Effectiveness of Insulation

Introduction

One of the most effective and economical ways to reduce energy consumption for heating and cooling buildings is to add insulation to the walls, roofs, and floors. While we may not be able to move away from fossil fuels completely, we can make much better use of them than we do currently. Our homes are often grossly inefficient energy users.

The purpose of insulation is to reduce the rate at which heat moves either to or from the building's interior to the outside. In winter, we want to reduce the rate of heat loss from the building and during hot summer days we'd like to reduce the heat gained by the interior of the building from the environment. If we can reduce heat loss in the winter, then the furnace will not need to run as often and energy consumption will be reduced.

Materials can be rated according to their insulating ability using the **R value**. The R value can be thought of as an indication of the material's ability to resist heat flow through it. The higher the R value, the better the insulating power. Heat loss or gain through a material can be calculated as indicated below:

$$\text{Heat loss or gain in BTU/hour} = \frac{\text{area of material in ft}^2 \times \text{temperature difference in °F}}{\text{R value}}$$

A **BTU** is a British unit for energy based on the amount of energy necessary to raise the temperature of 1 pound of water by 1 °F. A BTU is equal to 252 calories or 1055 joules. Table 1 lists typical R values for several types of materials.

Objectives

- Understand the process of heat exchange through insulation in a closed system
- Test the insulating effectiveness of different materials
- Examine the effect of holes in insulating materials

Hypotheses

Temperature increase will be greater in the absence of insulating material that in presence of insulating material.

Temperature increase will be less in the presence of *materials with higher R values than in the presence of materials with lower R values.*

For a given insulating material, temperature increase will be greater when the material is perforated by holes than when the material is not perforated by holes.

Table 1. Typical R values for several types of material.

Material	R value
No insulation	0
Single-pane glass	0.90
Double-pane glass	1.85
Triple-pane glass	2.80
1-inch wood	1.00 - 1.50
1-inch fiberglass batting	3.10 - 3.70
1-inch styrofoam	5.50
Foam insulation with black/silver backing	7.20

Materials

- Wooden heating chamber
- Light bulb, 75 watt
- Thermometer
- Rubber stopper (~7/8 inch diameter) with hole
- Watch or clock
- Insulating materials, cut to size
  - Foam core board
  - Foam core board, with holes
  - Styrofoam, ~5/8" thick
  - Insulation, foam type, ~5/8" thick
- Weather stripping
- Strip of foam

Procedure

1. Work in groups by lab table.
2. Each group will collect data from two set-ups, as assigned in Data Table 1.
3. For all set-ups:
   a. Examine the wooden chamber for any gaps along seams or around lid through which heat could escape and use the provided weather stripping to "plug" these gaps.
   b. Place the lid on the wooden chamber in such a way as to insure that the hole in the lid (for the thermometer) is over the side of the chamber that is opposite the light bulb.
   c. Place a 75 watt light bulb in the light bulb socket in the wooden chamber.
   d. Insert a thermometer through the hole in the rubber stopper.
   e. Place the rubber stopper with thermometer into the

hole in the lid of the wooden chamber.

4. For the control set-up:
   a. Record the initial temperature and time (T=0).
   b. Plug in the light immediately after taking the initial temperature reading.
   c. At 5 minute intervals, for a period of 25 minutes, record in Data Table 1 and on the overhead transparency (or blackboard) the temperature indicated on the thermometer.
   d. Prior to carrying out the next set-up, unplug the light, remove the stopper with thermometer from the lid, remove the lid from the box, and allow the temperature in the box to return to room temperature.
5. For set-ups with insulating materials:
   a. Allow the wooden chamber to return to room temperature.
   b. Place a panel of insulting material (as assigned in Data Table 1) in the middle of the wooden chamber (in such a way as to divide the wooden heating chamber into two chambers).
   c. Make sure that the material seals as well as possible by using weather stripping across the sides of the insulating panel and by placing a strip of foam along the top of the panel.
   d. Replace the lid on the wooden chamber and the rubber stopper with thermometer into the hole in the lid.
   e. Record the initial temperature and time (T=0).
   f. Plug in the light immediately after taking the initial temperature reading.
   e. At 5 minute intervals, for a period of 25 minutes, record in Data Table 1 and on the overhead transparency (or blackboard) the temperature indicated on the thermometer.
   f. Prior to carrying out the next set-up, unplug the light, remove the stopper with thermometer from the lid, remove the lid from the box, and allow the temperature in the box to return to room temperature.

Data Analysis

1. Copy all data from the overhead transparency (or blackboard) to your Data Table 1.
2. Calculate the mean temperature for each setup (control and each insulation type) at each time interval.
3. Graph 1: prepare by hand or using Excel a line graph in which you plot mean temperature (°C) versus time (each time interval) for each setup (your graph will have six lines).

Effectiveness of Insulation LAB WRITE-UP Submit Pages 5-7

Student Name: ________________________________Lab Date: ______
Lab Instructor: _____________________________ Lab Section: ______

Results (Data)

Data Table 1: Temperature (°C) over time in wooden heating chamber for control and 5 insulating materials.

Lab Table #:	Setup	Time (in minutes)					
		0	5	10	15	20	25
1	Control						
2	Control						
	Mean						
1	Foam Core Board w/o holes						
2	Foam Core Board w/o holes						
	Mean						
3	Foam Core Board with holes						
4	Foam Core Board with holes						
	Mean						
3	Styrofoam						
4	Styrofoam						
	Mean						
5	Foam Insulation						
6	Foam Insulation						
	Mean						
5	Glass, single pane						
6	Glass, single pane						
	Mean						

Graph 1: Mean temperature (in °C) at 5 minute intervals from T=0 to T=25 for control and 5 insulating materials.

Attach graph (prepared by hand or using Excel)

Conclusions (Questions)

1. Describe the comparison between the change in temperature over time in the control versus all the five forms of insulation?

2. Which of the materials you tested provided the most effective insulation? On what do you base this conclusion? List the materials in order from poorest performance to best performance as an insulating material.

3. Compare your results with the R values for the materials you tested (see Table 1). Are your results consistent with the R values? Why or why not?

4. How did the foam core board with holes compare as an insulating material to the foam core board without holes? What does this say about the effect of cracks and holes in insulation with respect to its effectiveness? What does this tell you about the effect of cracks and holes in buildings with respect to the energy required to heat or cool them?