Cooler Research: An evaluation of Block ice vs. Bottle ice.

Introduction

Coolers or “ice chests” are commonly used to store food and beverages when electricity is not available. Refrigerated storage helps prevent sickness due to foodborne microorganisms. The National Park Service “2016 Commercial Operating Requirement” states that commercial operators must keep “potentially hazardous” food at or below 45° F (7.2° C). (Ref. 1)

This third Cooler Research article evaluates bottle ice compared to block ice.

Methods and Materials

The experimental setup and protocol was described in a previous article (Ref. 2) and remains the same. Experiments were conducted at a room temperature of 107.2° F.

24.0 kilograms of ice were used in each cooler which is 47% of the manufacturers stated capacity of 113 pounds. The block ice was prepared as described in a previous publication (Ref. 2). The bottle ice was 12 two liter soft drink bottles, each filled with two liters water.

Experiments were initiated by removing the ice from a freezer, loading it immediately into coolers and closing the coolers.

Each cooler lid was held down using two NRS-9 tie-down straps around the lid and cooler.

Results

The results for each cooler are described below and the data presented in graphs. The temperature at the Bottom, Mid-Low and High sensors is plotted vs the hours since closing the cooler. For both coolers there is an initial period (Phase1) of ~10 hours when the freezer temperature ice is warming up. The header of the graph identifies the vertical position of each sensor in the cooler: (High, Mid-Low, Bottom). A red dotted horizontal line shows the Park Service upper limits for Commercial Operators. A blue dotted horizontal line shows the freezing point of water. In the graphs and summary table, we included the data for Drained vs Undrained Blocks from our previous article (Ref 2) for comparison.

Bottom: The results for the temperature at the Bottom are plotted in Fig 1.

The temperature stays below the Commercial Operators Limit of 45° F for 70.5 hours for the Horizontal Bottles and 80.6 hours for the Vertical Bottles.

Mid-Low: The results for the Mid-Low temperature are plotted in Fig 2.

The temperature stays below the Commercial Operators Limit of 45° F for 43.6 hours for the Horizontal Bottles and 77.3 hours for the Vertical Bottles.

High: The results for the High temperature are plotted in Fig 3.

The temperature stays below the Commercial Operators Limit of 45° F for 4.4 hours for the Horizontal Bottles and 9 hours for the Vertical Bottles.

Fig 1.

