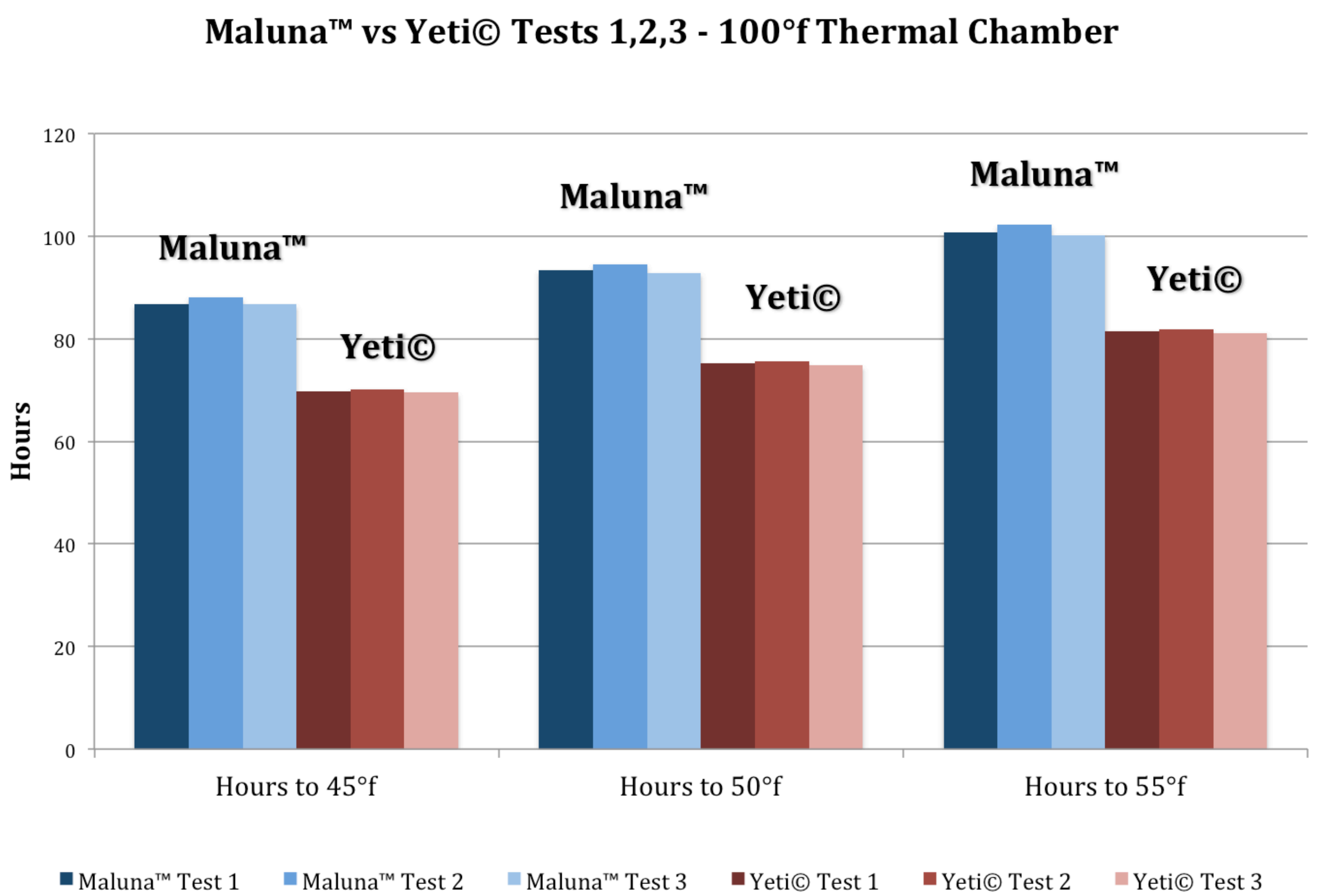
Maluna™ Unhinged™ vs Yeti© Tundra©
Thermal Performance Comparison – January 2017

Abstract
A Maluna™ Unhinged™ cooler was tested and measured for performance relative to a Yeti© Tundra© cooler. **Three identical tests were performed** in a controlled laboratory environment and conditions were set to create a typical user case scenario to keep beverages cold during hot Summer weather. **The Maluna™ cooler was determined to outperform the Yeti© cooler by more than 20%.**

