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The Effectiveness of Thermal Insulation

The conventional method of evaluating the performance of insulation is to measure the R-value, the conductive heat flow resistance of the material.

The measurement of conductive heat flow resistance is made using the guarded hotbox apparatus. This test procedure (ASTM C-518-02) measures the thermal conductivity of insulation material. In this test, one side of the specimen is heated to a specific temperature and after steady state heat flow has been reached, the temperature on the opposite side is measured. Through this temperature measurement the R-value is calculated. The outside surface of the test apparatus and the specimen is sealed and insulated to minimize the heat loss through the edge and eliminate the effects of any convection or radiant heat flow. This measurement solely defines the conductive heat flow resistance of the insulation material, the R-value.

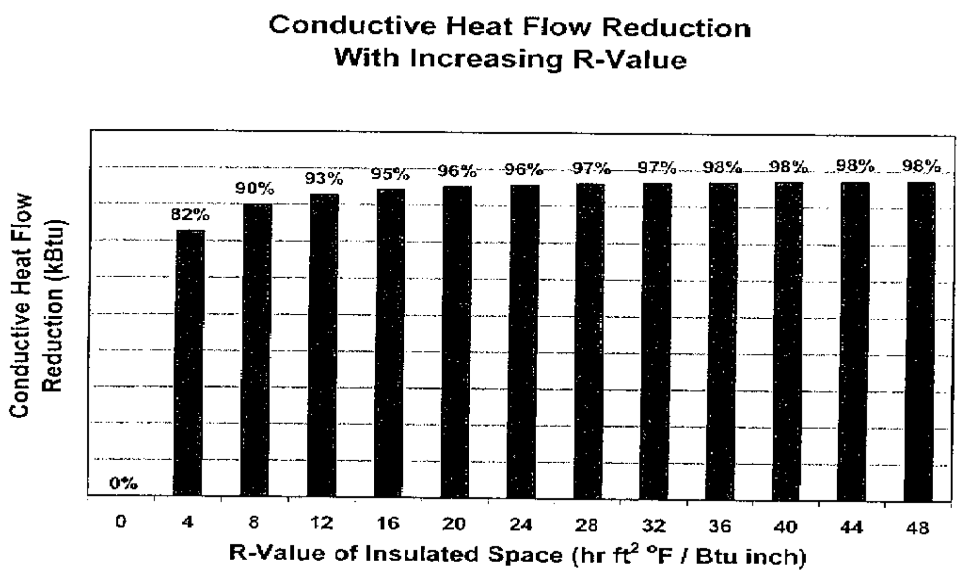
Once the R-value of an insulation material is determined, the heat flow through it can be calculated using Fourier's steady-state heat flow equation.

$$Q = \frac{A \times \Delta T}{R}$$

Where:

Q = Rate of heat flow, BTU/hr
A = Area, ft^2
ΔT = Temperature differential, ° F
R = Resistance to heat flow, hr.ft^2 ° F/BTU

This equation effectively calculates the benefit of increasing the thickness of any type of insulation *when there is no air movement (convective heat transfer) through the insulation.* As an example, consider 1000 ft^2 of insulated area with a temperature differential of 40°F. Let us include the outside air film at R-0.2 and the inside air film at R-0.7. The total R-value before the application of any insulation is 0.9. Increasing the insulation R-Value provides the following heat flow reduction rates as shown in Graphs 1.1



Graph 1.1

The Effectiveness of Thermal Insulation cont.

In Graph 1.1, we can see that R-4 reduces the heat flow by 82% of the total and at R-20, the heat flow is reduced to 96% of the total. The graphic results of the Fourier's equation demonstrates that doubling the insulation R-value from a total R-value of R-20 to R-40 generates a mere 2 % of additional heat flow reduction.

REDUCE AIR INFILTRATION - REDUCE ENERGY USE

In the case of insulation material with significant air permeance, conductive heat loss should not be the only criterion used for establishing insulation thickness. Convective (air infiltration) heat loss/gain must be considered as well, particularly when a substantial latent load is involved.

Oak Ridge National Laboratory (ORNL) conducted an experiment[1] to determine the efficiency of a roof assembly insulated with low density, loose-fill fiberglass insulation and discovered that up to 50% of the heat loss occurred as a result of convection; air circulation through the insulation. This result showed that the air-permeable insulation had lost its anticipated thermal performance level by half and that convective heat transfer had a significant negative impact on insulation performance.

The importance of reducing air infiltration can be easily demonstrated by analyzing the energy consumption for heating and cooling houses that have different R-values and air infiltration rates. The following evaluation was generated using the REM/Design energy analysis software. This evaluation deals with **three identical houses**, located in different North American cities with three different levels of insulation and air-infiltration. The house design is fully detached, has approximately 3,500 sq.ft. conditioned area, with two stories and a conditioned basement.

