APPENDIX 1-A-2

Infusing Engineering Design into

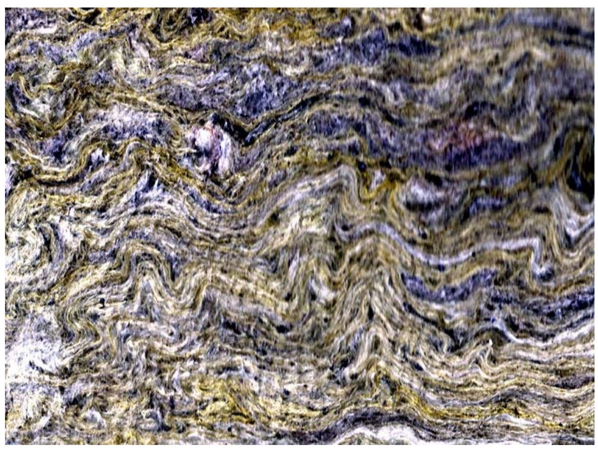
K-12 Engineering and Technology Teacher Education Program

Sample Unit 2:

Engineering Design Experiment

"Technology Education Design" Stage

Adopted From Previous "Original R&E Activity" Assignment in ETES 7070 (Fall 2007)



K-12 Engineering & Technology Teacher Education Course:

ETES 7070 - Research and Experimentation in Technological Studies

(For proposed course description, refer to UGA Website at

http://bulletin.uga.edu/bulletin/courses/descript/etes.html)

TECH (N 19A) - K-12 Engineering Design Senior Project I

(Proposed for CSULA)

(For proposed course description, refer to Appendix 1-F)

Eventual Clientele: Middle School (Grades 6 - 8)

Introduction and Description of the sample unit (Thermal Insulation Material Design Experiment):

Thermal insulation refers to the methods and processes of using insulating materials to reduce the rate of heat transfer and thus maintain the temperature of the insulated object. Examples of thermal insulation include protecting a person from heat or cold by covering the body with appropriate clothes, laying insulating materials beneath in-floor heat cables or pipes in order to reduce heat loss to the ground underneath, or inserting appropriate materials in the walls so as to reduce the effects of temperature changes outside the building on the interior space. With the cost of energy going up while the available natural resources used to generate energy dwindling, production and selection of appropriate thermal insulating materials help to save the planet and the utility bills.

Assignment:

In this project, students will conduct the following:

1. Research: Study the properties of thermal insulating materials;

2. Technology Education Design experiment: Design and fabricate compounds (or "mixtures") of insulating materials; and

3. Construction: Design and construct a thermal insulating box ("testing box") to test the materials (*Figure 1 through Figure 6*).

1. Instruction Unit Development: Develop an instructional unit for teaching the topic of thermal insulation to K-12 students. This should include: a. Plan of Instruction; b. Teacher's Report; c. PowerPoint presentation; d. Handouts for K-12 students (learning materials, home work assignment, basic principles and formulas sheets, useful Internet addresses, and others); and f. List of Reference. The information on thermal insulation can be found by searching online search and reading books (refer to List of Suggested Reference Sources at the end of this assignment handout).