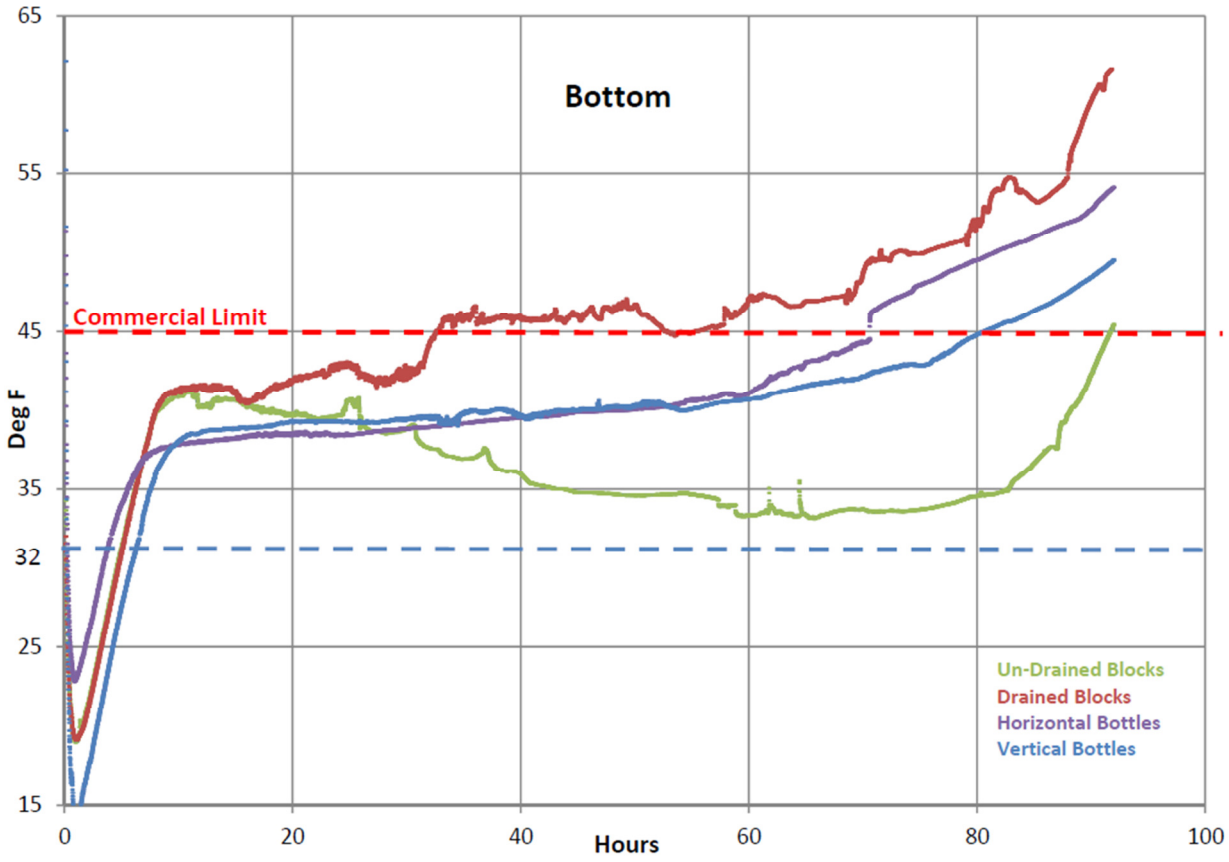


Fig 2.

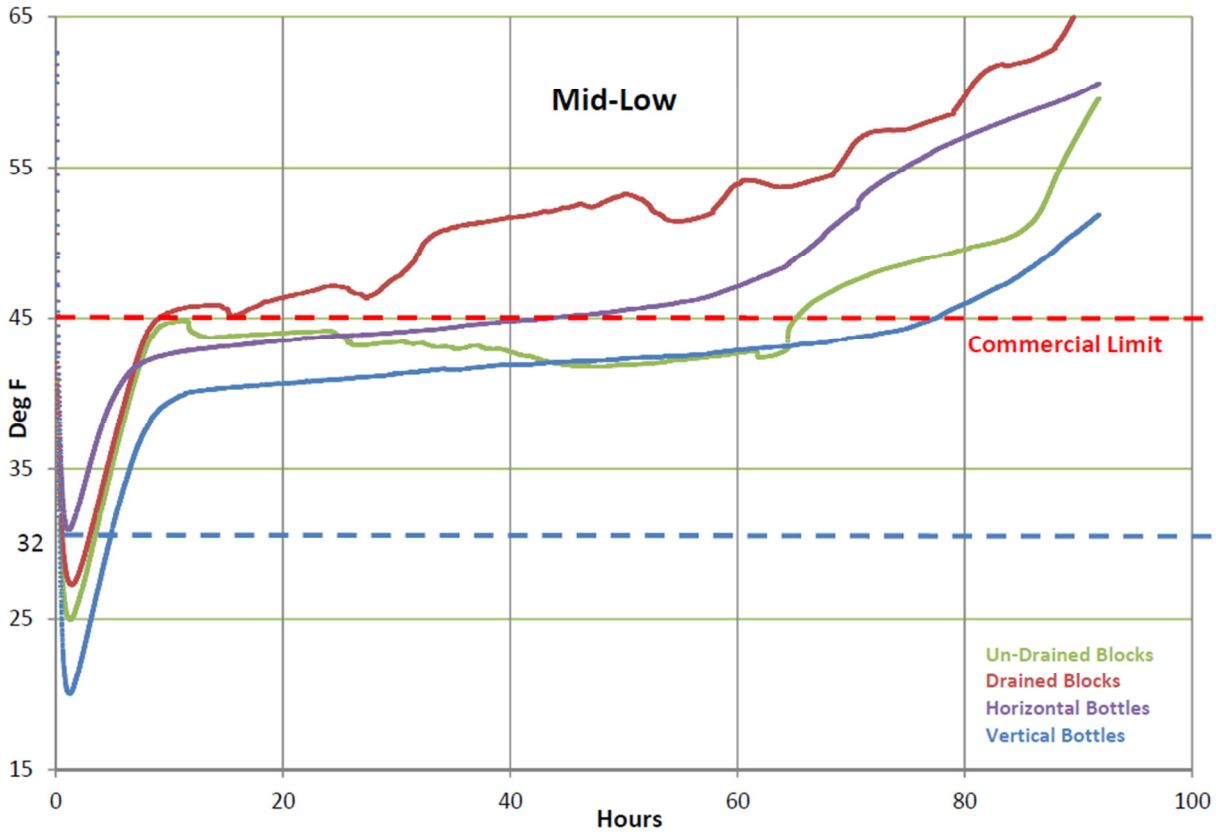
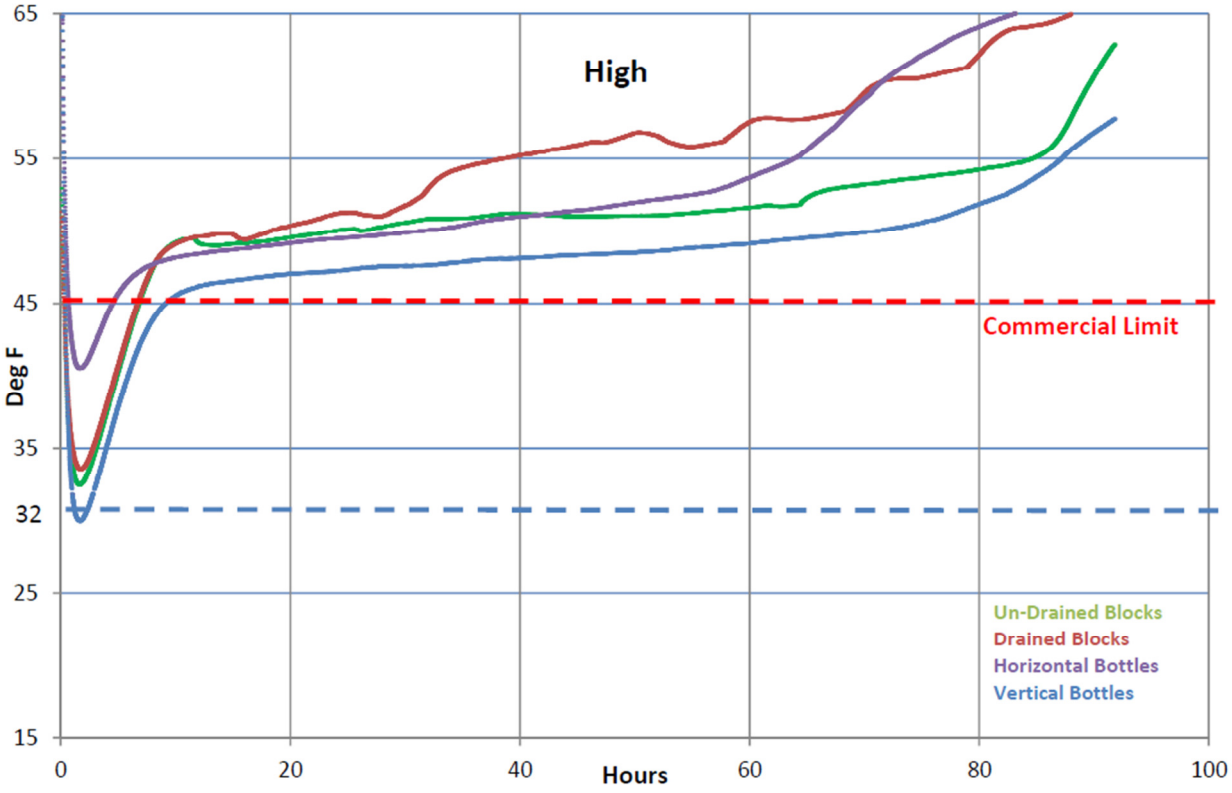