> The first is a **Typical house** with an R-19 air permeable insulation installed in the walls & R-30 in the ceiling. The air infiltration rate used for this analysis is 0.6 ACH at natural pressure.
>
> The second house has the same air permeable insulation material with a **Higher R-value,** R-43 in the ceiling & R-19 in the walls. The air infiltration rate is maintained at 0.6 ACH at natural pressure.
>
> The third is an **Icynene house** with R-11 in the walls, R- 18 in the ceiling. An air infiltration rate of 0.1ACH at natural pressure was used for Icynene because of its air sealing capability.
>
> Heating and cooling costs and the required heating and cooling equipment capacities for each house are plotted on the following graphs. The utility rates are set at $0.08 per kWh for electricity and $0.50 per Therm for natural gas.

Graph 2.1 shows the energy costs for heating the 3 different version of the same house in several cities throughout North America. It can be seen that savings on heating cost reached up to 40%~50% with Icynene® when compared to the **"Typical"** and **"Higher R-Value"** insulation systems. Also, the graph indicates that the colder the climate, the greater the heating cost savings are with Icynene.

[1] ORNL's Building Envelope Center: Fighting the Other Cold War
URL: http://www.ornl.gov/ORNLReview/rev26-2/text/usemain.html

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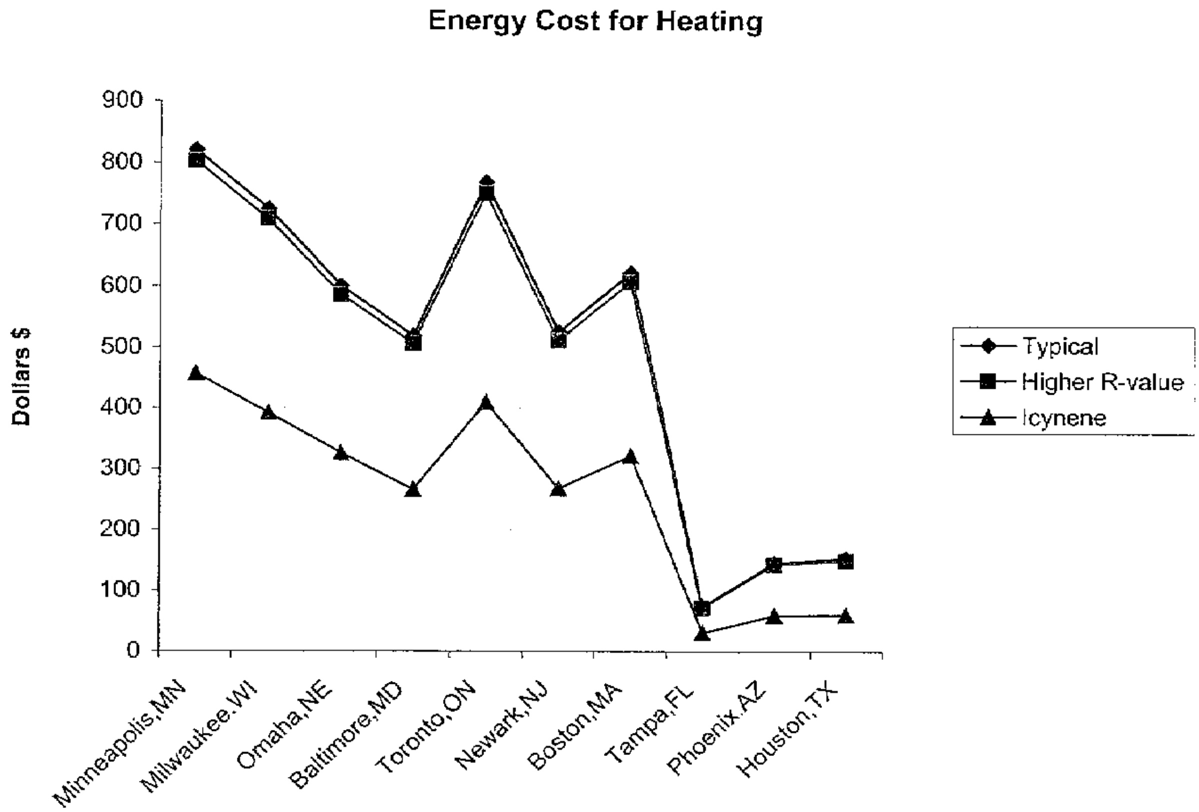
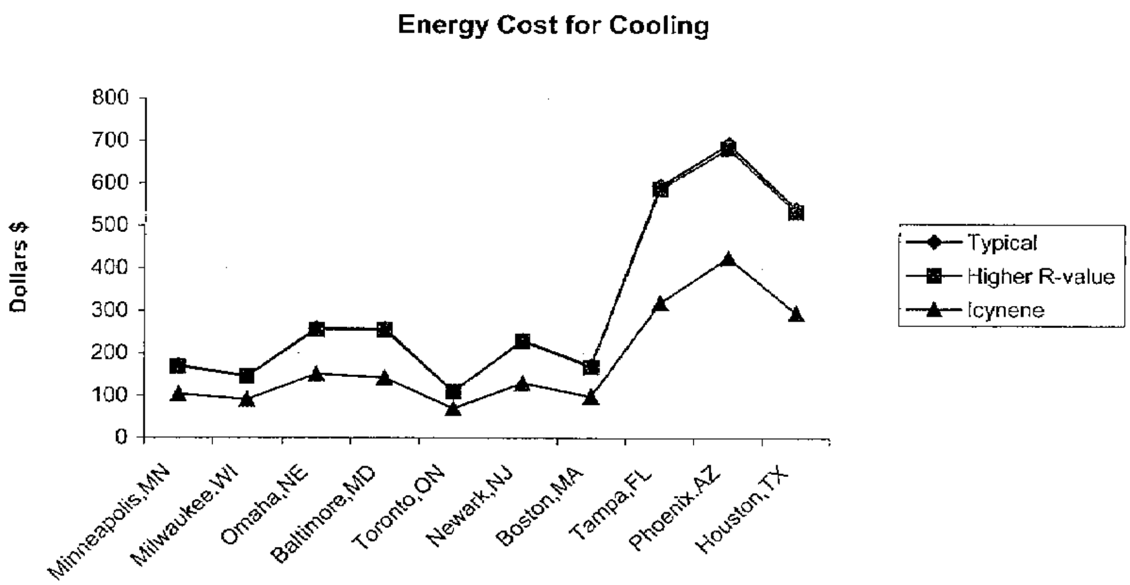