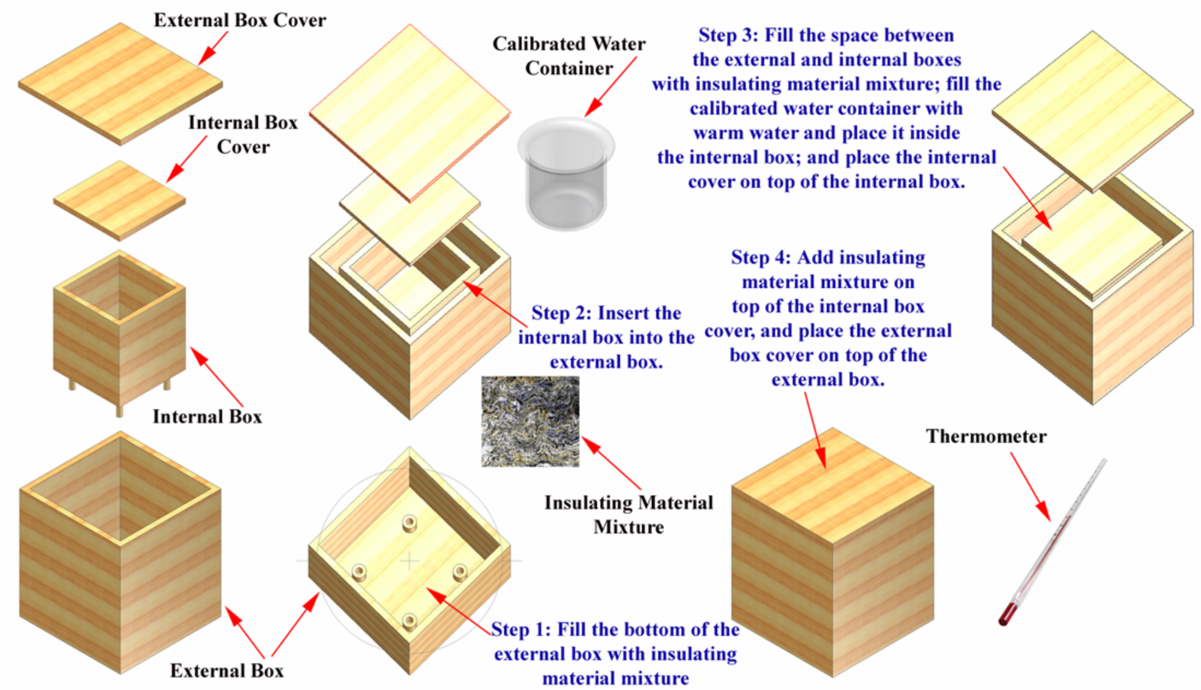


Figure 1: The thermal insulation box and step-by-step testing procedure.

Organization of design teams: Students will work in groups of 3 - 4 members working separately as individuals or cooperatively as teams, depending on the requirements of various components of the project, under instructor's supervision. Group members will work together to frame the overall research and design strategy, to divide the research and tasks among the members and to coordinate the efforts of individual members into achievement of group objectives.

Management of design teams: At each stage of the design process, each team will have a Coordinator to coordinate the activities of the members; the role of Coordinator will rotate among the team members. The Coordinator will keep a work progress log.

Supervision of design teams: The instructor of the course will supervise the activities of each student design team and give advice when requested.

Design process: The following steps of Technology Education Design Process will be used throughout the entire research and design process:

- ❑ Defining a Problem.
- ❑ Brainstorming.
- ❑ Researching and Generating Ideas.

- ❑ Identifying Criteria.
- ❑ Specifying Constraints
- ❑ Exploring Possibilities.
- ❑ Selecting an Approach and Develop a Design Proposal.

Project Components and Step-by-Step Procedures:

1. Research and Report: To start, each student will study the subject of thermal insulation through Internet or library research, write a research report (in MS Word), and share information with other team members. The research report should include information on a variety of insulating materials and their properties (create a table to record the data). Notice that traditional thermal insulating materials include foams and fibrous; alternative thermal insulating materials, such as recycled materials, should also be identified. Next, each team will develop a PowerPoint presentation for the whole class.

2. Predictive analysis, design and fabrication of mixtures of insulating materials: Each student teams will obtain a variety of available thermal insulating materials; create a table for comparing the thermal insulation properties of available material, using data from books and Internet sources; and design 2 - 3 mixtures that team members believe will provide the strongest insulating effects, based on tabulated analysis of the properties of all insulating materials. Each student will use an engineering design notebook to record his or her design concepts (these include a description of the properties of each material, the rationale for the different combinations of the materials, the percentage of each material in the mixture in terms of its mass and volume, etc.).

3. Testing, analysis and determination of the best insulating material mixture: See the 1st Testing section that follows.

4. Design and Fabrication of a Testing Box: Each student team will build the Testing Box for thermal insulation material samples, according to the working drawings shown in *Figure 2* through *Figure 6*, with pine wood material (3/4 inch or 1 inch thickness).

The main issues to be addressed:

For the thermal insulation material design experiment: Use as much recycled materials (from homes, industrial plants, or supply stores) as possible.

For the Instruction Unit Development: Students are to apply the principles of "Analytic Reduction" to break down the instructional material into small units that can be covered in one class meeting at K-12 level, with appropriate integration of technology education design principles, concepts, formulas, exercise and review problems, and other necessary elements.

