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Note to Teachers:

The investigation of the Challenger space shuttle disaster in 1986 found the probable cause of the accident as the failure of an O-ring used to seal the joint between two sections of one of the solid rocket boosters. Temperatures on the ground were much colder than normal on the morning of the launch, changing the properties of the O-ring material so that it did not function as it should. The first hint that this material could have been the culprit came when Caltech physicist and Challenger Investigation Committee member Richard Feynman impulsively plunged a sample of the O-ring material into his glass of ice water and noticed that it became significantly less pliable.

In this activity, students can devise their own tests to find out how the properties of an ordinary material may change under extraordinary circumstances, which certainly describes the environment in outer space.

This activity can be very simple—and safe—for younger students. Older students who understand the potential hazards of even small amounts of materials such as paint thinner and gasoline, and whose teachers can procure dry ice or liquid nitrogen, can extend the experiment greatly. It could also be the basis of a science fair project.

Testing new technologies and new materials in space is the focus of NASA's New Millennium Program. It is important to validate new technologies before they are depended upon for critical space science missions. Find out more about the New Millennium Program at http://nmp.jpl.nasa.gov/ .

This activity and article were created by Diane Fisher and Enoch Kwok. Ms. Fisher is a science and technology writer at the Jet Propulsion Laboratory and developer of The Space Place (http://spaceplace.jpl.nasa.gov), a web site with fun and educational space-related activities for children. Mr. Kwok is a high-school teacher and consultant. The cartoons are by Alexander Novati and Liliana Novati. Thanks also to Nancy Leon, Education and Public Outreach Manager for a number of programs and projects at JPL.

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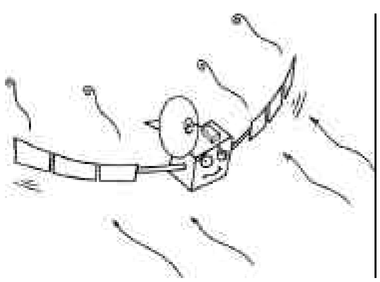
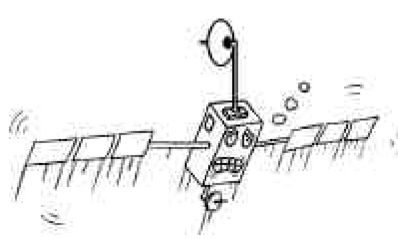
50 WAYS TO TORTURE A WHAT?!

You may think there's a big difference in temperatures during summer and winter where you live. You may have noticed that things like garden hoses seem almost as if they're made of different stuff, depending on whether it is hot or cold outside. The material is soft and flexible when it's hot, and hard and rigid when it's cold.



But even the most extreme temperature variations here at home on the surface of Earth are nothing compared to what a spacecraft may encounter in space.

Materials going into space encounter extremely harsh conditions not normally encountered on Earth. Radiation is terrible. Depending on which side of a spacecraft is facing the sun, it may be either very hot or very cold. There's no air and very little gravity. Probes dropped into the atmosphere of a planet like Jupiter or Saturn's moon Titan may encounter tremendous pressures, temperatures, and corrosive gases. It's not friendly out there!



If we are going to study Earth from space and learn about other planets, moons, asteroids, and comets, we have to build our spacecraft out of very special and tough materials.

STRE-E-E-ETCH YOUR IMAGINATION

In this experiment, you will take an ordinary material and subject it to just about any punishment you can think of, to see how the material holds up. Here are some suggestions for materials and objects to test:

- Rubber bands
- Aluminum foil, cut in 1-inch squares
- Silicone (similar to material used for the O-rings in the Space Shuttle solid rocket boosters), squeezed into small portions from a tube of silicone caulk
- Molded plastic packaging material, such as used to make containers for fruits and vegetables or disposable plastic plates, cut into 1-inch squares

For the class, you will need at least two identical samples of a material for each person or team doing an experiment. One sample is subjected to a test condition, and the other is not (it is the control). We suggest some ways to test your sample, but you are not limited to this list.

Some of these materials you may wish to try on your sample are hazardous. In addition, some are not very easy to find. The teacher will be the one to decide which materials to bring into the classroom.

You (or your team) will pick one test to do on your sample.