Graph 2.1

Graph 2.2 shows savings on cooling costs with Icynene. They provide savings of 25%~40% over the **"Typical"** and **"Higher R-Value"** insulation system. The cities in a hot & humid climate show greater savings due to the higher cooling demand and latent load.

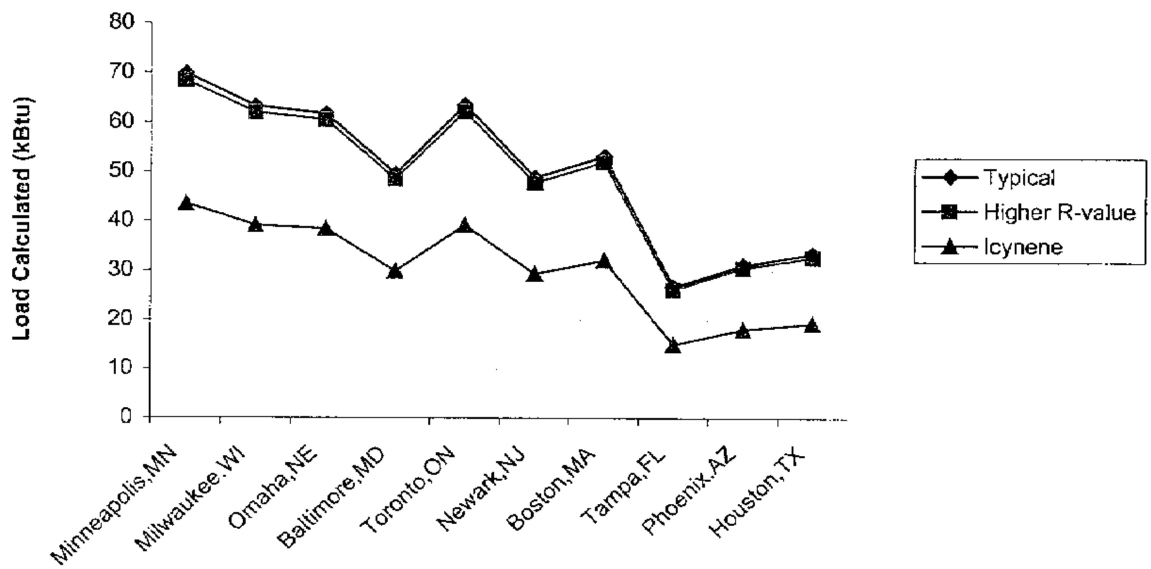


Graph 2.2

The Effectiveness of Thermal Insulation cont

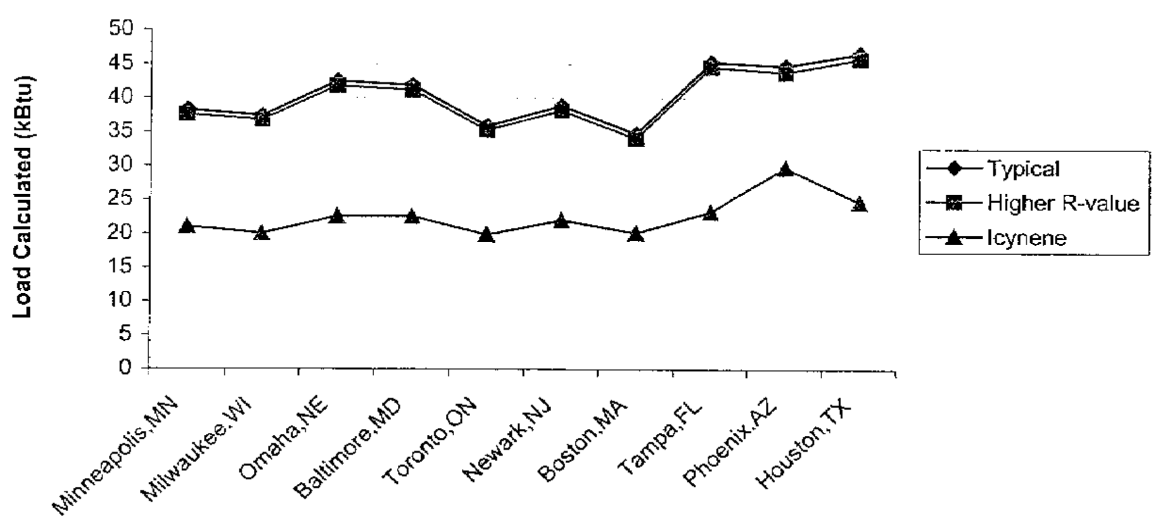
As far as sizing heating and cooling equipment is concerned, Icynene provides a significant reduction in both heating & cooling load due to its air sealing property. Graphs 2.3 & 2.4 illustrate the equipment size required in these houses for heating and cooling. The graphs show that there is a significant reduction in required capacity for both heating and cooling relative to **"Typical"** and **"Higher R-Value"** systems.

Calculated Load for Heating



Graph 2.3

Calculated Load for Cooling



Graph 2.4

The Effectiveness of Thermal Insulation cont

Icynene's air seal capability virtually eliminates convective heat transfer within the insulation and reduces unwanted air leakage through the building envelope. This feature improves the efficiency of the building envelope thereby reducing the heating and cooling costs and reducing the size of HVAC equipment. As a result lower operating costs are realized and the cost of the operating equipment is reduced.

The on-site spray applied application of Icynene provides an excellent air seal that ensures a low air infiltration rate for the building envelope. This product characteristic improves energy efficiency of the building, versus similar homes with more R-value but high air infiltration rates, as demonstrated in the graphs above.

In summary,

1. Heat loss/gain involves controlling: Conduction (R-value) heat flow
Convection (air leakage) heat flow
Radiant heat flow

2. An insulation's R-value rates it's performance in only 1 category – conduction.