Learning Objectives:

The most important objectives of this design project include:

1. To learn how to locate relevant information on science, engineering and technology from books and online sources.

2. To learn and practice the process of Technology Education design.

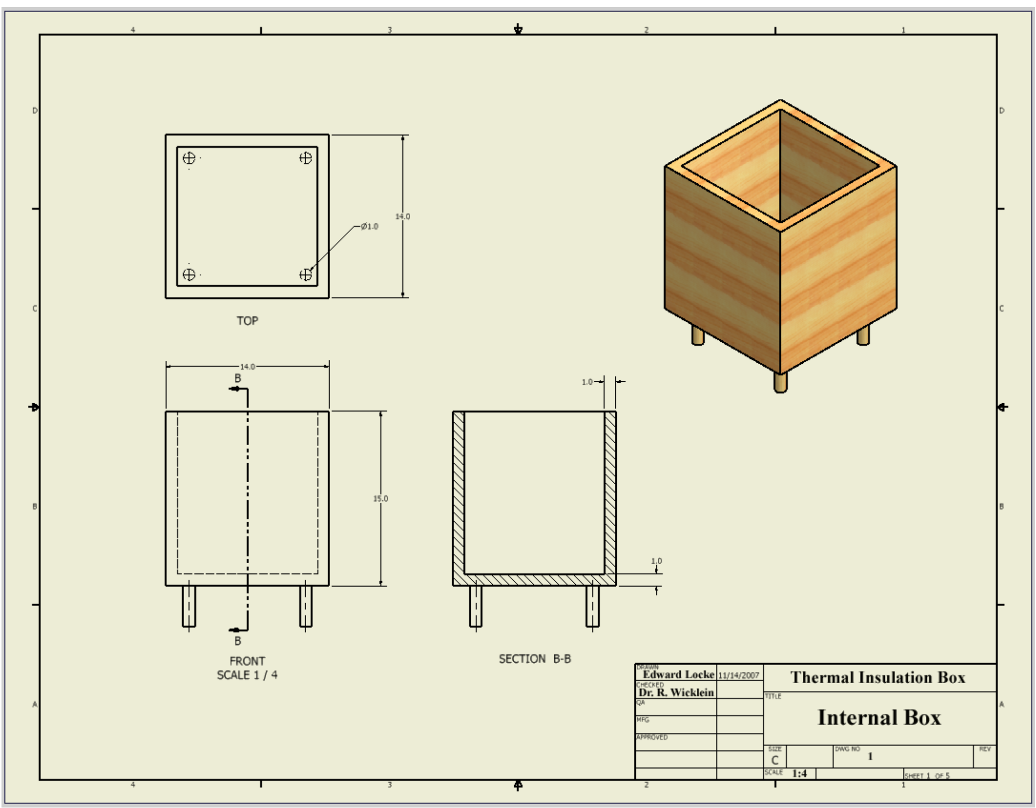


Figure 2 Working drawing for the Internal Box.

