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1 Overview

This report summarizes the testing conducted to evaluate the temperature behavior of two Nutribullet blenders operated on a standard test mixture following UL standard 982 protocols. Testing was carried out from December 27, 2017 to January 3 2018 in the Engineering Laboratory Facility, Laboratory 201.

2 Experimental Setup

2.1 Blenders

Two models of Nutribullet processors were used:

- 600 W Nutribullet was used (Model NB-101B, Serial Number J97C97F)
- 900 W Nutribullet Pro (Model NB-201, Serial Number 02S403121501957.

2.2 Diagnostics

A FLIR Model T640 thermal imaging camera (Serial Number 55907279) was used in the experiments. The primary method for obtaining temperature results was logging in real time the temperature associated with discrete points on the blender surface. Both the body and cup were monitored. In addition, still images were obtained through out the test in which the maximum temperature from the blender surface was noted.

The T640 imager was factory calibrated on December 10, 2014. Several checks were made using a handheld Amprobe infrared thermometer (Model IR-720) and the two instruments agreed within 1 degree F.

2.3 Test Load

Per UL 982 Standard for Safety—Motor Operated Household Food Preparing Machines, two sizes of diced carrots (Kroger Fresh Selection Baby Carrots) were prepared and soaked in water for 24 hours prior to the test. The load prepared for the tests consisted of 50% by weight carrot chunks that had a maximum dimension of 0.5" and 50% by weight carrot chunks that had maximum dimensions between 0.5 and 0.75". 175 gram of each size were added to the "tall cup" container along with 140 grams of water. This provided a 350g to 140g weight ratio (2.5) of carrots to water, consistent with the UL 982 procedure which calls for a carrot to water ratio of between 2-3:1 by mass.

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A Mettler PM2000 electronic scale was used to measure the weight of the mixtures. Figure 1 shows what the prepared carrot chunks look like along with the scale used for establishing the weight proportions called for by UL 982.

3 PRODUCTION TEST RESULTS

Test was conducted following UL 982. The blenders were operated for 3 minutes and the temperature monitored over that period. It is noted that the 600W blender has a warning on it to not operate the unit for more than 1 minute. Regardless, per UL 982, both units were tested for 3 minutes.

3.1 600 W blender

Figure 2 shows a thermal image of the 600W blender just prior to initiating the test. As shown, 7 discrete locations were monitored for surface temperature in this test. The values shown in the upper left portion reflect the temperature reading from the particular spot (Sp#) shown on the image. As shown, the initial temperatures were about 67-72 deg F. The ambient room temperature at the start of the test was noted as 70-71 deg F. In this image, the carrot load has been placed into the tall cup according to the recipe outlined above in Section 2.3.

Using the digital output from the T640, time resolved behavior of the temperature at each of the 7 test points shown Figure 2 were recorded. Figure 3 and Figure 4 show the behavior at each of the points shown in Figure 2 and the maximum temperature recorded anywhere on the thermal image, respectively. As shown, the cup temperatures (sp 1-3) approach 105 degrees F after 3 minutes. The blender body (sp4-6) does not increase nearly as much in temperature. Not much gradient in temperature is observed for the cup or the body. The region at the bottom of the blender does increase to about 90 deg F after 3 minutes.

To aide in interpreting the behavior vs time for the specific pixels as well as the maximum temperature, Table 1 summarizes the local temperate behavior of the interrogation locations at the start, stop, and 2 minutes after the stopping of the blender.

Test Point	Start, deg F	3 min (blender	5 min (2 min after	Reference Position
		stopped), deg F	stopping, deg F	(see Figure 2)
SP1	67.8	97.4	100.6	
SP2	68.8	101.2	101.5	593
sP3	68.9	101.8	101.3	
SP4	70.7	73.0	75.0	
SP5	70.8	73.0	75.0	
SP6	70.8	73.3	75.1	
SP7	71.5	90.0	83.5	+
				(Sp7)

Table 1. Temperature at start, 3 min (blender stopped at 3 min), and 5 min (2 min after stopping) for sp-1-7, image max temperature for 600W blender

After about 6 minutes after the test was completed, the cup seal was loosened to remove the blended material. It was noted that pressure was relieved upon loosening the seal, much like a sealed jar would upon opening for the first time. The pressure inside the blender after the 3 minutes of operation can be estimated from well-established gas laws. The current situation, the volume of gas in the blender can be approximated as being constant. In this case, the ratio of the gas pressure to gas temperature is constant. For the 600 W blender, the initial pressure is taken as 1 atm (14.7 psia) and the initial temperature as 68 deg F. The final pressure after 3 minutes, when the temperature is 101 deg F would then be 1.06 atm (15.6 psia) or 0.9 psi above room pressure. Note that this pressure is far below the typical pressure found in a sealed bottle of soda which may approach 50 times this level.

