Insulation Technology for the 21st Century

S. Morgan, R. Smith, R. Cormier
Proactive Technology
PO Box 252, Newport, NY 13416

ABSTRACT

Back in 1945, Everett Shuman promoted R-value as a standardized way to measure a material's resistance to heat transfer. But R-values can only be achieved in laboratory conditions where there is no wind, no moisture and no framing members. Of the three forms of energy transfer (conduction, convection and radiation), there is more heat transferred through radiation than through conduction and convection combined. In the summer, 93% of heat gain is caused by radiant energy and in the winter, between 50% – 75% of heat loss is due to radiant energy. Currently, there is no standard test to measure these real world conditions. So we must use other tools to see how insulation *performs*.

Keywords: insulation, heat and energy transfer, thermal bridging, vapor barrier, performance testing

INTRODUCTION

The Canadian National Research Council states that "between 50 and 70% of the effective thermal resistance of porous insulation is lost if the system allows vapor transfer..." They conducted tests with a 20°C / 70°F temperature difference, and found that moisture in the insulation reduced the thermal resistance of fibreglass batts from R-12 to R-4, a reduction of 60 to 70%. The NRC concluded that, "the reduction is so drastic that it is debatable whether the material can be considered to be a thermal insulation"[1]. Therefore, it makes sense that insulation needs to act as a vapor barrier. Regarding wind and air transfer, the Oakridge National Laboratory of the United States Department of Energy says that "the average home with all its windows and doors closed has a combination of air leaks equal to an open door". They conclude that air infiltration accounts for up to 40% of the energy lost in most buildings. In addition, thermal bridging occurs in external walls that contain poor or inadequate insulation, allowing the cold to pass easily between the studs and framing members. The Oak Ridge National Lab even states that the "market focus on clear-wall cavity R-value is misleading and is inhibiting the market penetration of high-performance wall systems into the residential construction industry. " [2]

THE PERFECT INSULATION

If we want insulation to perform well it should reflect radiant heat, stop moisture, stop air infiltration, prevent mold growth and overcome thermal bridging. The perfect insulation material can be found in the thermos bottle - a double layer of glass (later metal) with a reflective barrier on both sides, and a vacuum in between. The reflective barrier blocks radiant energy, and since a vacuum is a very poor thermal conductor, there is very little energy transfer. If we measured the R-Value of the thermos, it could be as high as R-250. NASA saw the potential of radiant barriers for the space program as they needed to cope with the drastic temperature changes of +400 degrees F. to -450 degrees F. In order for fiberglass to withstand these temperature ranges, it would have to be seven feet thick. So NASA developed Mylar: a thin, flexible radiant barrier that reflects up to 97% of radiant energy.

Here on earth, if we combined a double reflective barrier with a vacuum, we'd get something like vacuum insulated panels (VIPs). However, they cost up to $5 per sq ft and they are extremely fragile. If the seal is broken, the vacuum effect is lost.

There is another practical option that combines the benefits of a thermos bottle, Mylar and VIPs. It's called P2000. P2000 is an extremely thin, EPS panel with a reflective metalized plastic facer which seals the internal core and thereby reflects radiant energy, stops wind and blocks moisture. In the two infrared images below (Fig 1), notice there is significantly more heat loss and thermal bridging occurring in the fibreglass wall on the left than the wall with 1" of P2000 (on the right). On the right side of Figure 2, 3/8" P2000 has been installed on the interior of a bathroom. The outside of the bathroom wall is 5 degrees colder than the rest of the home, meaning less heat is escaping. Both of the homes in Figure 3 are 2x6 wood stud construction with cellulose insulation. The white stud lines in the house on the left exemplify heat loss due to thermal bridging. The home on the right was wrapped with 3/8" P2000, where there is no thermal bridging. Clearly infrared imagery can show us how insulation actually performs.