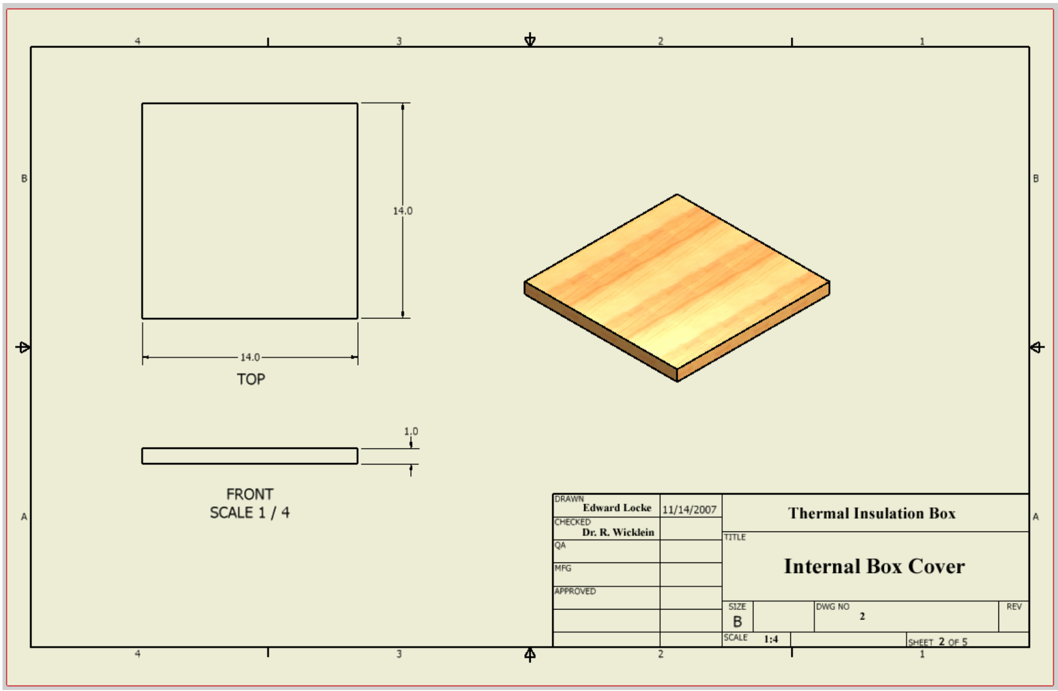


Figure 3 Working drawing for the Internal Box Cover.

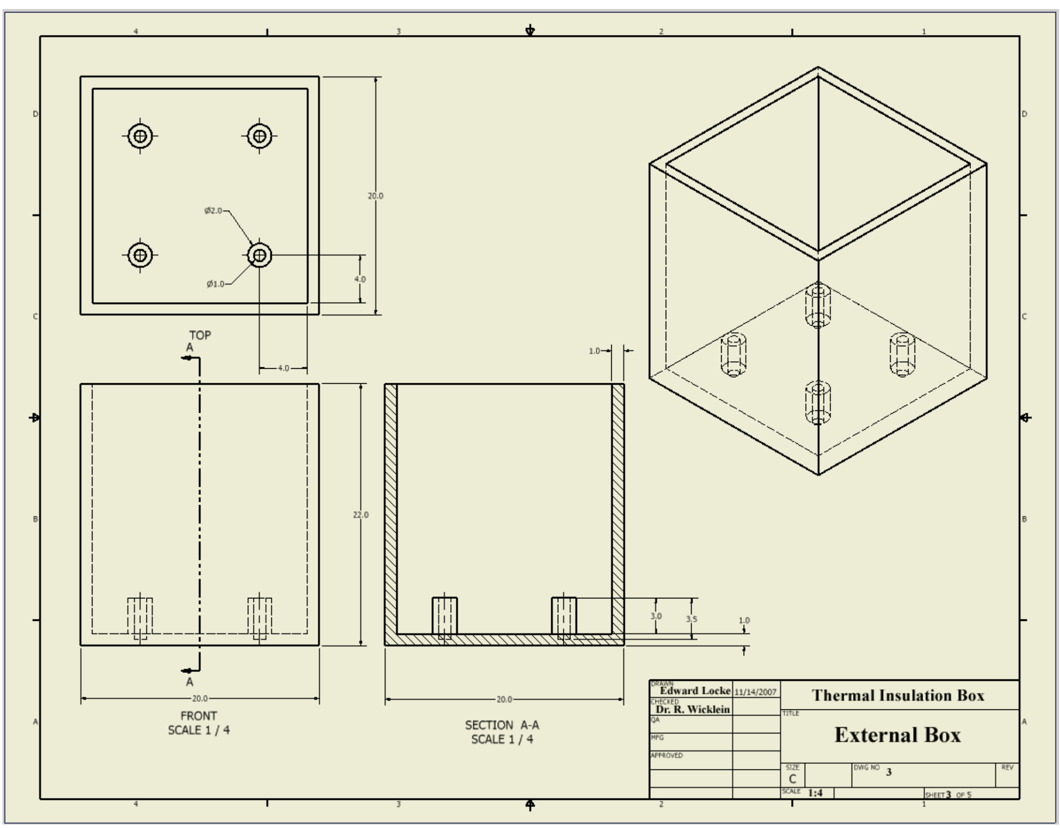


Figure 4 Working drawing for the External Box.