Maluna™ Unhinged™ 50 (52.5 quart capacity) and Yeti© Tundra© 65 (57 quart capacity) in a 100°f thermal chamber with a case of beer and 22 pounds of ice each:



	Hours to 45°f			Hours to 50°f			Hours to 55°f		
	Yeti©	Maluna™	**Improve**	Yeti©	Maluna™	**Improve**	Yeti©	Maluna™	**Improve**
Test 1	69.7	86.8	**24.5%**	75.2	93.4	**24.2%**	81.5	100.8	**23.7%**
Test 2	70.2	88.1	**25.5%**	75.6	94.6	**25.1%**	81.8	102.2	**24.9%**
Test 3	69.5	86.7	**24.7%**	74.8	92.9	**24.2%**	81.2	100.2	**23.4%**

Introduction
Maluna™ Unhinged™ coolers were designed in 2016 to compete in the high performance cooler market where cooler construction is made up with a roto-molded shell and pressure injected polyurethane insulation. The generally accepted market leader for these coolers (as defined by brand recognition and perceived thermal performance) is the Yeti© Tundra© series of coolers.

Maluna™ coolers were designed to be unmatched in performance, features and value. While there have been unscientific and uncontrolled performance tests by the consumer community, Maluna™ set out to create a cooler that outperforms a comparable Yeti© cooler in a controllable, measurable and scientific manner.

This test document outlines work that Maluna™ has performed which measures relative performance differences between a Maluna™ Unhinged™ cooler versus a comparable Yeti© Tundra© cooler, and provide evidence that these measurements are repeatable.

The Maluna™ Unhinged™ cooler was designed to outperform Yeti© coolers and other competition through innovation:

- Unhinged™ design: A primary source of improved performance is the patent pending Unhinged™ design. This design creates a floating lid with an oblong hinge pin hole that provides the lid freedom of vertical movement on every edge of the cooler when it is shut. It has rear tensioning straps that when shut, provides downward tension along the rear edge to match the same tension from the front straps and create a uniform seal.
- Seal design: While the competition uses 'freezer style' gaskets to seal between the lid and tub, the Maluna™ Unhinged™ cooler has designed a seal that was tested and optimized to be a high performance cooler gasket, not a freezer gasket.
- Tapered walls: Maluna™ coolers have walls that taper up from a standard wall thickness at the bottom of the cooler to increase wall thickness toward the top of the cooler to increase wall thickness by 50%. This provides more insulation at the top of the cooler where it is most important, and also provides a larger footprint for the specially designed high performance cooler gasket.
- Material selection: The materials sourced for the construction of Maluna™ coolers include a proprietary blend of additives to improve performance and durability. The polyurethane insulation has additives to eliminate or minimize any air bubbles and create a uniform and optimal density of insulation throughout the cooler. The polyethylene shell was designed to minimize thermal conductivity through the shell.
- Insulated drain plugs: Maluna™ Unhinged™ coolers come with a standard drain plug and an optional patent pending thermometer drain plug. Both of

these drain plugs are manufactured with insulation inside to ensure complete and optimal thermal protection.

A scientific and controlled environment is required to properly measure relative performance.

- Controlled: There are many variables that determine how long a cooler will hold temperature. To compare thermal performance between two coolers, it is necessary, among other things, to control identical ambient temperature environments, mass of payload, specific heat of payload, starting temperature of payload (including temperature of ice), pre-conditioning of coolers, arrangement and form factor of payload (ice shape and size), exposure to sunlight, and of course temperature data capture.
- Relative: It is not reasonable to state an absolute amount of time that a cooler will hold ice without qualifying the environment. All else held equal, the amount of time that a superior cooler will outperform an inferior cooler is relative to the temperature difference between outside ambient temperatures and the temperature inside the cooler. As an example, if the temperature difference outside and inside the coolers double, the absolute amount of time that the coolers hold ice will be halved, but the relative percentage of time difference between the two will stay constant. It is reasonable and acceptable to state a relative percentage difference of time that two coolers will hold ice in a controlled environment.

Purpose

This test is intended to establish and quantify the relative thermal protection performance between the Maluna™ Unhinged™ cooler and the Yeti© Tundra© cooler.

Scope

This test will determine and control a typical user case scenario of keeping beverages cold during hot weather, and will calculate the percentage difference of time that the coolers will hold temperature in that single user case scenario. In this scenario, the only differences are the coolers. This test is not designed to evaluate relative performance differences as controlled variables are changed or stressed. Differences from effects of sunlight, wind, different ambient environments, or anything else are not changed or considered. The effect of fluctuating temperature between day and night cycles is not considered, and also would not be practical for calculating relative thermal protection performance differences.

