

Test Report - VxScan v4.0 Ballot Box LP1 material Cold Storage Test (lo-fi)

Pius Wong Aug 29, 2024

Purpose

This is a basic test to see if the fabric and flexible materials used in the VxScan v4.0 ballot box LP1 and LP2 prototypes can withstand a cold storage test similar to that defined in VVSG requirements. This test could help evaluate if these parts would become brittle and crack in cold storage, especially if they are under stress and strain.

Background

NOVO Engineering helped design the LP1 and LP2 ballot box prototypes. Samples of the LP1 prototype were taken to analyze in cold testing.

Fabric (produced by EMKE) was cut out of the LP1 for testing. A separate fabric sample from EMKE also was provided for testing. Finally one of the thermoplastic polyurethane (TPU) straps on the ballot box was removed for testing.

Materials

1. Freezer

- a. [Insignia 14 cu. ft. garage-ready chest freezer](#) - Available at VxAustin as of Jun 17, 2024 (~\$300-\$400).



- b. Other freezers are fine if you can control the temperature and the size is large enough.

2. Thermometer-hygrometer

- a. [Govee thermometer-hygrometer H5705](#) - Available at VxAustin as of Jun 17, 2024 . Valid only between -5°F to 140°F. Works with associated [Govee app](#) for bluetooth data collection.
 - i. Ensure it has sufficient battery power (2+ bars out of 3). Replace the AAA batteries if needed.
 - ii. Plug in the [Govee smart space heater](#) to act as a “distributed gateway” for the device, to allow monitoring over wifi remotely. This smart heater is already configured with the VxAustin network as of Jan 1, 2024 , and coupled to the Govee app in Pius Wong ’s account. When logged into the app, you can monitor the thermometer data remotely.
 - iii. An alternative in the future may be [a wifi-connected similar device from the same brand](#). That way it can be monitored out of bluetooth range without the Govee space heater.
- b. [Analog freezer thermometer](#) - Available at VxAustin as of Jun 17, 2024 . Valid only between -20°F to 80°F. Backup to digital thermometer, and for lower temperature range, but less precise.

3. Test unit, testing tools, and documentation tools

- a. Sample of fabric provided by NOVO engineering
- b. Cutout of fabric from LP1.
- c. TPU strap from LP1.

Procedures

The test procedure below came from “Test E2-a” in broad test plans for VVSG compliance:
[Testing Plans - VxScan - Linked to VVSG & other requirements](#). Specific steps were as follows, only for testing the MCM, and not the ballot box nor UPS.

1. Check the test samples before testing.

2. Prepare the freezer for testing.

- a. Plan for at least 72 hours uninterrupted test time in the freezer past the initial stabilization time.
- b. Ensure there is no excess moisture/humidity inside the freezer. Let it air out if needed.
- c. Place protective material at the bottom of the freezer.
 - i. Thick corrugated cardboard is available at VxAustin. Pile it up to protect both the freezer internal surface and the test unit. You can also pile enough to align the test unit horizontally if desired.
- d. Place the thermometer-hygrometer in the freezer.

3. Prepare the test unit.

- a. Put the test unit into storage configuration.
 - i. For the samples, that meant folded up.

4. Freeze the test unit.

- a. Place the test unit in the freezer.
 - i. Photograph the unit for recordkeeping.
- b. Close the freezer.
- c. Condition the freezer. Plug it in and turn it on, aiming for a setpoint of -5°F.
 - i. Note time of turning on.
 - ii. Check the temperature without opening the freezer, if possible, to avoid introducing more humidity/condensation.
 1. Use the Govee app using the Govee thermometer.
 - iii. If possible, aim for a humidity of 25-55% relative humidity (RH).
 1. This isn't possible for the Insignia freezer at VxAustin. Instead the humidity was read for the duration of the test.
 2. If this is possible, then cycle the humidity over 24 hours, changing every 12 hours from 25% to 55%.

- d. Prepare to track internal freezer temperature after this time to see when temperature is stabilized again.
 - i. Note time of temperature stabilization.
 - ii. Add 72 hours (3 full days) to this time of stabilization; plan to turn off the freezer at this future date and time.
 - iii. Add a note to the freezer to prevent people opening it up and introducing temperature and humidity changes.
- e. Let the freezer sit until at least 72 hours have passed since stabilization.

