Approaching the Final Frontier

Near Space

The Thermal Test Chamber

Got a new item for near space that you want to test? Simple tests on the ground can ensure that your design functions well in near space. This way, failures identified during a test can be corrected before a near-space flight (where a failure can lead to the loss of a near spacecraft).

One of the simplest tests is the thermal test. It's cold in near space, and as the chart in Figure 2 indicates, it can drop to minus-60 degrees F during a mission. I have seen at least one camera and several batteries fail because of the cold temperatures in near space.

The thermal test chamber (TTC) I will describe here (see Figure 1) has tested several of my BalloonSat designs. However, this TTC is not just for near space testing. It's also for testing weather stations or other sensors that you'll leave to the elements.

Materials

Many people have made a TTC by tossing a chunk of dry ice into a Styrofoam ice cooler. I'm not happy with that design because the sides of the TTC aren't straight, the walls aren't thick, and it limits the selection of volumes. Instead, I designed a thick-walled Styrofoam box to my own dimensions and added fans. I figured this would let me use the interior volume more effectively and create colder temperatures. Besides, it's easier to make a square box look high tech than it is to make a beer cooler look high tech.

I used the following materials to make my TTC:

- Two-inch-thick Styrofoam sheet
- Half-inch-thick Styrofoam sheet
- X-acto Knife (with two-inch-long blade)
- Metal yardstick
- Pencil
- Hot glue
- Space blanket
- Aluminum tape
- 1/8-inch modeling plywood
- Miniature CPU fans (2)
- #22 AWG stranded wire
- 1/8-inch heatshrink tubing
- Packing tape
- #4-40 hardware (four sets)
- Five-volt wall-wart power supply
- Power plug
- Desk top letter boxes (three)

Procedure

My TTC is a cube measuring about 18 inches on each side. This is large enough to hold the dry ice in a cage and test two BalloonSats. Feel free to assemble a TTC with different dimensions. However, be aware that if you make your TTC larger, you'll need to use larger fans and charge it with more dry ice.

Begin by laying out the sides of the TTC on the two-inch-thick Styrofoam. Use a pencil and metal yardstick to draw the lines. Then use the yardstick to guide the X-acto knife as you make each cut. Styrofoam cuts cleanly with a sharp X-acto knife blade.

Make several cuts through the Styrofoam with the blade held at as shallow of an angle as you can. The cut edge of the Styrofoam should be smooth. If the knife breaks out chunks of Styrofoam, then the blade

Figure 1. The completed thermal chamber.

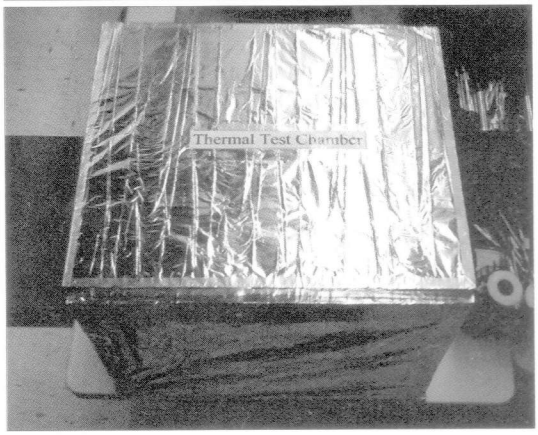
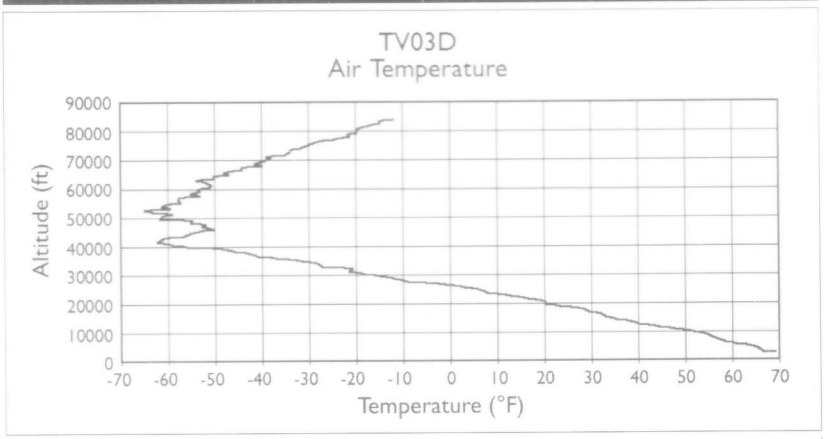


Figure 2. Outside air temperature is compared against altitude.