3. Increasing R-value from R-20 to R-40 decreases conductive heat flow by 2 % - as demonstrated in Fourier's steady-state heat flow equation.

4. Once an optimal and cost effective level of conduction heat flow control has been obtained, further substantial gains in energy efficiency can only be obtained by minimizing the air leakage of the building envelope.

Sizing of Heating, Ventilation & Air Conditioning Equipment

with

The Icynene Insulation System®

The design of a heating, ventilating, and air-conditioning system that is compatible with an Icynene® insulated home is an important factor in achieving:

- personal comfort
- maximum indoor air quality
- long term durability of the HVAC equipment
- proper indoor humidity levels

The extremely low air infiltration rates (approximately 0.1 ACH with whole house installation) achieved with by The Icynene Insulation System® must be considered when designing a heating, ventilation, and air conditioning system for the structure. It is recommended that the following procedures be implemented:

1. A heat loss and heat gain calculation is generated for the structure so as to precisely size the HVAC system. We recommend the use of a recognized calculation program / standard to properly size the equipment: ACCA-Manual J or other approved methods.

2. Ventilation to supply fresh air and exhaust stale indoor air must be provided for in the HVAC system. We recommend the use of a recognized standard for calculating the proper amount of ventilation to be used to introduce fresh air into the house - ASHRAE 62.2-2003 or manufactured approved method.

In order for your mechanical contractor to design the correct heating, ventilation, and air-conditioning system for your structure, you must inform them that The Icynene Insulation System® has been installed.

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