Materials & Methods

<u>Materials</u>

- Thermal chamber with thermostat control designed to hold a constant temperature and accept two coolers in identical fashion at the same time.
- Maluna™ Unhinged™ 50 cooler (52.5 quarts actual volume)

- Yeti© Tundra© 65 cooler (57 quarts actual volume)
- 24 Cold beers each cooler
- 22.0 Pounds of ice for each cooler (approximately 1.0” cubes)
- 13 Probed temperature recorders with new batteries – Deltatrak model 20902
- 1 in each cooler: 12oz cold bottle of water prepared with an internal temperature probe
- 1 in each cooler: Drain plug prepared with a temperature probe to the inside of the plug

Methods

- *Symmetrical chamber:* The thermal chamber used is designed to have perfectly symmetrical characteristics to perform A/B tests. Thermal chambers can have varying temperatures in different areas within the chamber, but a symmetrical chamber mitigates these conditions because it is the same differences for either cooler placement within the chamber. In this case, heat inlet and heat exhaust are directly across from each other, in the middle and between each cooler placement. Each cooler placement is exposed to identical conditions. Each cooler is placed equal distance from each side wall with similar distance from each other. Chamber seams where the lid opens and may create temperature changes are also symmetrical between the two sides. Multiple probes are placed symmetrically to confirm identical conditions for each cooler.

- *Pre-conditioning:* Care is taken to pre-condition the coolers and payload identically. Both empty coolers are pre-conditioned for a minimum of 48 hours next to each other in room temperature conditions (68°f -70°f) with lids open, drain plugs removed, away from any direct sunlight exposure. Payload must be exact same beginning temperature. This is accomplished with a splitting method; for instance, 48 pre-chilled beers in a refrigerator can have different temperatures depending where they are in the fridge (colder in the back, or warmer in the front by the door). Rather than removing the front 24 and place in one cooler and remove back 24 into the other cooler, splitting method removes them and places “one for me one for you” routine while placing into the coolers. Same is done as the ice is removed from freezer. Exactly 22 pounds of ice is measured for each cooler. It is also important that both payloads have exact same treatment during measurement and transport into controlled environment (time of exposure and handling methods must be identical). Pre-conditioning target temperature for ice is 0°f, and the target pre-conditioning temperature for beers and probed water bottles is 36°f. Thermal chamber is not pre-heated, it is conditioned to room temperature with the lid open because the heat up cycle is very fast.

- *Data recorder placements:* 8 temperature data recorders are placed around the chamber, 4 on each side and completely symmetrical from each other. One above the cooler, one to the side wall of the cooler, one on the front wall in front of the cooler, and one on the back wall behind the cooler. All of them symmetrical to the placement of the probes of the other cooler. This is to confirm chamber symmetry and create redundancy for any failed data recorders. One additional data recorder is placed in the center of the chamber at the heat inlet source. 1 data recorder each is placed through each drain plug to measure internal temperature just inside the wall of the cooler. 1 data recorder each is placed with the probe inside a 12oz water bottle placed in the direct middle bottom of the cooler.

- *Payload placement:* 24 pre-chilled beers are placed standing up in the bottom of the cooler, surrounding the single pre-chilled probed water bottle. Any of the 24 beers that do not have room to stand up are placed on their side on top of the other beers. The ice is scattered over the top of the beers and water bottle until is it level across the entire cooler, while we make sure there is no "mounding" or ice stuck together during the process. The ice is not tamped, it is poured in to settle itself. Payload exposure during placement is exactly the same and the lids to the coolers are closed and strapped down at the same time.

- *Data recording settings:* Each data recorder is set manually to start data recording and to capture temperature readings every 2.5 minutes for up to 6.5 days which is maximum capacity for data points recorded, and most granular frequency for expected potential duration. Data recorders are set to begin capturing data as soon as cooler lids are strapped shut, chamber is shut and heater is turned on.

- *Temperature setting:* The temperature of the thermal chamber is set to a constant 100°f.

- *Duration:* Conditions are maintained and data is captured until both coolers drain plug probes have reached a minimum temperature of 60°f.

- *Repeatability:* The test is performed 3 times to confirm and ensure repeatability.

