Testing Thermal Storage Materials

RENEWABLE ENERGY
THE INFINITE POWER OF TEXAS

FOR USE WITH FACT SHEET NO. 17: PASSIVE SOLAR DESIGN FOR THE HOME

TEXAS ESSENTIAL KNOWLEDGE AND SKILLS

TEKS utilized include: **SCI.** (b) 6.2(B) collect data by observing and measuring; 6.2(E) construct tables…to organize, examine, and evaluate data; 6.4(A) collect...information...using...beakers...thermometers; 6.7(B) classify substances by their physical and chemical properties; **MATH** (b) 6.1(C) use integers to represent real life situations; 6.4(A) use tables and symbols; **SOC. S** (b) 6.3(A) create…charts... depicting various aspects of world regions; 6.5(A) explain factors such as...natural resources that influence the economic development…of societies; 6.6(B) describe...the physical processes that produce renewable... natural resources; 6.7(A) analyze ways people have adapted to the physical environment in…regions; 6.7(C) describe ways...technology influences humans' capacity to modify the environment; **L.A.** 6.13(A) revise questions for investigations; 6.13(C) use multiple resources, including electronic texts; 6.13(D) use graphic sources of information such as…tables; 6.20(D) summarize and organize ideas gained from multiple resources; 6.22(B) interpret important...ideas gathered from charts.

OVERVIEW

Students will recognize the value of using thermal mass to conserve energy in the home and the importance of building orientation and window sizing. By measuring temperature changes in several thermal storage samples, students will appreciate the need to plan construction with proper materials. Students will learn that simple measures, such as landscaping and installing thermal storage, make a big difference in energy consumption.

TIME FRAME

Two 45-minute periods

TEACHER GUIDE

Teaching Instructions

Teacher should read the student activity first. Review vocabulary based on Fact Sheet #9, Energy Conservation in the Home. There are choices for the teacher to make in the student activity. Groups of students can each be assigned all 3 materials to use, or each group can be assigned only 1 (or 2) materials (differing by group). The materials to be used can include sand, water, shredded paper, powdered samples like Sakrete (concrete), plaster, finely crushed rock, etc. Students can also bring in materials the teacher approves for testing.

The variables students will be evaluating are:

1. the kind or kinds of materials they are testing and
2. water temperature (testing in hot water or testing in cold water or both).

The teacher can choose to divide the hot and cold water testing among groups or have every group do both. Students need to understand their group's task clearly, before beginning. They should review Fact Sheet #17, *Passive Solar Design for the Home*, and the activity instructions. Appropriate safety guidelines should be reviewed. Thermometers are assumed to be non-mercury. Caution students to pour some of the materials, like sand, into the beaker first, place the thermometer into the beaker and then continue filling the beaker with sand. Students should not try forcing a thermometer through a dense material, as the thermometer will break.

Students can outline their tasks or use a graphic organizer.

The teacher can obtain containers such as dishpans or buckets to hold the materials to be tested. One container may have sand and be labeled "sand, room temperature," another can be labeled "powdered concrete,

room temperature," etc. Some materials, like sand (after being used) need to be collected in a separate container until they return to room temperature, since they may be cold or warm for a while as a result of the experiment. Dense materials gain and lose heat slowly.

To obtain the correct amount of materials, students can estimate the 200 ml of sand or other materials in a 250 ml beaker. Hot water from the tap (around 85° C) can be used or the teacher can heat a larger container of water (85° C) and distribute the water to students, if necessary. Students can create their own data-collecting tables with teacher approval.

After all of the measurements have been made, students can make a bar graph showing each material and the highest temperature or the lowest temperature it reached. If there is time, the teacher can direct students to either record the number of minutes each material took to lose a two degree increase in temperature after the heating occurred, or to record how long each material took to gain 2 degrees in temperature after being cooled.

Teacher's Sample Data Table

- Record the starting temperature of the 200 ml beaker of water, sand, and paper etc., and the temperature of the hot water bath at "0" minutes.
- Record the temperature reading of each of the thermometers every 1 (or 2) minutes on the table.

Temperature readings (°C) in hot water bath, 2 minute intervals

Min.	200 ml water	200 ml sand	200 ml paper	water temp
0	35	35	35	85 (starting temp)
2	39	35	35	75
4	43	36	36	63
6	44	36	36	58
8	45	37	37	52
10	45	37	37	50

Temperature readings (°C) in cold water bath, 2 minute intervals

Min.	200 ml water	200 ml sand	200 ml paper	water temp
0	38	38	38	8 (starting temp)
2	32	38	37	8
4	30	38	37	9
6	28	37	37	9
8	25	35	34	9
10	23	34	33	10

- Before placing the beakers in the cold water bath, record the starting temperature of the 200 ml beaker of water, sand, and paper etc., and the temperature of the hot water bath at "0" minutes.
- Record the temperature reading of each of the thermometers every 1 (or 2) minutes on the data table.