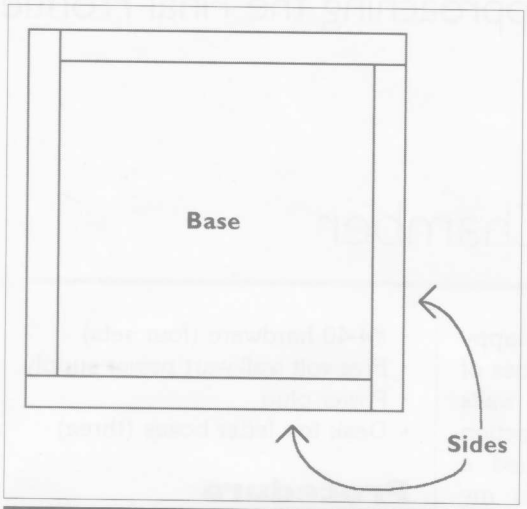


Figure 3. This is the top view of the TTC.

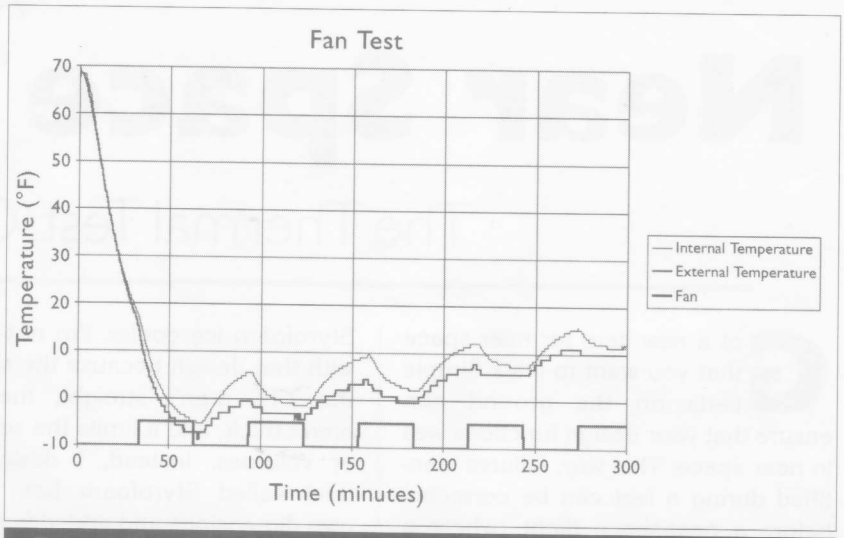


Figure 4. This test shows that overall temperature is affected by air circulation.

is dull. You may notice that Styrofoam cuts better in one direction than another. I get the impression that extruding Styrofoam creates a grain in the sheet.

I cut the two-inch-thick Styrofoam into four 16 by 16-inch-squares and two squares measuring 18 by 18 inches. I also cut a half-inch-thick Styrofoam sheet into a 16 by 16-inch square. Select one of the 18-inch squares to be the base and set the other one aside for later (it will be the lid). The four 16 by 16-inch squares are the sides of the TTC.

Fire up the hot-glue gun, as you have some gluing to do. By the way, I find my students are not humored when I hold up a hot-glue gun and say, "Bond, James Bond."

Styrofoam is a good insulator, and I find that hot glue doesn't quickly cool down on it. Moreover, hot glue can get hot enough to melt Styrofoam, so keep the glue gun from getting too hot by unplugging it every once in a while.

Apply glue to the bottom edge of the first side and align it with one corner of the TTC base (as in Figure 3). The side may not want to stay vertical, so work fast and glue two edges of the next side and put it into place. Repeat this with the remaining two TTC sides.

For additional strength, wrap a length of packaging tape around the top edges of the TTC box. The tape puts the top edges under compression and keeps them from splitting apart.