Exceptional Conditions

Individual cooler samples: Each of the three tests used 3 different individual Maluna coolers that were randomly selected from production. However, each of the three tests used the same cooler sample from Yeti© which was a brand new Yeti© Tundra© 65 purchased at a retail location and went directly to testing. Based on the 3 samples from Maluna™, there appears to be very little performance deviation among them. A full analysis of individual performance deviation from different production units from either manufacturer was not within the scope of this test.

Different sized coolers: At the time of testing, the only production cooler available from Maluna™ to test was the Unhinged™ 50 cooler which has an actual capacity of 52.5 quarts. The closest available cooler from Yeti© to test was the Tundra© 65 with an actual capacity of 57 quarts. Capacity may affect the ability of a cooler to hold temperature, and generally accepted that a smaller capacity cooler may have an advantage, but may be slight and not a measurable difference with a pairing this close. This cooler pairing was the closest possible (Yeti© Tundra© 50 has an actual capacity of 44 quarts).

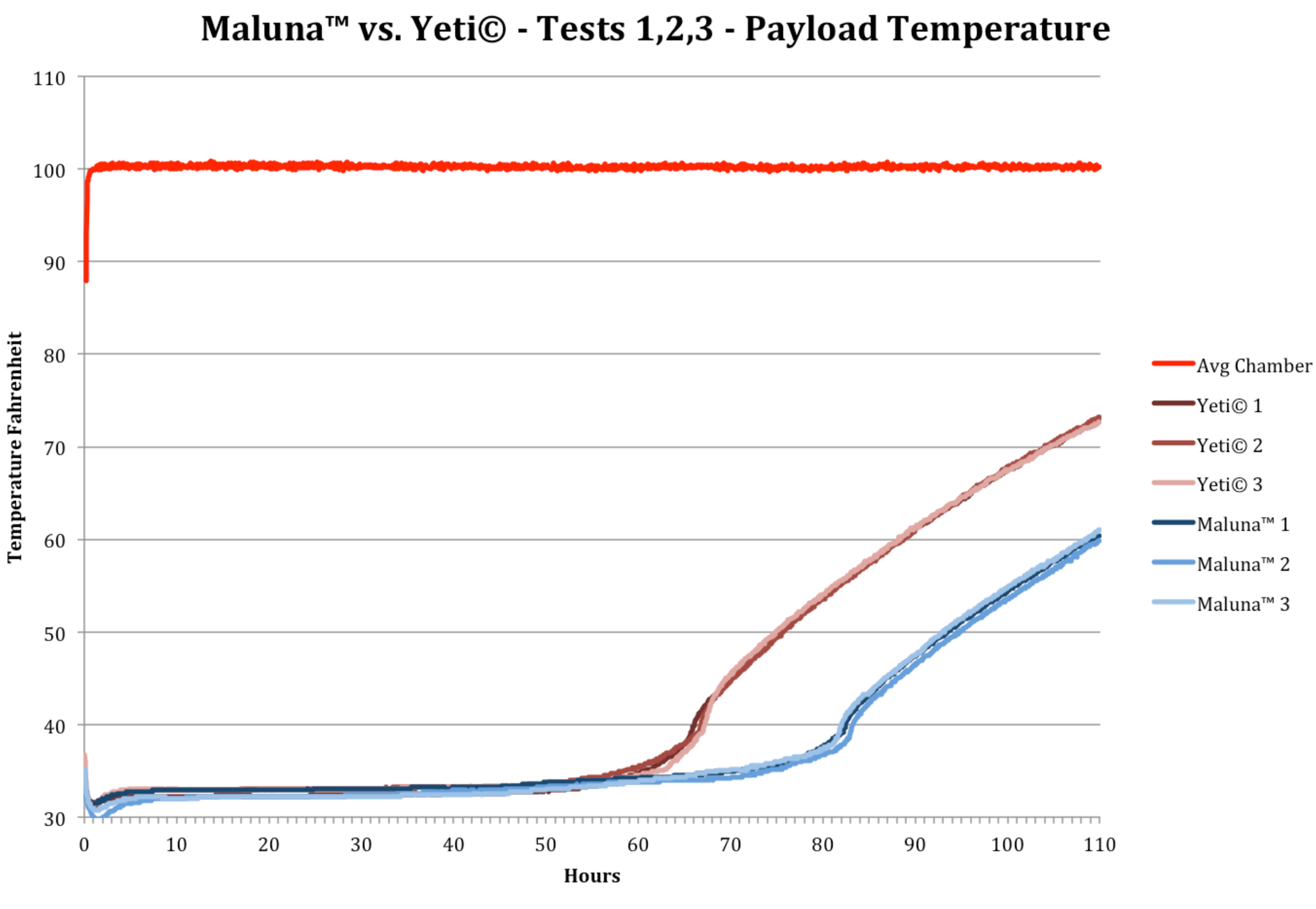
Thermostat control: Temperature control for the thermal chamber is a mechanically controlled heater that cycles on and off to maintain a constant mean temperature. With a setting of 100°f, the temperature may cycle +/- 2.5°f above and below 100°f on approximately 6 minute cycle time and 50% duty cycle. This method of thermostat control is instead of a more stable solid state controlled pulse width modulated heater that maintains a more constant temperature using a proportional–integral–derivative controller (PID controller). This is noted as an exceptional condition, but with the test conditions used, and the high frequency of cycle time, it is not considered to have any effect to the results and conclusions.