5. Let the test unit naturally come back to room temperature and normal humidity.

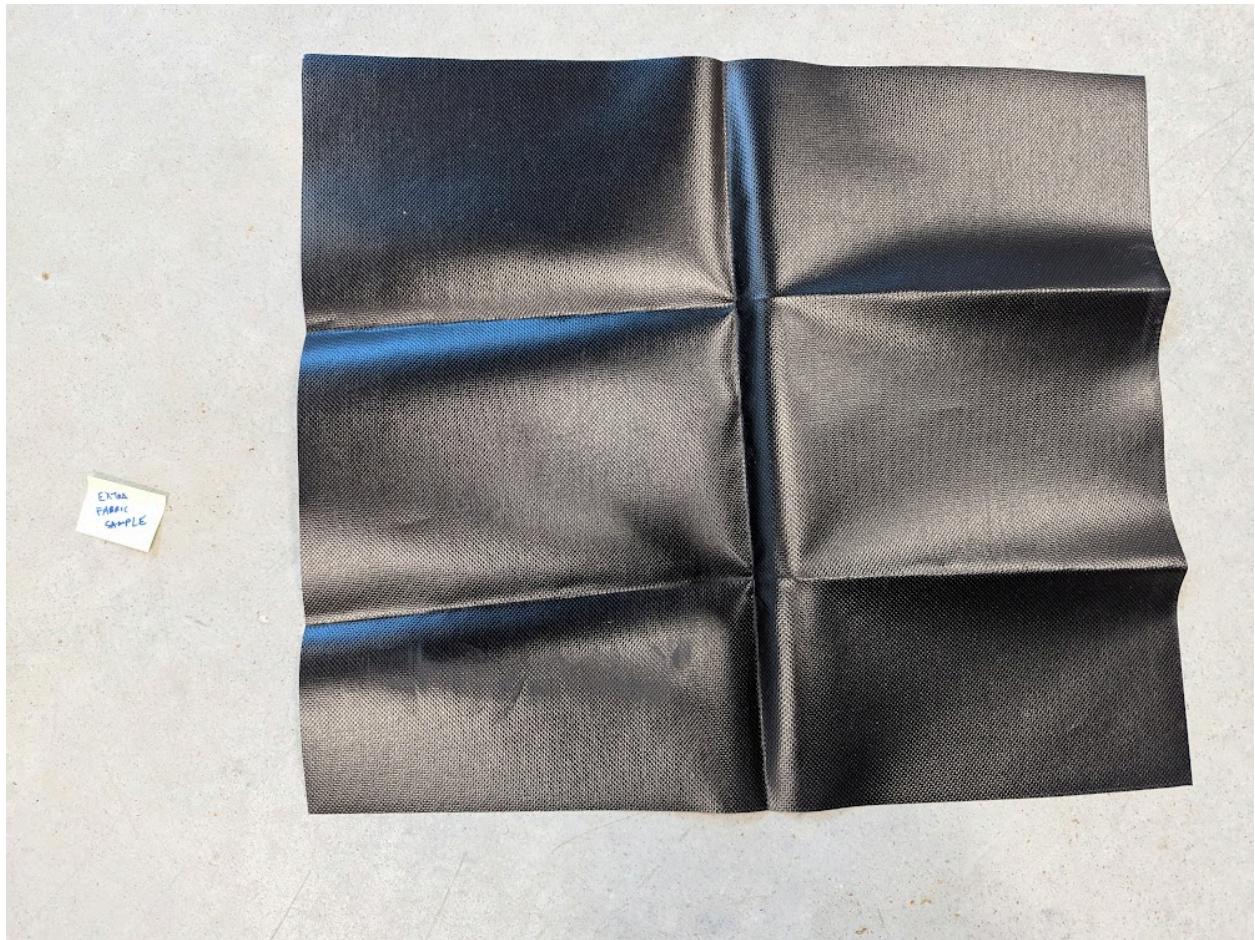
- a. At the end of the test period, turn down the freezer setting and unplug the freezer.
- b. Note the time of unplugging.
- c. Leave the freezer closed; do not open until either the inside has come back up to room temperature (60-80°F), or 24 hours has passed.
 - i. This is important to prevent condensation formation on or in the test unit.
- d. Open the freezer and take out the unit.
- e. Let the test unit sit outside to equilibrate for at least another hour.