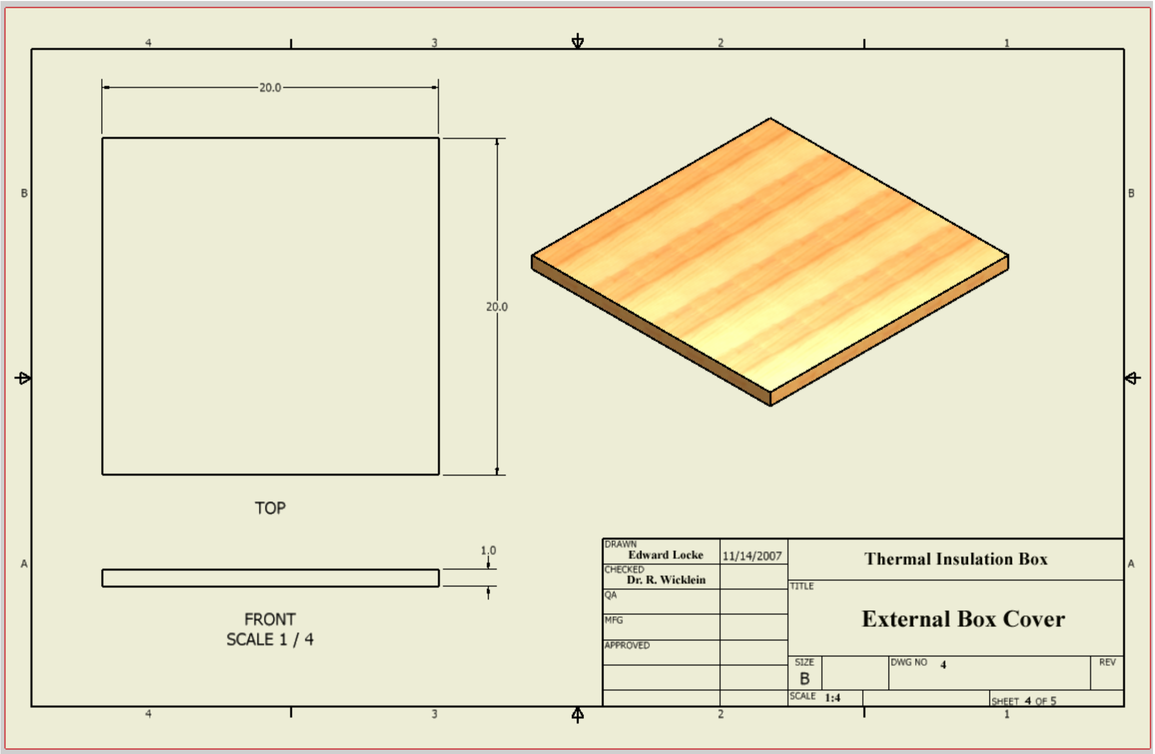


Figure 5 Working drawing for the External Box Cover.