Drain plug: The Maluna™ Unhinged™ coolers come standard with a polyurethane insulation filled drain plug, and an optional insulation filled drain plug with an electronic readout of internal cooler temperature. The drain plugs used for both coolers for this test, were modified Yeti© drain plugs that were drilled to accept a temperature probe. This was done because they were well suited to internally seal the probe hole with water proof silicone sealant. It is expected that the Maluna™ cooler may have performed better with the insulated drain plug it was designed to use.

Drain plug readings: The metal probe tips that were positioned through the drain plugs have a tip that reads temperatures just inside the bottom wall of the cooler. When payload is placed into the cooler (before any ice has melted), these tips can either be touching an ice cube, or be suspended in air between ice cubes and beer cans. A probe tip touching an ice cube can have a reading of 32°f or lower (prior to fusion), and a tip suspended in air can have a reading more than 40°f if not touching ice or a beer can. As ice melts, and probe tips submerge under water the drain plug probe readings then equilibrate. This has no effect on conclusions, as the measurements used for cooler performance are from the center placed water bottles with submerged probes.

Drain plug orientation: While the thermal chamber is designed to be perfectly symmetrical, drain plug orientation when cooler is facing inward or outward is not symmetrical. For instance, the coolers are placed in the chamber so that heat flow is from one end of the coolers to the others. If both coolers are placed in the chamber facing inward so that both coolers have front straps facing each other, then one cooler has a drain plug facing the inlet side, and the other cooler has a drain plug facing the exhaust side. If both coolers are oriented so that drain plugs are on the same side of the chamber, then one cooler would have front straps facing inboard, and the other cooler would have front straps facing outboard. It was determined to prioritize front strap symmetry so that the drain plug placement either on inlet side or exhaust side is not symmetrical. Drain plug orientation was rotated for each test and was determined to not be a material variable and have immeasurable impact to the results.

Results



	Hours to 45°f			Hours to 50°f			Hours to 55°f		
	Yeti©	Maluna™	**Improve**	Yeti©	Maluna™	**Improve**	Yeti©	Maluna™	**Improve**
Test 1	69.7	86.8	**24.5%**	75.2	93.4	**24.2%**	81.5	100.8	**23.7%**
Test 2	70.2	88.1	**25.5%**	75.6	94.6	**25.1%**	81.8	102.2	**24.9%**
Test 3	69.5	86.7	**24.7%**	74.8	92.9	**24.2%**	81.2	100.2	**23.4%**

Discussion
The test protocols were executed without any exceptions. There were no failed temperature recorders or interruptions to the controlled variables during testing.

In a stable temperature environment, such as the 100°f thermal chamber, the relative performance difference can be calculated as the additional amount of time required to reach certain temperature thresholds. In this case, three thresholds were chosen within a reasonable temperature range that represents a range of temperature after the ice has completed it's fusion process (melted). The three temperature thresholds chosen were 45°f, 50°f, and 55°f.

