TECH TIP # 30

HEATING, AIRCONDITIONING & REFRIGERATION DISTRIBUTORS INTERNATIONAL

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U Values: A Close Look at a Basic Tool

Almost every system design must begin with a load calculation. And a first step in any heat loss calculation is obtaining the correct heat transfer coefficients (U values). The U values are conveniently tabulated in numerous design manuals for many kinds of building construction, and if an overall coefficient isn't listed for a particular type, then a U value can be readily calculated by simply adding up the resistances of all individual materials which go to make up the building member. Then the reciprocal of the total resistance is the overall transfer coefficient.

That is: $U = 1/R_t$ where U = heat transfer coefficient, Btuh/sq ft ºF and R_t = sum of the individual resistances. Ru[1]

Typically, here's how it's done. Suppose a frame wall is composed of: a) ½" by 8" bevel wood siding; b) 25/32" impregnated sheathing; and c) 3/8" plasterboard. Between the sheathing and plasterboard there are conventional 2 x 4 studs, 16" on center (OC), and the stud space is filled with mineral wool insulation.

From a table of resistance values, such as Table A-1 in Air Conditioning Contractors of America's Manual J, we would find the following resistance values for each material:

Inside wall air film2	0.68 R_u
Plasterboard	0.32
Insulation	13.41
Sheathing	2.06
Siding	0.81
Outside air film	0.17
Total	17.45 R_u

Now we add these together and take the reciprocal (1/17.45) we arrive at an estimated U value for this wall of 0.0571 Btuh/ sq ft ºF. This whole procedure should be familiar to us all.

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Two Paths for Heat to Leak Out

If we take a closer look at the paths available to the flow of heat through this wall, we find that there are really two different ones. First, there's path A (refer to Figure 1). Here, heat flows through the inside film, plasterboard, insulation, sheathing, siding and finally the outside film -- just as we have calculated. But then there's also path B. Here, heat flows through the inside film, plasterboard, 2 x 4 studs, sheathing, siding and the outside film. Notice that heat flowing at this point does not meet the resistance imposed by the insulation. Such a phenomenon is known as ***parallel heat flow***.

Calculate U Value for Each Path

Suppose we calculate the U value for the part of the wall containing the wood studs. It is as follows:

Inside wall air film	0.68 R_u
Plasterboard	0.32
2 x 4 stud	4.55
Sheathing	2.06
Siding	0.81
Outside air film	0.17
Total	8.59 R_u

[1] Resistance units.
[2] We should recall that a film of "dead" air clings to both the inside and outside wall surfaces and that it imposes a small barrier to heat flow.

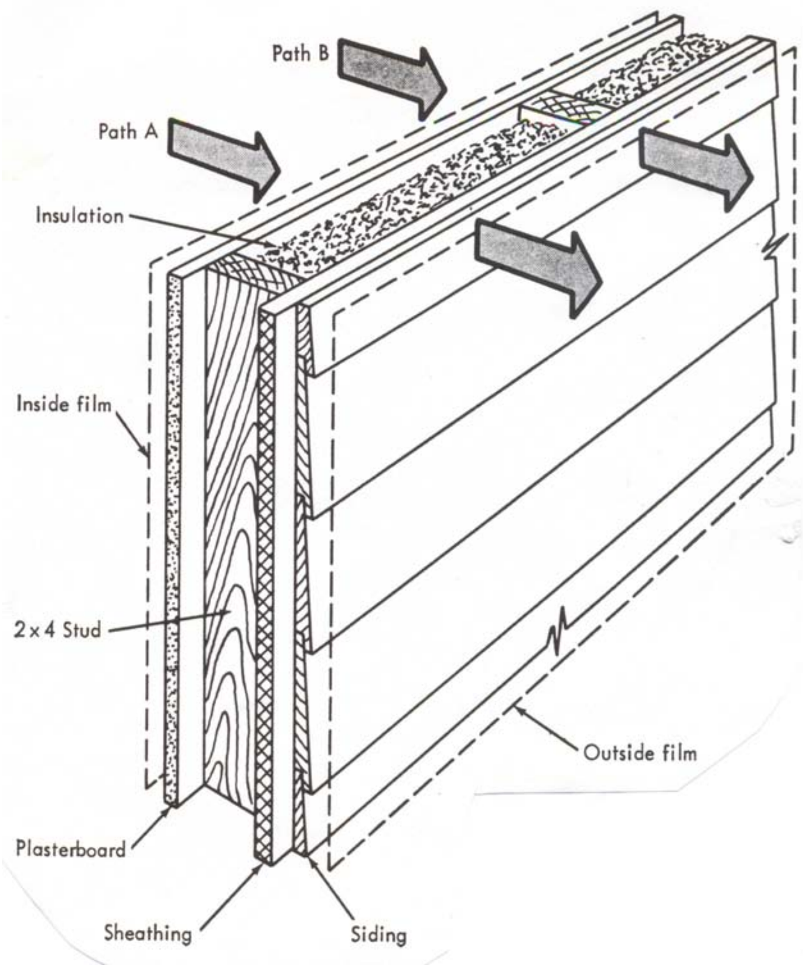

Figure 1. A FRAME WALL serves as a good example of building construction which offers dual paths for heat to escape to the out-of-doors. At path A (between the studs) any heat flow meets the strong resistance of the insulation. But at path B (the 2 x 4 studs) only the resistance of the wood -- which is about 1/3 as effective a barrier -- impedes the loss of heat. To compensate for the "holes" in the wall, the U value for each path must be considered and averaged together based on the surface area provided by each.

So the U value at path B is 1/8.59 or 0.116 Btuh/ sq ft ºF. Note that the wood stud is about one-third as effective a barrier to heat flow as the full thick insulation (4.55 R_u vs. 13.41 R_u for the stud and insulation respectively.) This means, of course, the heat will "leak out" faster for each point along the wall containing a stud (i.e. every 16 inches). So the U value of the wall isn't really 0.0571 Btuh/ sq ft ºF as we originally calculated but rather some "looser" value between 0.0571 and 0.116.

To find the "correct" value we "weight" each U value by taking into account the percentage surface area contributed by the respective paths.

Since the stud surface area represents 20 percent of the total wall area, we take 20 percent of 0.116 and add it to the 80 percent of 0.0571. Then the corrected value is: U = (0.2) (0.116) + (0.8) ().0571) = 0.0689. Thus, by considering path B, we increase the U value of the wall by more than 20 percent. In other words, the heat loss through the wall will be 20 percent greater than expected.

For other types of wall construction considering parallel heat paths can often lead to even greater percent changes -- especially when highly conductive materials such as stone and metal are used as "framing" members, and when the secondary paths represent a greater percentage of the total wall area.

Steel Studs in Residential Work

In recent years, builders have begun using steel studs in residential buildings for any number of reasons, but the rising cost of wood is a significant factor.
If steel studs were to replace the wood studs in this example, the U value of the composite wall would increase from 0.0689 to 0.0898 or over 30 percent higher.
Again, this means the heat loss through the wall would be 30 percent higher than if wood studs were used in construction. It is important for the designer to have complete details on the building construction to effectively estimate the design load and select equipment.