Mid-Low
65
55
45
35
32
25
15
Deg F
0
20
40
60
80
100
Hours
Commercial Limit
Un-Drained Blocks
Drained Blocks
Horizontal Bottles
Vertical Bottles

Fig 3.


High
Commercial Limit
Deg F
65
55
45
35
32
25
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0
20
40
60
80
100
Hours
Un-Drained Blocks
Drained Blocks
Horizontal Bottles
Vertical Bottles

Discussion

The Table below summarizes the results.

	Drained Blocks	Un-Drained Blocks	Horizontal Bottles	Vertical Bottles
Sensor Location	**Hours below Commercial Limit**	**Hours below Commercial Limit**	**Hours below Commercial Limit**	**Hours below Commercial Limit**
High	~7	~7	4.4	9
Mid-Low	9	65	43.6	77.3
Bottom	32.5	91.6	70.5	80.6

In our prior articles, we detailed the difference in performance between a drained and undrained cooler. The undrained cooler outperformed the drained cooler at all sensor levels, due primarily to the high heat capacity of the retained meltwater. While enhancing the cooling performance, the retained meltwater may pose a food safety issue itself. Water could leak into food containers and affect the integrity of the packaged product. Freezing water in containers solves this problem. Meltwater is contained and the high heat capacity of the mass of water is preserved. An added benefit is the contained water presents a source of potable drinking water.

The physical orientation of the bottle ice had a significant effect. The Vertical Bottles closely paralleled the performance of the Horizontal Bottles at the Bottom sensor and outperformed the Horizontal Bottles at the other sensor levels. This is particularly noticeable at the High sensor.

Cold air is denser than warm air and sinks to and remains at the bottom of the cooler. This difference creates a stratification in the temperature profile from low and cool to high and warm. This effect occurs in all test cases: Drained, Undrained, Horizontal and Vertical Bottles.

In the case of the Vertical Bottles, the temperature profile is altered. Ice is less dense than water, rises to the top of the bottle, keeping a colder presence higher up in the air column. This is most noticeable in the graph for the High sensor.

Conclusion

The results of this study show that Un-Drained Blocks provide lower cooler Bottom temperature than Bottles after 30 hours.

At the Mid-Low level of the cooler, the temperature with the Vertical Bottles stays below the Commercial limit longer than all other test conditions.

At the High level in the cooler, the Vertical Bottles maintain a lower temperature than all other test conditions for the entire run.

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References:

1. 2016 Commercial Operators Requirements, Page 18, Section 2a.
2. LaCroix and Werness: Cooler Research: An evaluation of Drained versus Un-Drained coolers loaded with ice. The Journal of the Grand Canyon River Guides, Inc., Volume 31, Number 4, Winter 2018 - 2019, pages 6 - 8.

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