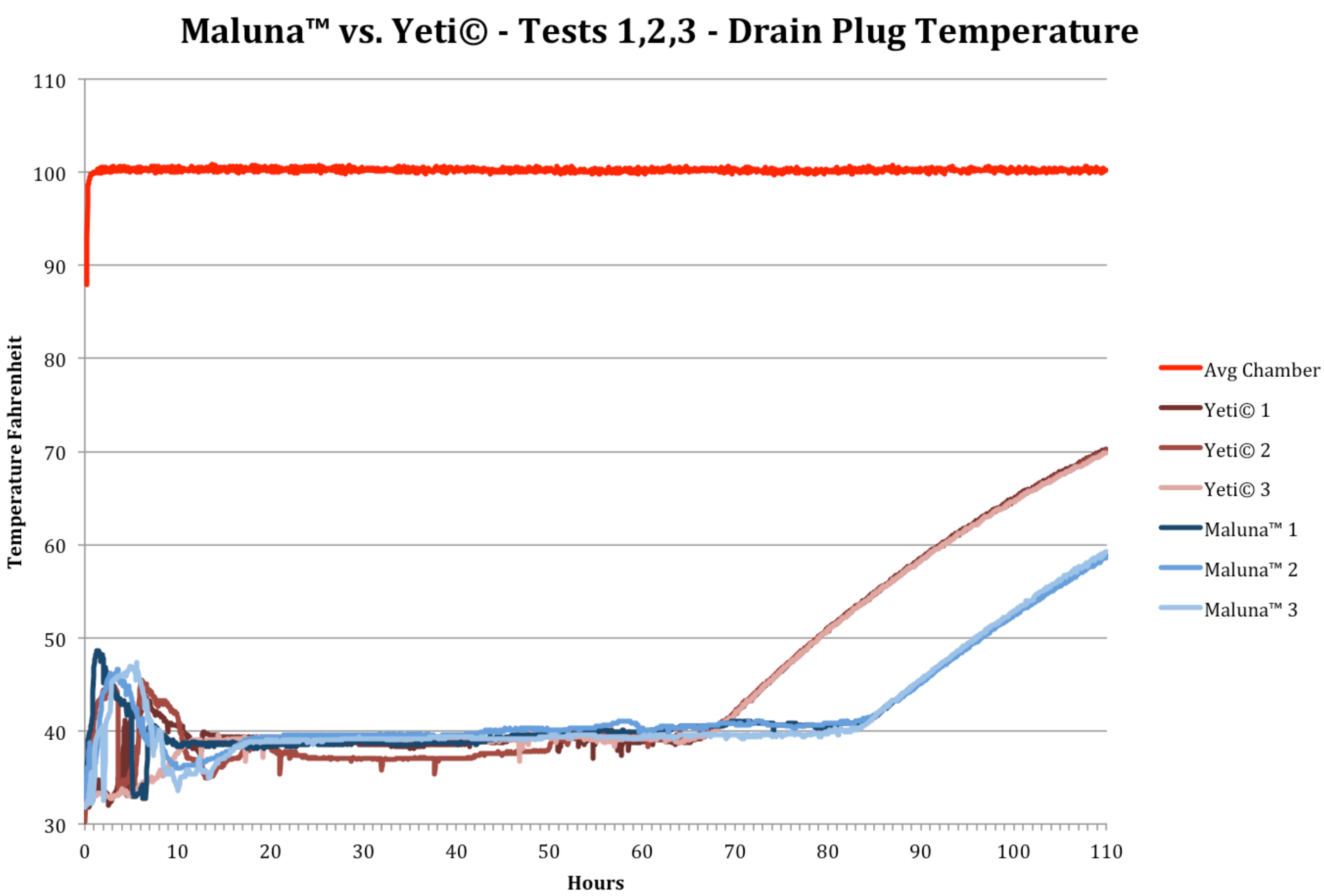
During the three tests, the Maluna™ cooler required between 17.1 and 17.9 additional hours for the probed water bottle to reach a temperature of 45°f, which is an improvement of 24.5% to 25.5% over the Yeti© cooler. The Maluna™ cooler required between 18.1 and 19.0 additional hours for the probed water bottle to reach 50°f, or 24.2% to 25.1% improvement over the Yeti© cooler. The Maluna™ cooler required between 19.0 and 20.4 additional hours for the probed water bottle to reach 55°f, or 23.4% to 24.9% improvement over the Yeti© cooler.

The data exhibited expected behavior. The temperature of the probed water bottles initially dropped from pre-conditioning temperatures, even temporarily below freezing because it was surrounded by ice that was pre-conditioned at 0°f. As the ice began it's fusion process, the probed water bottles settled into a stabilized temperature at or just above the ice melting point of 32°f. After the ice completely melted, the temperature rise displays an expected convex shape as the rate of temperature rise begins to slow as the difference between internal cooler temperature and ambient chamber temperature of 100°f begin to approach each other.