6. Check the test samples again.

Results

1. Samples had minimal defects before testing.

- a. Fabric sample (see images below)



EVA
FABRIC
SAMPLE



b. Fabric cutout from LP1 (see images below)



L.P.S.
left wall,
right strap



L.P.S.
left wall
right wrap



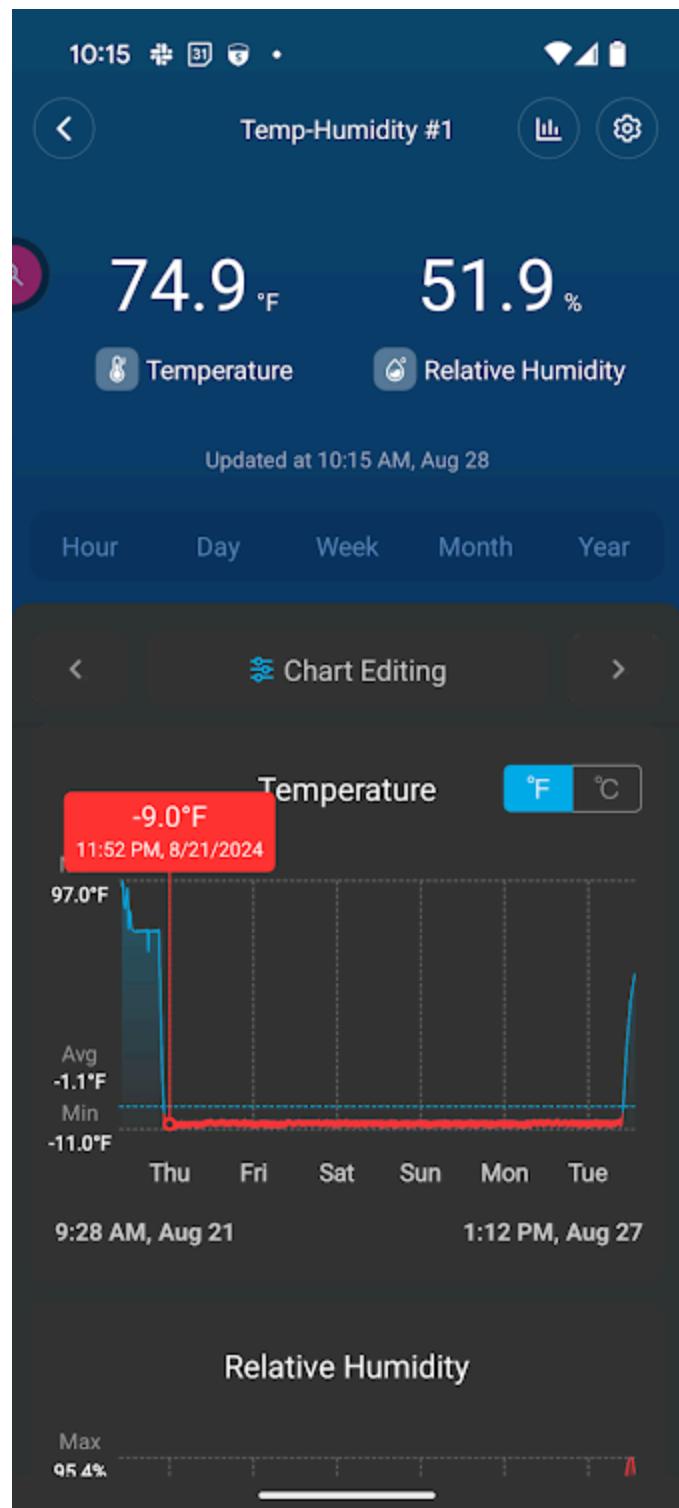
c. TPU strap from LP1 (see images above)