The lid has an inner lip made from the half-inch-thick Styrofoam. First, test fit the lid's inner lip by trying to set it inside the TTC. Be careful you don't damage the inner lip trying to get it in or out of the TTC. I found it was better if I just tried fitting one edge of the inner lip at a time. This way, part of the inner lip

The 2004 Winner of the OnSet Prize

Last year marked a turning point in the amateur radio high altitude ballooning (ARHAB) community when OnSet Computing sponsored a competition for the highest altitude flight in 2004. The competition, called the OnSet Prize, was open to all ARHAB groups. To qualify, flight attempts had to be announced in advance and tracked with GPS over amateur radio.

The winner of the 2004 OnSet Prize is the Treasure Valley Near Space Program (TVNSP). The TVNSP launched their winning flight on the morning of December 27. The 1.1-pound payload was carried on a Kaysam 1,200-gram balloon and in two hours and 26 minutes, reached a peak altitude of 118,946 feet. Their flight beat Bill Brown's previous day's record altitude by only 299 feet!

TVNSP won a four-channel, eight-bit Hobo data logger that measures temperature, relative humidity, light intensity, and one external voltage. Along with the Hobo, they received the professional version of the Boxcar software (Boxcar Pro 4) and an external temperature sensor on six-foot cable.

I'd like to thank OnSet Computer Corporation for sponsoring this competition. You'll find their products used in the NASA Space Grant Consortium's BalloonSat Program. Be sure to check out the OnSet website and see all the great products they offer. You'll find a lot of justifications for launching near space missions with OnSet's computing data loggers.

OnSet Computing
www.onsetcomp.com

Treasure Valley Near Space Project
www.tvnsp.org

remains outside of the TTC while I did the test fit. Trim the inner lip if necessary to get it to fit. Apply hot glue to one face of the half-inch-thick Styrofoam and center it over the lid.

After the glue sets up, test-fit the lid. You may want to do some additional trimming after this fitting.

Now you have an ugly Styrofoam box with a lid.

I added insulation to the TTC by wrapping its interior and exterior with aluminized space blanket material. Cut pieces of the space blankets for the interior of the TTC into squares slightly smaller than the interior dimensions of each side. Use short strips of double-sided tape to hold each sheet of space blanket in place. Then finish the interior by hot gluing thin strips of half-inch Styrofoam onto the inside edges of the TTC box. This way the Styrofoam strips are

Announcing The 2005 Amateur Radio High Altitude Ballooning (ARHAB) Competitions

Last year, OnSet Computing (**http://onsetcomp.com**) sponsored the maximum altitude competition between amateur near space groups. The competition was so popular that this year, there are six different ARHAB Competitions. The 2005 ARHAB Competitions are in these categories:

1. Highest Altitude Reached by a Near Spacecraft

2. Greatest Distance Traveled by a Near Spacecraft (release to touchdown)

3. Longest Mission Duration (release to touchdown)

4. Greatest Distance that Telemetry from a Balloon is Received (for frequencies greater than 50 MHz)

5. Greatest Distance that Telemetry from a Balloon is Received (for frequencies less than 50 MHz)

6. Greatest Distance for Two-Way Radio Contact Through a Near Spacecraft

The ARHAB community is fortunate to have four sponsors for this year's slate of competitions. The following companies are sponsoring the 2005 ARHAB Competitions:

- For Maximum Altitude — *OnSet Computing* and *Amateur Television Quarterly*
- For Greatest Distance Traveled — *Amateur Television Quarterly*
- For Longest Mission Duration — *Kaymont* and *Amateur Television Quarterly*
- For Greatest Telemetry Range (greater than 50 MHz) — *Kaymont* and *Amateur Television Quarterly*
- For Greatest Telemetry Range (less than 50 MHz) — *Kaymont* and *Amateur Television Quarterly*
- For Greatest Radio Contact — *CQ VHF* and *Amateur Television Quarterly*

Please take time to visit the sponsor's websites:

OnSet Computing
www.onsetcomp.com

ATV Quarterly
www.hampubs.com

Kaymont
www.kaymont.com

CQ VHF
www.cq-vhf.com

The ARHAB community is interested in looking for more sponsors. If you are interested in spurring innovation in amateur near space, please consider sponsoring one of this year's competitions.

The rules for the 2005 ARHAB Competitions are pretty simple.

1. The maximum altitude of the near spacecraft is determined by data generated from its onboard GPS receiver (transmitted and/or captured onboard).