ENERGY SAVINGS

And all this adds up to energy cost savings. In a seven day test, the energy consumption of four identical buildings, with different insulations, was monitored. The building with R-20 fibreglass consumed 258.5 watts of energy; the 1" P2000 building consumed only 146.3 watts of energy, 40% less than the fiberglass building. Tony Lynch, a supplier of Green Build & Energy Efficient building products, chose P2000 for the ceilings and crawlspace for a Solarium Home in Ferry, PA. Out of 20,000 houses, the Solarium Home was deemed by Energy Star as the most energy efficient home ever tested in PA, NJ, NY and DEL Contractor Gilles Barbarie was skeptical about P2000 Insulation until another dairy farmer insisted he use P2000 in his new barn. Gilles wrote; "I didn't believe that such a thin insulation could do all it claimed. When I saw the results - I was amazed. The new barn with one-inch P2000 insulation did better over the winter than the older barn with 8 inches of fiberglass." And finally, Ken Harman from Manitoba, Canada constructed a new 1400 sq ft. home. Over the first four months of the winter, his heating bills have averaged less than $50 per month.

CONCLUSION

Any insulation we use should be cost effective, environmentally friendly, recyclable, highly durable and withstand adverse weather conditions. It should reflect all three forms of heat transfer, thwart thermal bridging, act as a vapor barrier and not promote mold or mildew growth. Many of these factors can be tested in real world environments with infrared imagery. It helps us see exactly where heat is escaping, and to what degree.

REFERENCES

[1] M.C. Swinton, W.C. Brown and G.A. Chown, "Controlling the Transfer of Heat, Air and Moisture through the Building Envelope" www.irc.nrc-cnrc.gc.ca/pubs/bsi/90-3_e.html

[2] Oak Ridge National Laboratory, "Whole-Wall Thermal Performance: R-Value" http://www.ornl.gov/sci/roofs+walls/whole_wall/rvalue.html

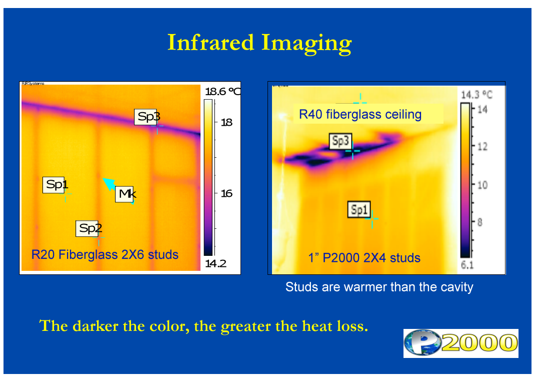

Fig 1

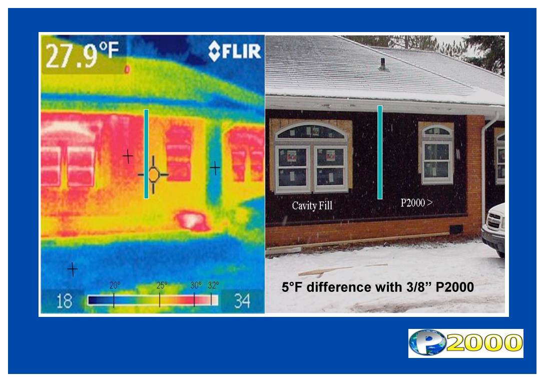

Fig 2

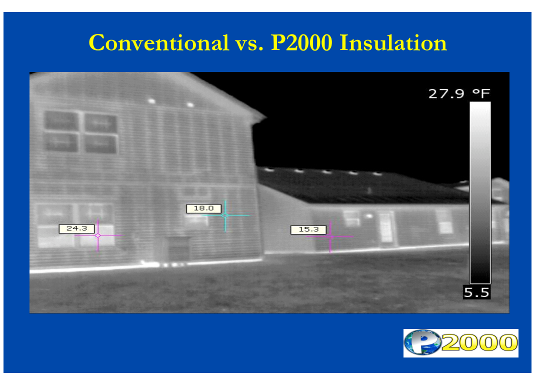

Fig 3

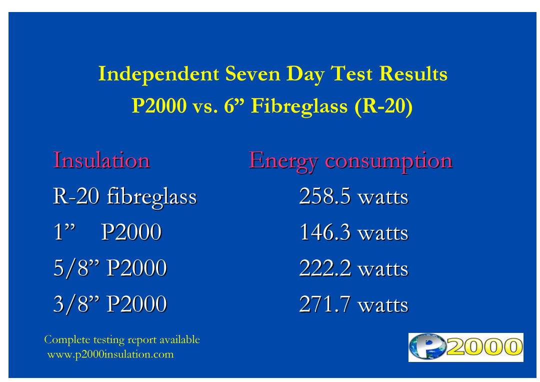

Fig 4

Clean Technology 2009, www.ct-si.org, ISBN 978-1-4398-1787-2