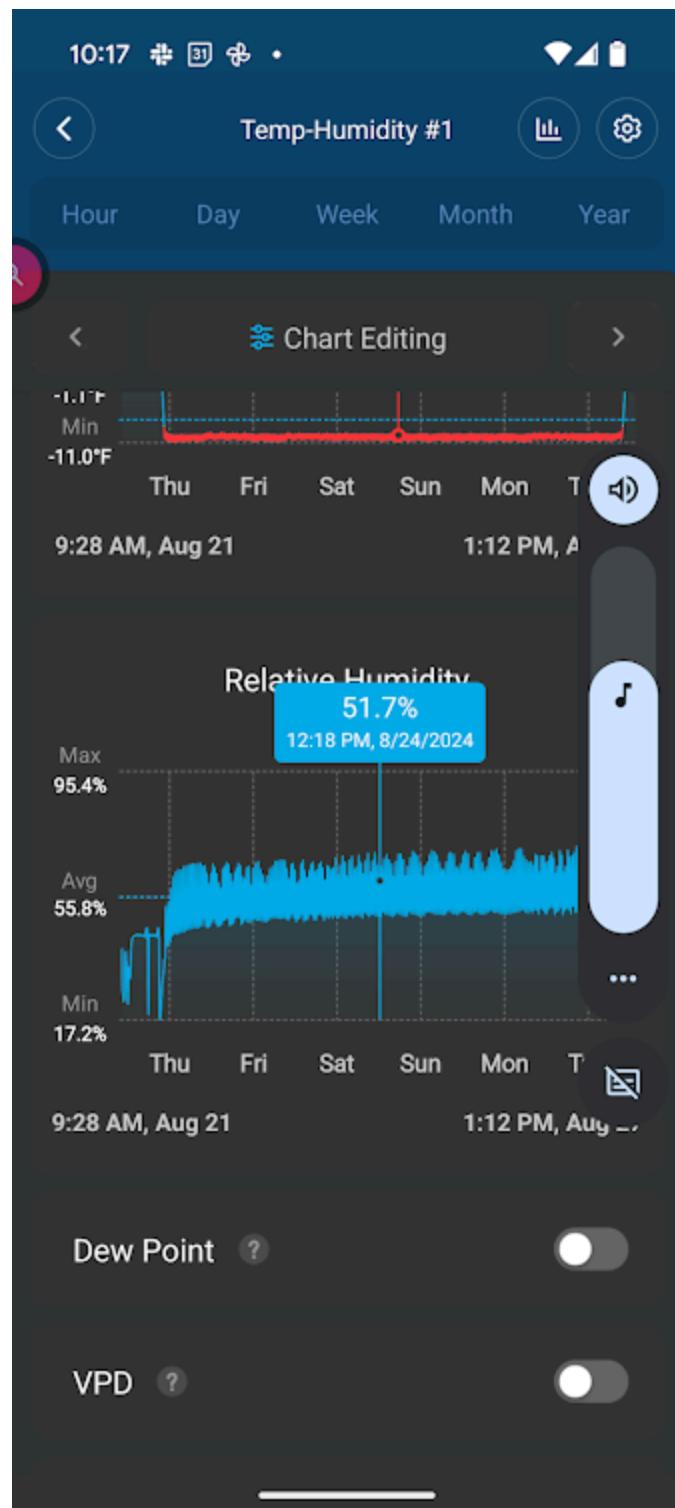
2. The samples were frozen for about 106 hours undisturbed.

- a. The MCM was placed in the freezer on 8/21/24 at about 5:30pm, starting at a temperature of 75°F and 46%RH. (see photo below of setup)



- b. The freezer held a temperature between -8 to -11°F (digital thermometer reading), and humidity of 50-60%RH, from 8/22/24 at about 12AM to 8/27/24 at about 9am when it was unplugged. It held these conditions for a total of about 129 hours. (See sensor data below)





- c. The samples were removed from the freezer on Aug 28, 2024 to analyze.

3. The samples had minimal defects after cold storage.

a. Fabric sample (see images below)





b. Fabric cutout from LP1 (see images below)





c. TPU strap from LP1 (see image below, reattached to LP1)



Conclusions

The LP1 fabric and strap likely can withstand cold storage.

The fabric and strap materials did not see any fractures, rips, tears, or other obvious damage after cold storage. This includes at folds, seams, and areas that may have seen bends or other stresses/strains.

Changes to Test Protocol in the Future

The TPU strap should have been stretched and bent more like how it would have been when in storage in the ballot box. This would have better represented the worst case expected scenario. However, [TPU products can remain flexible to -35C](#) (-31F), and so it is not expected that we would have seen embrittlement or a glass transition point of the strap at these warmer temperatures defined in VVSG cold storage of -20C (-4F).

References

1. [!\[\]\(7867ccc96698fb002c5a60a3a1283862_img.jpg\) dFMEA VxScan3.1/4.0 - VotingWorks - 20240207](#)
2. [!\[\]\(a185bcb38fbd8d6a6b157b5cb0e840ca_img.jpg\) Testing Plans - VxScan - Linked to VVSG & other requirements](#)
3. [Insignia 14 cu. ft. garage-ready chest freezer](#)
4. [Govee thermometer-hygrometer H5705](#)
5. [Govee app](#)
6. [Analog freezer thermometer](#)