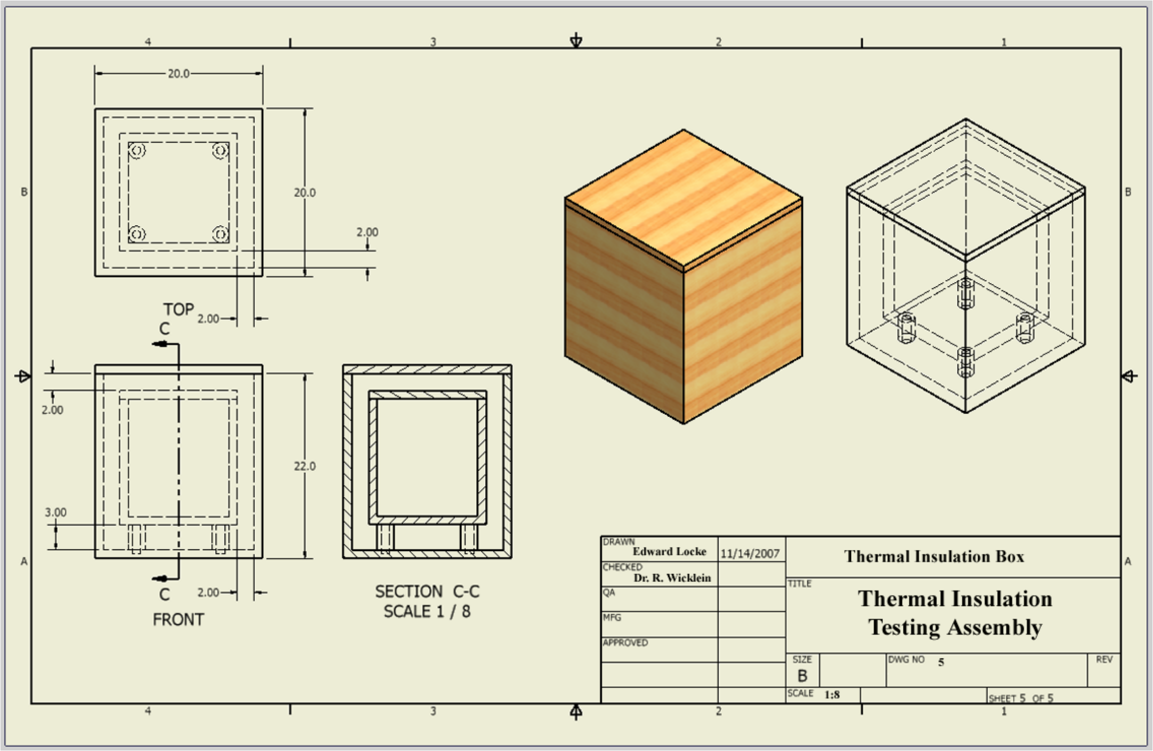


Figure 6 Working drawing for the assembly for the testing box.

Design Constraints (Limitations/Specifications on Insulation Material Mixtures):

1. The uncompressed volume for each mixture to be fabricated should be approximately 2.5 cubic feet (it should fill a 1' x 1' x 2.5' box to be created by each student team, as shown in *Figure 7*).

2. At least 50% of thermal insulating materials used in each mixture (in terms of mass) must be recycled materials from household or office/business facility usage.

3. The balance of materials used in each mixture will be proposed by each student team, and purchased by the instructor from local stores (such as Lowe, Home Depot, Hobby Lobby, etc.) within the county where the school is located.

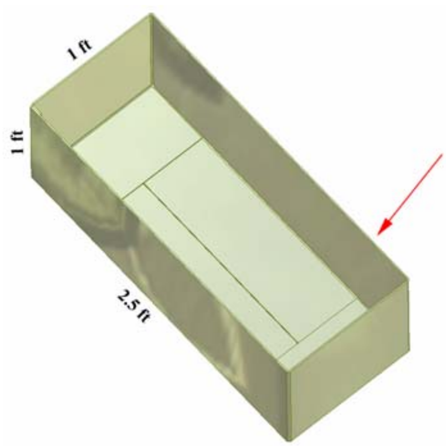


Figure 7: The 1' x 1' x 2.5' box.

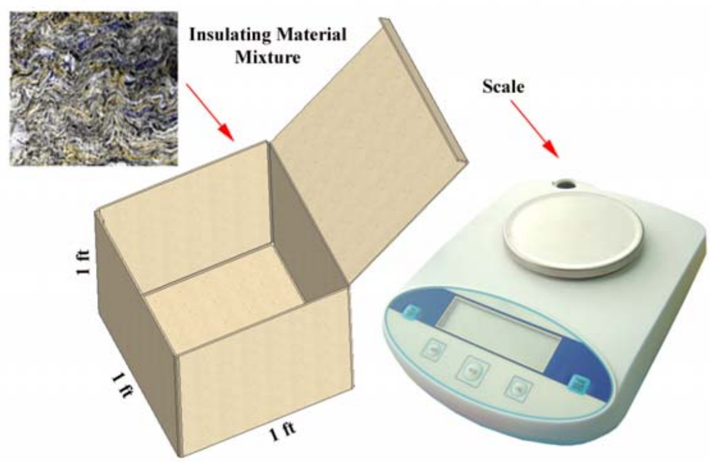


Figure 8: Measuring the mass of insulating material mixture.

1st Testing:

Before you start the 1st testing, use a mechanical or electronic scale to measure the mass of the 1' x 1' x 1' cardboard box (to be created by the instructor. See *Figure 7*); next, fill the box with insulating material mixture; next, measure the mass of the filled box and calculate the mass of the insulating material mixture ($\text{mass}_{\text{insulating material mixture}} = \text{mass}_{\text{filled box}} - \text{mass}_{\text{box}}$); record the measurements and calculations in the data table (note: the unit volume mass is also called the density of the material).

Data Table:

Mass [gram]			Temperature [°F]		
Cardboard Box	Filled Box	Mixture of Insulating Materials	Initial	Final	Change
Efficiency of thermal insulation material mixture:					

Next, refer to *Figure 1* and proceed as described in the following paragraphs.