2. All distances are measured in great circle distances and will be determined by a GPS receiver or mapping software.

3. Data generated by the onboard GPS receiver is required to determine telemetry ranges.

4. Due to GPS errors, any differences in distance less than one mile, altitudes less than one foot, and times less than one minute are considered ties.

5. The 2005 competitions are open to entrants worldwide.

6. So that ARHAB groups will know to monitor a competition attempt, flights must be announced at least 24 hours before launch to be considered for a record (notify ARHAB on their website).

7. All attempts must comply with applicable regulations, like FAR 101 (a statement of compliance is sufficient).

8. Results from the attempt, including all pertinent data, must be posted on a website ASAP.

9. In order to advance the state of the art, all hardware and software used in an attempt must be open source.

10. To accommodate those flying without a GPS receiver, there is no minimum altitude a flight must reach to be eligible for any record attempt (except for those vying for altitude and telemetry records, which requires an onboard GPS to be valid).

11. Because near spacecraft are occasionally lost, near spacecraft have until the end of 2005 to be recovered. The one exception is when the near spacecraft is proven to be lost in a completely inaccessible area (like the Atlantic Ocean).

12. The rules, decisions, and awards are at the sole discretion of contest officials.

You can track this year's competitions at Ralph Wallio's ARHAB website: **http://users.crosspaths.net/wallio/RECORDS.htm**

To announce an attempt, email Balloon_Sked@yahoogroups.com

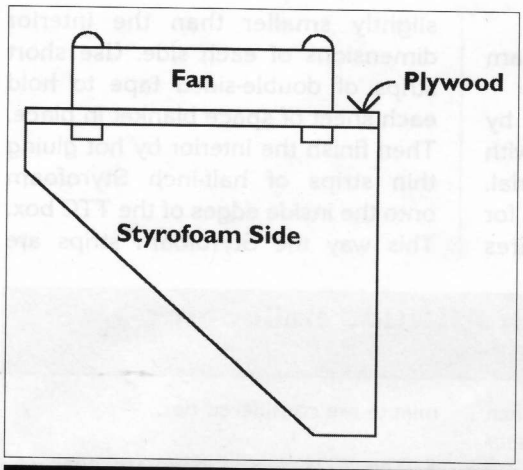


Figure 5. The fan mounting base is shown here.

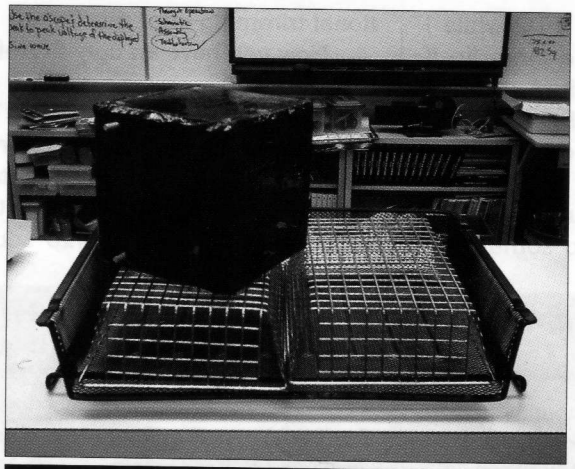


Figure 6. This is how the baskets are placed.

glued to the interior of the TTC and sandwich the edges of the space blanket.

Next, wrap the exterior of the TTC in space blanket material. After wrapping, tape the outside edges and corners of the TTC with aluminum tape to add durability to the space-blanket exterior.

Now, let's do the electrical work.

I used two small CPU fans to circulate cold air inside my TTC. The chart in Figure 4 shows the benefits of using fans. I cycled the fans on and off in 30-minute intervals, and during the test, I measured the temperatures inside and outside of a BalloonSat. You can see that the fans (remember, these are small fans) lowered the temperature by 10 degrees.

First, connect each fan to a battery so you can be sure the fans work before you modify them. The leads on the CPU fans are too short, so you need to extend their length. The fans are mounted to opposite sides inside the TTC, so keep that in mind when you extend the leads. Cover the solder wires with heat-shrink tubing before proceeding.