The displayed chamber temperature in the graph represents an average of all 9 temperature probes from each test, and represents an average of the trailing 15 minutes chamber temperature to smooth out the swings from the thermostatically controlled swings of temperature of approximately +/-2.5°f on 6 minutes cycles with approximately 50% duty cycle (3 minutes temperature rise from ~97.5°f to ~102.5°f, followed by 3 minutes temperature drop from ~102.5°f to ~97.5°f). Essentially, the displayed chart of chamber temperature displays an average chamber temperature of 100.2°f for all 3 tests (2,641 data points over 110 hours), the actual calculated averages for all 3 tests are 100.1°f, 100.3°f, and 100.2°f for tests 1, 2, and 3 respectively.

Each cooler was arranged with 2 internal probes. One probe was submerged in a 12oz water bottle in the middle of the payload mass as a representation of beverage temperature. The second internal probe in each cooler was through the drain plug to take an internal temperature just inside the cooler wall, which was submerged in a bath of water after the ice melted a sufficient amount.

The drain plug probes exhibited expected behavior and similar performance results:



DRAIN PLUG PROBES

	Hours to 45°f			Hours to 50°f			Hours to 55°f		
	Yeti©	Maluna™	**Improve**	Yeti©	Maluna™	**Improve**	Yeti©	Maluna™	**Improve**
Test 1	73.4	89.4	**21.8%**	79	96.1	**21.6%**	85.2	103.6	**21.6%**
Test 2	73	89.7	**22.9%**	78.9	96.4	**22.2%**	85.4	104	**21.8%**
Test 3	73.2	89.3	**22.0%**	79	95.8	**21.3%**	85.4	103	**20.6%**

The performance improvement of the Maluna™ cooler as measured at the inside of the drain plugs was still more than 20%. However, while the drain plug probes exhibited similar, consistent, and expected behavior, the performance improvement at the drain plug probes was not as great as the beverage probe. The beverage probes had a range of improvements between 23.4% and 25.5%, while the drain plug probes had a range of improvements between 20.6% and 22.9%. While this test was designed to measure performance difference as measured in the center probed water bottle, it was not in the scope of this test to determine cause of differences between probe locations. The results are presented as a matter of interest. It is speculated that the difference may be caused by difference in cooler shapes. The Maluna™ cooler has a slightly taller shape with smaller footprint, while the Yeti© cooler is more spread out. It is possible that a shape closer to a cube holds a temperature at center of payload mass more effectively than a shape closer to a pancake.

A close look at the data shows a consistency in the chamber symmetry. An analysis of the first 110 hours of each test (2,641 data points each probe) shows that the different locations within the chamber can differ in temperature range (3.9°f test 1, 3.5°f test 2, 3.5°f test 3). However, the average difference in temperature between the two cooler locations using 4 symmetrical probe locations each are within 0.9°f for test 1 (advantage Yeti©), 0.3°f for test 2 (advantage Maluna™), and 0.1°f for test 3 (advantage Yeti©).

	110 HOUR AVERAGE TEMPERATURES (°F)		
	TEST 1	TEST 2	TEST 3
Chamber Variance			
Both Tops	100.6	101.5	100.6
Both Sides	101.7	101.6	101.6
Both Fronts	100.4	100.6	101.1
Both Rears	97.8	98.0	98.0
Center Inlet	100.2	99.2	99.3
Symmetry			
Maluna™ (top, side, front, rear)	100.6	100.3	100.4
Yeti© (top, side, front, rear)	99.7	100.6	100.3

Conclusion

This test was designed to establish and quantify the relative thermal protection performance between the Maluna™ Unhinged™ cooler and the Yeti© Tundra© cooler. This performance difference was tested using typical user conditions to keep beverages cold during hot Summer weather.

The test was executed according to written protocols without any exceptions or failures. An analysis of the data shows that the experiment showed no unusual or unexpected behavior. The controls in the experiment were maintained and the conditions that both coolers were exposed to were identical.

An analysis of the recorded temperature data of a beverage placed in the center of payload mass of both coolers shows that the **Maluna™ Unhinged™ cooler held ice and beverage temperatures for more than 20% longer duration than the Yeti© Tundra© cooler**. This result was shown to be repeatable using three tests of identical conditions.

Data Package
See attached raw data package addendums, one for each test.