heat transfer rate, which reduces the amount of heating required in the winter and air conditioning in the summer. Insulation also provides warmer surface temperatures on the inside of exterior walls during cold weather, which increases the comfort level and reduces the chance of condensation on cold surfaces. Cool surfaces may create areas of high humidity. Damp surfaces can result in mold growth. Recommended levels of insulation have been determined for all areas of the United States depending on the climate. The effectiveness of insulation is referred to as the R-value of a given material, which is its resistance to heat flow. The recommended R-values for a home in North Dakota are listed in Table 1.

Table 1. Recommended insulation values for houses in North Dakota.

	Insulation Value
Ceilings	R-49 to R-60
Wall above foundation	R-21
Foundation wall	R-19
Floors over unheated space	R-30

(U.S. Department of Energy, 2006)

Air infiltration around doors, windows and other areas is a major energy waster. Depending on the construction of the house, you can save up to 20 percent on your heating and cooling bill by controlling air leaks. If cold areas or a cool draft exist near the door or windows, heat is being lost. Heat lost due to cold air infiltration costs money. When checking areas for insulation levels, keep in mind that you may have adequate levels of insulation but its efficiency is reduced because of air leaking around the insulation. Any temperature difference of a few degrees should be an area of concern and investigated to determine the cause of the difference.

Determining Insulation Levels and Heat Loss Areas

Determining areas of heat loss in a building has not always been easy. But a simple method has been developed using an infrared thermometer. The difference between interior (both sides are heated) and exterior (one side is indoors and one is outdoors) wall surface temperatures and outside air temperatures are measured. By comparing the difference between wall temperatures with the outside air temperature, you can get an estimate of the insulation value of the surface measured using Table 2.

Procedure for determining insulation levels using an infrared thermometer

To obtain the most accurate reading, the thermometer should be within 1 to 3 feet of the surface. Infrared thermometers measure an area that gets larger as the thermometer is farther from the surface. For example, it might measure a circle 10 inches in

diameter at 20 inches from the surface and a circle of 40 inches at 80 inches from the surface. The thermometer does not actually measure the temperature of the exact spot where the laser beam hits, but an average temperature of the area surrounding the beam. The farther away from the object being measured, the larger the area averaged. While an average of a wall temperature would not be bad, if you are trying to find specific areas of air infiltration or specific spots lacking insulation, you need to be as close as possible.

Take care to avoid areas that are directly influenced by heating elements or lights. You also should take these measurements in the evening or a couple of hours after dark to reduce the affect of solar radiation on the walls or roof. Solar radiation on a surface may warm the walls and attic several degrees, which will reduce the difference in temperature values and provide false insulation estimates.

Be aware that the temperature in different rooms may vary. Be sure to measure the interior wall temperatures in each room.

Table 2. Temperature difference between interior surface of an exterior wall and an interior wall surface for various outside temperatures and insulation values. Insulation R-values are estimates due to inaccuracies in the measuring device.

		Estimated R-value							
		5	10	15	20	25	30	35	40
Outside Temp (°F)	40	4.1	2.0	1.4	1.0	0.8	0.7	0.6	0.5
	30	5.4	2.7	1.8	1.4	1.1	0.9	0.8	0.7
	20	6.8	3.4	2.3	1.7	1.4	1.1	1.0	0.8
	10	8.2	4.1	2.7	2.0	1.6	1.4	1.2	1.0
	0	9.5	4.8	3.2	2.4	1.9	1.6	1.4	1.2
	-10	10.9	5.4	3.6	2.7	2.2	1.8	1.6	1.4
	-20	12.2	6.1	4.1	3.1	2.4	2.0	1.7	1.5
	-30	13.6	6.8	4.5	3.4	2.7	2.3	1.9	1.7
	-40	15.0	7.5	5.0	3.7	3.0	2.5	2.1	1.9

For example, if you measure the temperature of an exterior wall and the difference in temperature between that wall and an interior wall is 4 °F and the outside air temperature is minus 20 °F, the estimate of the level of insulation in that wall is R-15.



Figure 1. Infrared thermometer



STEP 1.

Determine the outside air temperature. Using the infrared thermometer, go outside and take a temperature reading of various objects. The temperature of the objects outside should have the same temperature as the air. Take a number of readings and average those to use as the accepted value.

Outside air temperature

STEP 2.

Inside the house, determine the temperature of an interior wall. An interior wall for this process is one inside the house with both sides of the wall in the heated portion of the house.

Interior wall temperature

STEP 3.

Inside the house, determine the temperature of an exterior wall. An exterior wall is a wall **inside** the house with one side of the wall in the heated portion of the house and the other side on the outside or unheated portion of the house.

Exterior wall temperature

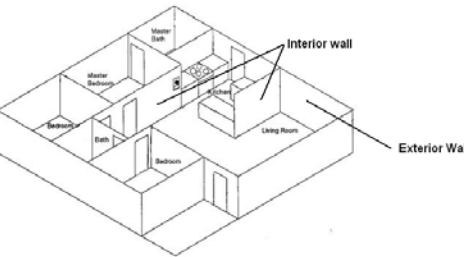


Figure 2. Diagram showing interior and exterior walls.

STEP 4.

Subtract the **inside** temperature of the exterior wall from the interior wall temperature. This will give you the difference between interior walls and exterior walls and will be used to determine the amount of insulation.

Interior (I) wall temperature

Exterior (E) wall temperature

= Difference between Interior and Exterior (I - E)

STEP 5.