NOTE THE STARTING CONDITIONS

However, before subjecting it to any testing, observe and record the properties of both the test and the control samples. Note such characteristics as

- Elasticity (for example, if testing a rubber band, you could hang a weight from it and measure how long it stretches out)

- Brittleness (how stiff and breakable is it; just describe in words)
- Strength (does it break easily by bending or stretching?)
- Color
- Transparency
- Light reflection (dull/shiny)
- Texture (smooth, sticky, crumbly)
- Odor

And Start the Test

Now, pick out one way to "torture" your test sample. The control sample just lays around and escapes punishment. Subject the sample material to the test for anywhere from a few days to a couple of weeks. Decide the duration of the test based on how harsh you think the hazard will be to the material.

When you have finished your torture test, compare the properties of the test sample with the control sample and report your findings.

Note: For tests that involve soaking the sample in a liquid, we suggest using small glass jars with tight-fitting lids. Some of these liquids could dissolve or otherwise ruin a plastic container.

Simple tests, very safe for the tester:

- Freeze the sample in the freezer.
- Put the sample in a bowl of water and freeze the water (don't put a lid on the container), then thaw the ice.

- Heat the sample over a candle or Bunsen burner flame (don't allow the sample material to burn or smoke!)
- Keep the sample in a warm place (not over flame) for several days (like near a furnace or fireplace)
- Put the sample in a glass jar with a tight lid and leave in a warm spot for a few days (check jar for any film deposited on inside).
- Expose the sample to sunlight for a few days/weeks (don't put it in a jar, since glass will protect the sample from ultraviolet light, which is what can damage materials).

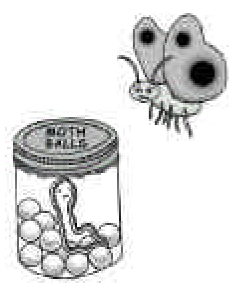
- Expose the sample to lots of air pollution for a few days (such as near the exhaust pipe of a vehicle, but not where it will get too hot—if possible).
- Soak the sample in water.
- Boil the sample in water.
- Soak the sample in vinegar.
- Soak the sample in tomato juice or sauce.
- Soak the sample in a bottle of cola soft drink.

- Soak the sample in motor oil.
- Soak the sample in cooking oil.
- Soak the sample in isopropyl (rubbing) alcohol.
- Soak the sample in liquid dishwashing detergent.
- Soak the sample in a brine (salt) solution.
- If a stretchy material, stretch the sample out and keep it stretched for several days (hang a weight from it).
- If a stretchy material, find some way to stretch the sample over and over, hundreds of times. (For example, rig it to stretch every time a frequently used door is opened.)

More hazardous tests:

> **CAUTION!**
> **Wear safety glasses when handling these solvents!**
> **Please handle this stuff with care!**

- Freeze the sample with liquid nitrogen.
- Freeze the sample by putting it between layers of dry ice.
- Soak the sample in gasoline.
- Soak the sample in acetone.
- Soak the sample in nail polish remover.
- Soak the sample in paint thinner.
- Soak the sample in formaldehyde.
- Soak the sample in a strong household cleaning solution.
- Soak the sample in carpet shampoo.
- Soak the sample in chlorine bleach.
- Put the sample in a glass jar (tight lid) with some moth balls, Borax (or some other reactive dry substance).
- Or expose the sample to any other environmental hazard you can think of.



Damage Report

Before checking for property changes, if the sample has been soaking in a liquid, rinse it with water (if a water soluble liquid) or dry it off with a paper towel (if a non-water-soluble liquid).

Again, check the “treated” sample for the same properties you checked at the beginning. Record your observations. Compare the treated with the untreated sample.

Can you draw any conclusions about the kinds of space environments where this material would or would not be suitable? Keep in mind there are no doubt environments out there that we haven’t even begun to imagine!

How NASA Tests New Space Materials and Technologies

The engineers and scientists working on NASA’s New Millennium Program don’t exactly sit around thinking up ways to torture potential space-faring materials. But they have a pretty good idea of what conditions may be like out there and know the only way to really test promising new materials or other advanced new technologies is to send them into space on a special test mission. In addition to new materials, New Millennium Program missions test new propulsion and communication technologies, new types of computer and data handling systems, new navigation technologies and new types of imaging and mapping instruments. This way, future missions of discovery will have the advantages of the latest and best technologies for space without having to risk their missions on the new and untried.

A New Millennium Program mission called Earth Observing 1 will test new imaging technologies that will help us understand changes (such as the disappearance of the rain forests) that affect the environment.