Cut the 1/8-inch modeling plywood into two squares that are one inch larger than the outside dimensions of the fans. Drill holes in the

plywood so you can bolt the fans to the plywood. Then use the #4 hardware to bolt the fans to the plywood. I only bolted two diagonal corners of each fan to the plywood. Next, cut two supports for each fan out of half-inch Styrofoam. I made mine triangular in shape and clipped the corners. Hot glue the supports to two opposite edges of the wooden fan base.

Locate two opposite sides inside the TTC to mount the fans. Mount the fans high, but not so high that the lid can't shut properly, as there must be some clearance above the fans to circulate air.

To mount my fans, I first trimmed two narrow strips from the space blanket. Then I hot glued the fan supports to the bare Styrofoam in the TTC sides and sandwiched the raw edges of the cut space blanket.

Drill a small hole in the wall of the TTC near the top, as the wires from the fans will exit this hole. To prevent the space blanket from ripping at the hole, cover the hole with a small square of aluminum tape. Pass the wires of each fan through the exit hole you drilled in the walls of the TTC. Use tape to immobilize the wires of each fan against the interior walls of the TTC.

Now seal the exit hole with hot glue on the inside and outside of the TTC.

Slide the jacket of the power plug over the fan wires. Then solder the ends of the wires together and to the tabs of the power plug. I like to put a drop of hot glue over the soldered tabs of the power plug to make sure the interior of the power plug is well insulated. Slide the jacket of the power plug back over the soldered tabs and screw it closed. Change the power plug on your wall-wart power supply to match the fans' power plug. When you're done, plug in the wall-wart and apply power to the fans.

They should spin up and begin moving air. I can't verify this, but I suspect that the larger the fans, the

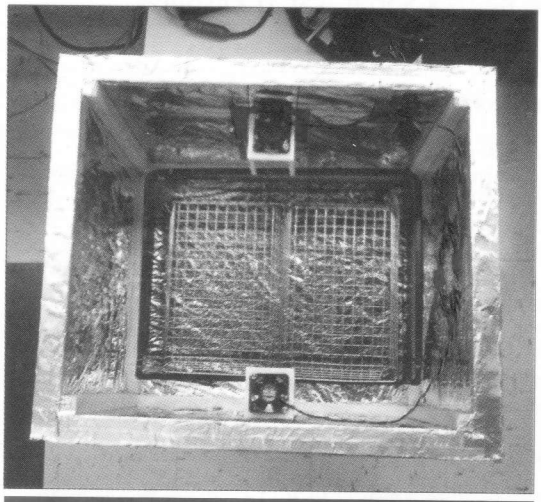


Figure 7. Inside the thermal chamber.

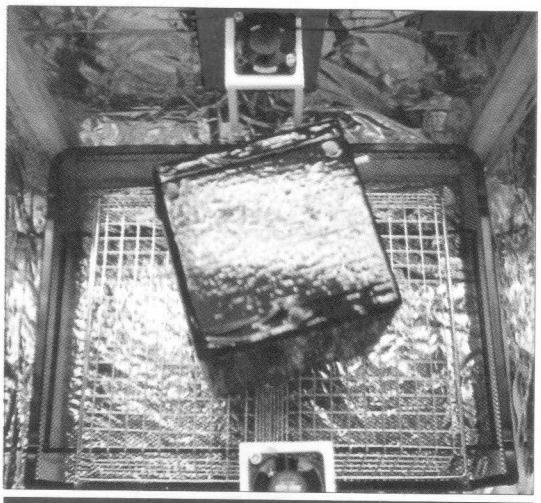


Figure 8. One of my BalloonSats undergoing testing.

cooler the interior of the TTC (unless the fans are so large they generate lots of heat).

To assemble the dry ice chamber, I used two desktop metal mesh letter baskets and one wire mesh "in" basket. The larger "in" basket holds two chunks of dry ice, and the two smaller letter baskets cover them. The open-mesh design allows air to circulate freely around the dry ice while keeping the device undergoing testing and the space blanket inside the TTC from making direct contact with the dry ice.

Using the TTC

First, you need to get a victim to test. Purchase about a pound of dry ice and break it into two or more pieces. Use gloves when handling dry ice, as getting frostbite is not a good source of entertainment. Put the "in" basket into the TTC and place the two chunks of dry ice onto it. Place the letter baskets over the dry ice and then place the item to test on top of the upside down letter baskets. Close the lid and let the TTC sit. Temperatures inside the TTC will drop to below zero within 30 minutes. NV