Step 1: Fill the bottom of the external box with a mixture of insulating material;

Step 2: Insert the internal box into the external box;

Step 3: Fill the space between the external and internal boxes with insulating material mixture. Next, fill the calibrated water container up to the highest mark with hot water from the faucet; measure the temperature of the hot water (the "Initial" temperature) with the thermometer and record it in the data table; next, cover the container and place it inside the internal box; next, place the internal cover on top of the internal box;

Step 4: Add insulating material mixture on top of the internal box cover; and place the external box cover on top of the external box; use tape to seal the closed box. Wait for 15 minute. Next, open the insulation box and the container covers; use the thermometer to measure the temperature of water (the "Final" temperature); and calculate the magnitude of the temperature change. Use the following formula to calculate the efficiency of thermal insulation material mixture:

Thermal Insulation Efficiency = 100% - [(Temperature Change in Hot Water)/(Mass of Thermal Insulation Material Mixture per 1 Cubic Foot)]x100%

$$\text{Efficiency}_{\text{Thermal Insulation}} = 100\% - \frac{\Delta T_{\text{Hot Water}}}{m_{\text{Thermal Insulation Material per Cuic Foot}}} \times 100\%$$

2nd Testing:

Step 1: Analyze the results of the 1st testing, and redesign 2 - 3 mixtures as a whole class for the 2nd testing activity (Hint: Select and compare the 3 mixtures with the highest efficiency scores, find out what material elements these mixtures have in common);

Step 2: Test the redesigned mixtures using the same procedures as in the 1st testing; and determine the best mixture in the second testing;

Step 3: Fill the wall space of the testing Box with the best thermal insulating material mixture, and create a set of 3D modeling and 2D drawings using Autodesk Inventor software. This part will be done by each student separately.

Evaluation Criteria:

Scoring will be based on:

- Your rationale for your solution (grounded on strong research).
- Technical design of your solution (tabulated data related to properties of individual thermal insulating material used in the mixture).
- Functional test (the 1st testing).
- Post test analysis of your solution and re-testing of the mixture of insulating materials.
- Design and fabrication of your personal Testing Box.
- Accurate documentation and application of Engineering Design Notebook

R & E Experiment Evaluation Form:

_____/3 Sufficient Rationale for Solution (Based on Research and Report)

_____/2 1st Test of Mixtures of Insulating Materials

_____/1 Post Test Analysis and Rationale for Redesign

_____/2 2nd Testing of Mixture of Insulating Materials

_____/2 Technical Design of Ice Box (Technical Drawing & Parts/Material List)

_____/2 Craftsmanship and Construction Specifications of Ice Box

_____/3 Accurate Documentation and Application of Engineering Design Notebook

_____/15 Total

This project is an exercise on correctly applying the principles of Technology Education Design Process; the most important objective is to learn how to tabulate and compare technical data and to design and experiment for solutions that might work. The process is essentially composed of three steps: (1) Research and data collection; (2) Analysis of data and design of possible solution based on reasonable hypothesis; and (3) Testing possible solutions to determine which one is the most suitable. This is to some degree a "trial-and-error" approach and several rounds of design experiment might be needed to find a workable solution.

Engineering design documentation:

The following documentations are required for both projects:

Technology Education Design progress log: The rotating Coordinator of each team will record the progress of each team member.

Engineering notebook: Throughout the entire design process, each team member will record all related activities with sketches, notes, and calculations, on engineering notebook, following the standards and conventions of its usage.

PowerPoint presentation: Each team will develop PowerPoint files and handouts for in-class presentations of the final design.

List of Suggested Reference Sources:

1. Books related to heating and insulation at any high school library.

2. National Insulation Association (NIA) website: http://www.insulation.org/techs/standardsmanual_materials.cfm

3. Other websites:

    - http://www.fao.org/docrep/006/y5013e/y5013e08.htm (Thermal insulation materials, technical characteristics and selection criteria)

    - http://en.wikipedia.org/wiki/Thermal_insulation (Thermal insulation)

    - http://www.insulation.org/techs/standardsmanual_materials.cfm (Insulation Materials)

    - http://www.ornl.gov/sci/roofs+walls/insulation/ins_tab1.html (Types of Insulation-Basic Forms)

    - http://www.ornl.gov/sci/roofs+walls/insulation/ins_02.html (How Does Insulation Work for You?)

    - HowStuffWorks at http://www.howstuffworks.com/

    - Wikipedia at http://www.wikipedia.org/)

4. University of Georgia Science Library *Appropriate Technology Reference Library CD collection.*