GLOSSARY

convection – transport of heat by the movement of parts of a fluid (air or water); cool air is denser than warm air and as it settles the cool air pushes the warm air upward

deciduous – a tree whose leaves shed each year at the end of the period of growth (often in autumn)

direct gain – solar radiation directly entering and heating living spaces, such as south-facing windows that admit heat from the winter sun and warm the room's air

indirect gain – storing or trapping heat so that it can be used in other parts of a building, such as a room with a substantial amount of thermal mass (concrete, adobe, brick, water, etc.), with many windows through which the thermal mass captures the heat from the sun and releases the stored heat at night

insulation – the material, stuffing or padding that prevents heat from passing through

thermal mass – a dense material that gains or loses heat slowly (examples are concrete, adobe, stone, brick, water)

trombe wall – a glass covered thermal mass wall on the south side of a home. small vents in the top and bottom of the wall allow warm air to flow in the house

ASSESSMENT ANSWERS

Short Answer Questions

1. The materials locally will vary among concrete, brick, adobe etc.
2. Materials advertised for use in fireplaces, walls, floors, and other thermal mass applications may include: brick, adobe, limestone, river rock, tile, marble, slate, granite, sandstone, cast stone, concrete, and even water in barrels, camouflaged in walls.
3. Thermal mass increases in temperature slowly and releases the heat gained slowly back into the room over time. The more dense materials have more potential for use as thermal mass. Water in barrels is used in the walls of rooms for the same purpose, even though its density is less. Answers will vary according to materials used. Color can also be a factor, along with the material itself.
4. In castles, carpets were hung on walls, large fireplaces were used with stone masonry that retained heat, ladies wore long gowns to keep off drafts as clothes were common insulators also. Regardless, the huge rooms and stairwells were drafty and very inefficient.
5. Well planned landscaping with deciduous trees can provide shade, especially on the west side of the house in the summer, and can allow sunlight to filter into the home in the winter. Plants and grass around the home are cooler than rocks and concrete, which create thermal mass in the yard, making the house hotter.
6. Reordering the data table on page two is a critical thinking activity, which provides insight into the meaning of the data.

Multiple Choice Questions

1 d 2 c 3 d 4 a 5 d 6 d 7 c 8 b 9 a 10 d

STUDENT ACTIVITY #17: TESTING THERMAL STORAGE MATERIALS

Key Vocabulary

define the following terms:

convection, deciduous, direct gain, indirect gain, insulation, thermal mass, trombe wall

Materials

- 200 ml each water, packed: sand, shredded paper; or powdered: cement, mortar, plaster, rock etc, (measure each into a separate beaker)
- 3 small thermometers
- 1 lab thermometer
- 3 beakers (250-300 ml for sand, water, shredded paper, and other thermal material)
- 1 liter of ice water
- 1 liter of hot water 85° C approximate, (hot from tap)
- 2 large beakers or cans or other containers for cold or hot water
- 2 containers to hold beakers (cake pans work well)
- goggles
- ice
- cake pan

Performing the Experiment

(wear goggles ,use gloves)

1. As your teacher has directed, obtain sand, water, paper or other material (you will need about 200 ml of each).
2. Obtain 3 beakers (250 – 300 ml in size) you need one beaker for each different material.
3. Place 200 ml of sand in beaker #1, 200 ml water in beaker #2, 200 ml shredded paper or other material in beaker #3 etc. (If you are using a more dense material as the teacher instructs, fill the beaker halfway then place the thermometer into the material and finish filling the beaker. You should avoid forcing a thermometer into dense materials because the thermometer may break.)
4. Place a small thermometer in each beaker (of sand, water, shredded paper) you will test. Be sure sand, water, etc. covers the thermometer bulb or bottom.
5. Record the initial temperatures of the sand, water, shredded paper or other material in a data table.
6. Place your 3 beakers to be tested (or the number your teacher assigned) into a container (cake pan can be used).
7. Take 1 liter of hot water about 85°C (from tap), or as directed by your teacher, and pour the water into the cake pan container where the 3 beakers are standing.
8. Place a separate thermometer in the water bath (cake pan).
9. Read and record in your data table the temperature of the sand, water, shredded paper or other materials and the water bath (cake pan) every minute for 10 minutes and record the temperature in your data table.
10. Dispose of the contents of your beakers as directed by your teacher.
11. Repeat the activity steps 1 through 10 using ice water (by adding ice to some tap water) as the water bath instead of hot water.

ASSESSMENT

Short Answer Questions

1. What local materials do you think would provide good thermal mass?
2. What materials are advertised in home improvement centers, magazines and on the Internet for creating floors, walls, fireplaces and other thermal mass applications?
3. Which material used in the activity was best?
4. How did people living in large drafty castles (in medieval times) try to conserve heat energy?
5. What use is landscaping in an energy efficient home design?
6. In Fact Sheet #17 on page 2, Table 1 shows cities with their percent annual heating from solar contribution (alphabetically). Create a new data table grouping the cities from highest to lowest in percent of annual heating from solar contribution. For example, El Paso would be first and the numbers 58 to 77 would be written beside El Paso; Houston would be last with 28 to 58.

Multiple Choice Questions

1. Passive solar design:
   a) is useful in all climates
   b) depends on proper house orientation
   c) can save you money
   d) all answers a, b, and c

2. The sun is:
   a) higher in the sky in winter
   b) the same height in winter and summer
   c) lower in the sky in winter
   d) lower in the sky in summer

3. The direct gain system is dependent on:
   a) south facing design
   b) correct sun angles
   c) any sun angle
   d) answers a and b

4. An example of thermal mass is:
   a) adobe
   b) styrofoam
   c) shade
   d) glass

5. Landscaping can:
   a) change the sun's position
   b) be thermal storage system
   c) be a direct gain glazing
   d) reduce energy costs

6. The Trombe Wall is:
   a) a fire wall
   b) a glass covered thermal mass wall
   c) vented on top and bottom
   d) b and c

7. Deciduous means:
   a) evergreen
   b) indecisive
   c) losing leaves in autumn
   d) a flowering bush

8. Solar contribution is greatest in
   a) Lufkin and Corpus Christi
   b) El Paso and Lubbock
   c) Brownsville
   d) Houston

9. Generally in Texas:
   a) Cooling is more of a problem than heating.
   b) Having east-facing windows is important
   c) Porches are unnecessary for shade.
   d) a and b

10. In order to keep a home cooler:
    a) shade trees are used
    b) blinds (for windows) are shut during the day
    c) hot air spaces are allowed to be vented
    d) all answers a, b, and c

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