Additional details regarding the cup removal at the end of the test are discussed here. The cups were initially loosened at an approximate 45 degree angle (the cup near the bottom) for natural comfort. This is when the pressure would be relieved. Pressure was heard releasing from the cup/blender seal for less than half a second as it was being loosened. None of the blended mixture was observed leaving the blender at this time. They were then fully opened vertically (with the cup at the bottom as would typically be done) so the mixture would not spill out once the cup was detached from the blender.

3.2 900 W blender

In this section, similar results are shown for the 900 W blender. The behavior is very similar to that of the 600 W, but slightly higher temperature are reached, consistent with the larger power motor. Figure 6 provides context for the 7 monitored points on the blender. Figure 7 and Figure 8 present temperature as a function of time for the 7 monitored points as well as the maximum temperature noted in the thermal image. The blender was turned on at about 125 seconds in these figures. The results show that the cup temperature approaches 110 deg F while the body remains around 75 deg F after 3 minutes of operation. The peak temperatures are just over 110 deg F after about 3 minutes of operation.

To aide in interpreting the behavior vs time for the specific pixels as well as the maximum temperature, Table 2 summarizes the local temperate behavior of the interrogation locations at the start, stop, and 2 minutes after the stopping of the blender.

Test Point	Start, deg F	3 min (blender	5 min (2 min after	Reference Position
		stopped), deg F	stopping, deg F	(see Figure 2)
SP1	68.0	106.0	109.4	
SP2	68.6	107.0	109.0	
sP3	68.1	107.4	108.9	Sp3
SP4	70.7	74.0	75.9	Sp2
SP5	70.7	74.1	75.8	-Spt
SP6	70.7	74.6	76.0	5p5
SP7	70.7	89.2	82.9	+
				Sp7

Table 2. Temperature at start, 3 min (blender stopped at 3 min), and 5 min (2 min after stopping) for sp-1-7, image max temperature for 900W blender

As with the 600 W blender, it was noted that pressure was relieved upon loosening the seal, much like a sealed jar would upon opening for the first time. Using the same methodology as for the 600 W blender, the final pressure for the 900 W blender, when the temperature is 110 deg F would then be 1.08 atm (15.9 psia) or 1.2 psi above room pressure, but again well below typical carbonated soda bottle pressures. As with the 600 W blender, a short (less than 0.5 second) pressure relief was noted upon initial removal of the cup from the blender housing in the 45 degree orientation. No blended material was emitted from the blender assembly upon removal of the cup.

4 Conclusions

The surface of the blender tall cups reached temperatures between 100 and 110 deg F after 3 minutes of continuous running. This is relative to an ambient temperature of 70-71 deg F. The maximum temperature attained for the 900W unit was about 10 deg F higher than that for the 600 W unit. Upon opening the tall cups, it was noted that pressure was relieved at the gasket. The pressure relief lasted about 0.5 seconds and no material was emitted during the tall cup removal.



Figure 1. Prepared Carrot Chunks (L) 0.5" maximum dimension (R) 0.5-0.75" maximum dimension



Figure 2. Reference for specific surface temperature reading locations.



Figure 3. Local Spot Temperature vs Time Behavior for 600W blender (blender on at 30 sec).



Figure 4. Maximum Temperature on Image vs Time Behavior for 600W blender (blender on at 30 seconds).



Figure 5. Images of 600W blender at various points within the test sequence.



Figure 6. Reference for specific surface temperature reading locations for 900 W blender.



Figure 7. Images of 900W blender at various points within the test sequence.



Figure 8. I Maximum Temperature vs Time Behavior for 900W blender (blender on at 30 seconds)



Figure 9. Images of 900W blender at various points within the test sequent.