

# E xploration Brief

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## Keeping Your Cool

### Context

It is not sufficient for the health and well-being of an astronaut just to be protected from the hazards of the environment in which he or she is trying to work. It is also necessary to consider the conditions that are created by the suit itself. One of the most important of these conditions is temperature. Suit insulation technologies protect the astronaut from extreme high and low temperatures of the space environment. However, the same insulation technology also works to keep heat released by the astronaut's body inside the suit. To get an idea of what this is like, imagine walking around in summer wearing a plastic bag. For this reason, an active cooling system is employed.

In Space Shuttle Extravehicular Mobility Units or EMUs, the cooling system consists of a network of small diameter water circulation tubes that are held close to the body by a Spandex® body suit. Heat released by the astronaut's body movements is transferred to the water where it is carried to a refrigeration unit in the suit's backpack. The water runs across a porous metal plate that is exposed to the vacuum of outer space on the other side. Small amounts of water pass through the pores where it freezes on the outside

of the plate. As additional heated water runs across the plate, the heat is absorbed by the aluminum and is conducted to the exposed side. There the ice begins to sublimate, or turn directly into water vapor and disperses in space. Sublimation is a cooling process. Additional water passes through the pores, and freezes as before. Consequently, the water flowing across the plate has been cooled again and is used to recirculate through the suit to absorb more heat.

Supplementing the EMU cooling system is an air circulation system that draws perspiration-laden air from the suit into a water separator. The water is added to the cooling water reservoir while the drier air is returned to the suit. Both the cooling system and the air-circulation system work together to contribute to a comfortable internal working environment. The wearer of the suit controls the operating rates of the system through controls on the Display and Control Module mounted on the EMU chest.

### Objective

- To investigate and experience the way the water cooling system in the Space Shuttle EMU functions.



## Investigation

### Water Cooling—Part One

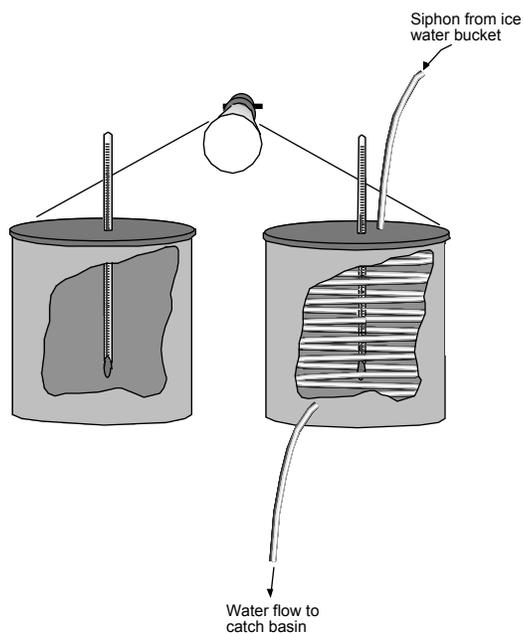
This demonstration shows the principle behind the operation of the Space Shuttle EMU liquid cooling garment. Instead of an internal heat source (the suit wearer), the heat is provided by a strong electric light bulb or flood lamp.

#### Materials and Tools Checklist

- Two coffee cans with plastic lids
- 4 meters of aquarium tubing
- Two buckets
- Two thermometers
- Duct tape
- Water (solid and liquid)
- Heat source (light bulb and fixture)
- Hole punch
- Flood light and fixture

#### Procedure

- Step 1. Punch a hole near the bottom of the wall of a metal coffee can. The hole should be large enough to pass aquarium tubing through. Punch a second hole in the plastic lid of the can so that tubing can pass through it as well. Punch another hole in the center of the lid so that a thermometer will fit snugly into it. Finally, punch a hole in the center of the second coffee can lid for another thermometer.*
- Step 2. Loosely coil the aquarium tubing and place it inside the first coffee can. Use bits of tape to hold the coils to the walls and to keep them spread out evenly. Pass the lower end of the tube through the hole in the can wall and the upper end through the outer hole in the lid. The lower tube should extend to the catch bucket that will be placed below the can. The upper end will have to reach to the bottom of the ice water bucket. That bucket will be elevated above the can. Insert thermometers into each can.*



- Step 3. Place the two cans on a table top. Direct the light from a strong light bulb or flood light to fall equally fall on the two cans. The light should be no more than about 25 centimeters away from the cans. Fill a bucket with ice water and elevate it above the two cans. Place the catch bucket below the two cans.*
- Step 4. Turn on the light. Observe and record the temperatures on the two thermometers. After two minutes, again observe and record the temperatures.*
- Step 5. Place the upper end of the aquarium tubing into the ice water and suck on the other end of the tube to start a siphon flowing. Let the water pour into the catch bucket.*
- Step 6. Observe and record the temperature of the two cans at regular intervals for ten minutes.*

#### Tips

- If more than one student is going to start the siphons with sucking on the end of the tube, make sanitary mouthpieces like those called for in the activity "O<sub>2</sub> How Much?"
- Color the water with food coloring to increase its visibility in the siphons.



## Assessment

Have students design a graph to display the data collected in step 6.

## Extensions

• How can the flow of icy water be controlled? Find a way to maintain a constant temperature inside the can with the tubing. Move the light source closer to the can so that it is heated more than before. Try to maintain the internal temperature at the same level as before.

## Investigation

### Water Cooling —Part Two

This demonstration permits students to experience the water cooling technology used in the Space Shuttle EMU.

#### Materials and Tools Checklist

- Two buckets
- 3 meters of aquarium tubing
- Water (solid and liquid)
- Kitchen size plastic garbage bag (one per student)

#### Procedures

- Step 1. Distribute one plastic garbage bag to each student. Have students wearing long-sleeve shirts roll up one sleeve.*
- Step 2. Ask each student to place their bare arm inside the bag and then gather the plastic so that it fits closely along the entire length of the bag. Tell students to repeatedly make a fist or wave their arm while it remains in the bag for a for two minutes. (Steps 1 and 2 can also be done with plastic gloves.)*
- Step 3. After two minutes, have students remove their arms from the bags and observe any sensations that come with their removal. Discuss what students felt. Make sure they understand that a spacesuit, like the plastic bag, retains body heat. Also discuss why their arms suddenly felt cooler with the removal of*



*the bags. (Warm air in the bag was released and moisture from perspiration began evaporating.)*

- Step 4. Select a student volunteer for another experiment. Wrap the middle of the length of aquarium tubing around the bare arm of the volunteer several times.*
- Step 5. Start a siphon flow from the ice water bucket through the tube. Ask the student to describe for the rest of the class the sensations he or she feels. (See note about mouthpiece in part 1.)*

#### Extensions

- Discuss how a liquid cooling garment could be constructed that could operate continuously without siphons and buckets of ice water that eventually run out.
- What professions on Earth might find liquid cooled garments useful?
- Design and construct a liquid cooling garment out long underwear or Spandex® running tights.