Using the outside air temperature from Step 1 and the difference in interior and exterior temperatures from Step 4, find the estimated R-value in Table 2.

Estimated R-value

If the R-value is below the recommended levels from Table 1, then upgrading the insulation in that area may need to be considered.

Make sure to measure more than one spot on each exterior wall. Insulation values can vary along a wall surface. Pay attention to areas in walls where the temperature is several degrees different than in other areas. Wall insulation can settle, and occasionally sections of wall are not insulated. Check the corners to ensure they have sufficient insulation. Insulating these areas easily can be overlooked due to the difficulty to insulate.

Other locations to check

After checking the walls; consider the ceiling. Check ceilings that have unheated space (either an attic or the outside) above them. Again, check several areas of the ceiling since insulation levels may be different in different sections of the ceiling. Problem areas in the ceiling are often around recessed light fixtures and attic access doors. When checking the temperatures around lights, make sure they are off and have been off long enough to cool down to avoid false readings. Avoid using the thermometer on reflective surfaces; it can give inaccurate readings.

Window R-values can be estimated as well. The best windows available will have an R-value of about 5. The temperature of a double-glazed window in excellent condition with an outside temperature of about minus 20 °F would be about 58 °F and have a temperature difference of 12 °F. This assumes an inside room

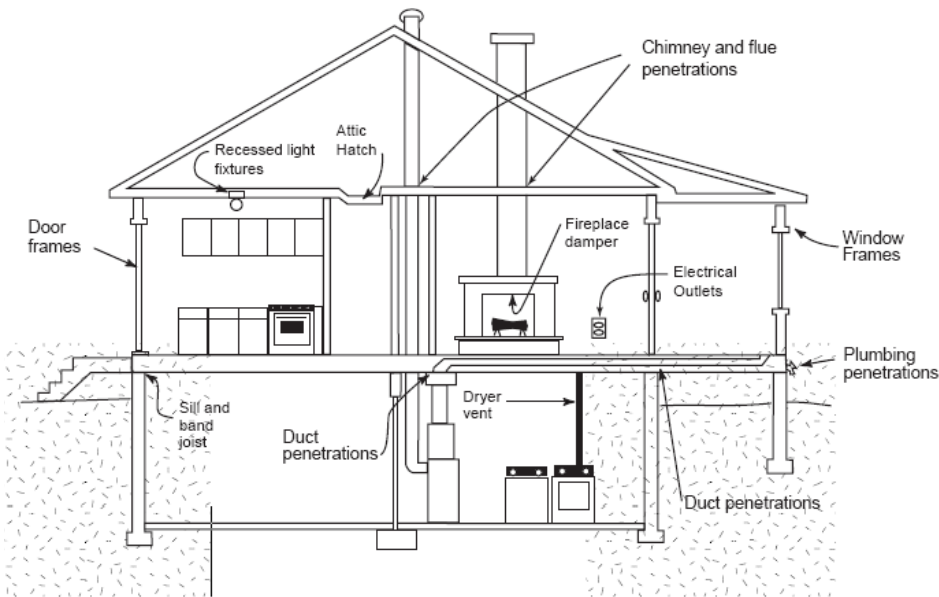


Figure 3. Possible areas of air infiltration. (U.S. Environmental Protection Agency)

temperature of 70 °F. Again, take the window temperature after dark to reduce the effect of solar radiation. Check the R-value of your window treatments. Close the drapes or blinds and allow the temperature to stabilize. Using the infrared thermometer, measure the temperature of the window coverings. Then compare this value with the R-values in Table 1. Install insulated window treatments to increase the insulation value of the windows.

The next place to check insulation levels is in the basement. Pay particular attention to the rim joists. This is the area where the framing meets the foundation. Check the temperatures of the foundation wall. This is one of the most overlooked

areas to insulate. Many people mistakenly believe the ground provides insulation for the foundation. Insulating an uninsulated basement wall to an R-19 can save homeowners 20 percent on their annual heating bill. If the heating bill is \$1,000, the added insulation could save the homeowner \$200 per year. Compare the wall temperature from floor to ceiling to assist in determining the heat loss. Depending on the time of year, soil temperatures will vary from the surface to the base of the foundation.

A rough estimate of air infiltration also can be done using an infrared thermometer. By looking for changes in temperatures of more than several degrees along walls and windows,

you can determine areas in a home where air is leaking between heated and nonheated spaces. Move the thermometer around window frames to see if you find changes in temperature of more than a few degrees. Also check areas where plumbing, electrical and any other penetrations are located.

The infrared thermometer is a tool to detect where heat is being lost in the home. Look for areas where you think insulation levels may be inadequate or where air may be leaking from the house. This process is meant to enable homeowners to identify areas that need attention. The R-values determined from this process are only estimates. Many infrared thermometers are rated at plus or minus 1.5 percent of the reading or plus or minus 3 °F, whichever is greater. The best way to reduce incorrect readings due to this variation is to use the same thermometer for all readings and also take all readings as close to the same time as possible. The other source for error comes when the measurements are taken when the difference between the inside and outside temperatures is not large. The greater the temperature difference, the easier you will be able to determine areas in the house that need better insulation.

References

U.S. Department of Energy. EERE. (2006, 05 30). Insulation. Retrieved March 10, 2008, from Energy Savers, Tips on saving energy and money at home: www1.eere.energy.gov/consumer/tips/insulation.html

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