P18347 Climate ConStroller
Ambient Temperature Testing
Date Completed: 3/21/18

Purpose:

The purpose of this test is to determine how the ambient temperature inside the enclosed stroller when the heated seat is on and producing heat. This test also will determine the time it takes for the surface of the seat to heat up and cool down.

Materials Required:

- Stroller with heated seat and plastic cover
- stopwatch
- Thermocouples/Thermocouple reader (3)
- Tape to hold thermocouples (if needed)

Procedure (ambient temperature):

1. Connect the heated seat to the battery and place it in the stroller
2. Place one probe thermocouple in the middle of the heated seat (foam)
3. Have one team member hold the other two thermocouples underneath the seat and under the visor as shown in the picture below
4. Record the number of each thermocouple and its location for data collection
5. Place the plastic cover over the stroller so that it covers the opening and foot tray on the stroller as best as possible
6. Turn on the heated seat and immediately start a stopwatch
7. Record the temperature from each thermocouple and the heated seat every 30 seconds

Procedure (heating up/cooling down):

1. Connect the heated seat to the battery
2. Place a probe in the middle, top, and bottom of the foam underneath the nylon
3. Record the number and location of each thermocouple for data collection
4. Turn on the heated seat and immediately start a stopwatch
5. Record the temperature from each thermocouple every 30 seconds
6. After one probe reads a temperature of 109, unplug the seat
7. Record the temperature from each thermocouple every 30 seconds as the seat cools

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Set-up (ambient temperature):

1. Place/hold the thermocouple probes in the three locations as shown in Figure 1 below:

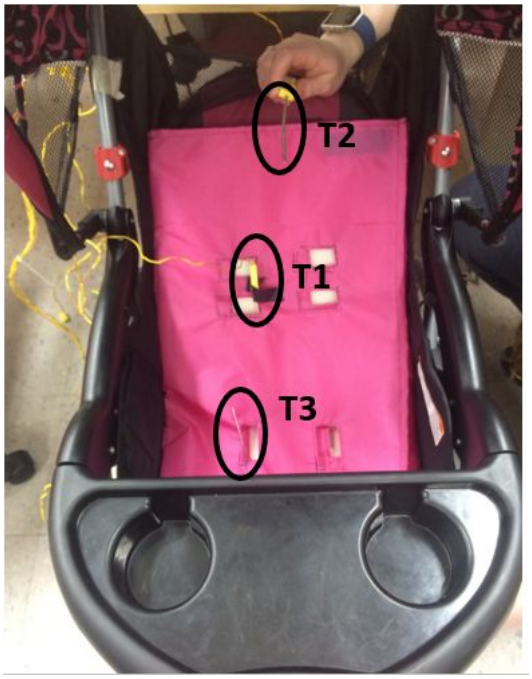

Figure 1: Thermocouple placement

2. Cover the stroller with plastic as shown in Figure 2 below:

Figure 2: Test setup

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Results:

As the seat became gradually warmer, the ambient temperature underneath the tray increased (T3). T3 started at a temperature of 71.7 F with the heated seat off, and reached a temperature of 75.7 F with the seat at 115.7 F. The opposite happened to the ambient temperature underneath the visor (T2). T2 started at a temperature of 75.2 F and decreased to a final temperature of 73.4 F with the heated seat at 115.7 F after fluctuation. Figure 3 shows the temperature fluctuation of the three thermocouples over time. Exact temperature data collected from the thermocouples can be seen in Table 1.

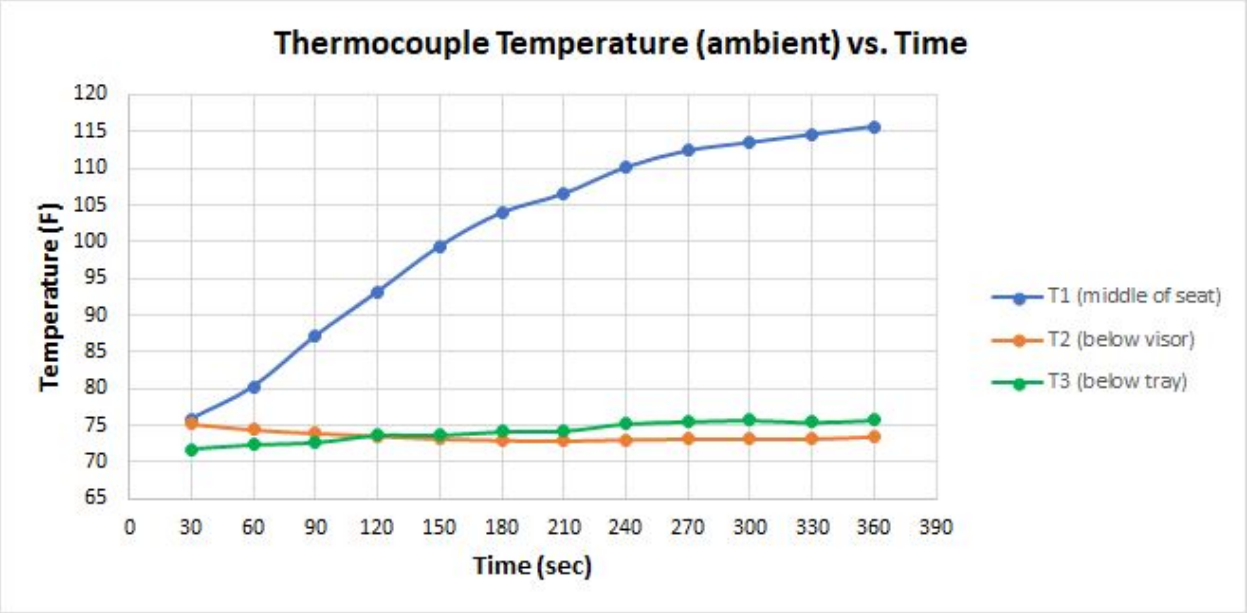

Figure 3: Plot of ambient temperature in stroller vs. time

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Time (sec)	T1 Temp [F] (surface of foam)	T2 Temp [F] (under visor)	T3 Temp [F] (under tray)
30	75.8	75.2	71.7
60	80.2	74.4	72.3
90	87.1	73.9	72.6
120	93.1	73.5	73.6
150	99.3	73.1	73.6
180	103.9	72.9	74.1
210	106.5	72.8	74.2
240	110.1	73	75.2
270	112.4	73.1	75.5
300	113.5	73.1	75.7
330	114.6	73.1	75.4
360	115.7	73.4	75.7

Table 1: Temperature data for each thermocouple

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Figure 4 shows a plot of the time it takes for the heated seat to reach the maximum specified temperature of 109 F. The test was stopped when one part of the foam reached the max temperature because that is enough to burn the baby. Unexpectedly, the top part of the seat increased in temperature the fastest. It took 510 seconds (8.5 minutes) for the top part of the seat to reach 109 F, while the middle and bottom reached a temperature of about 99 F.

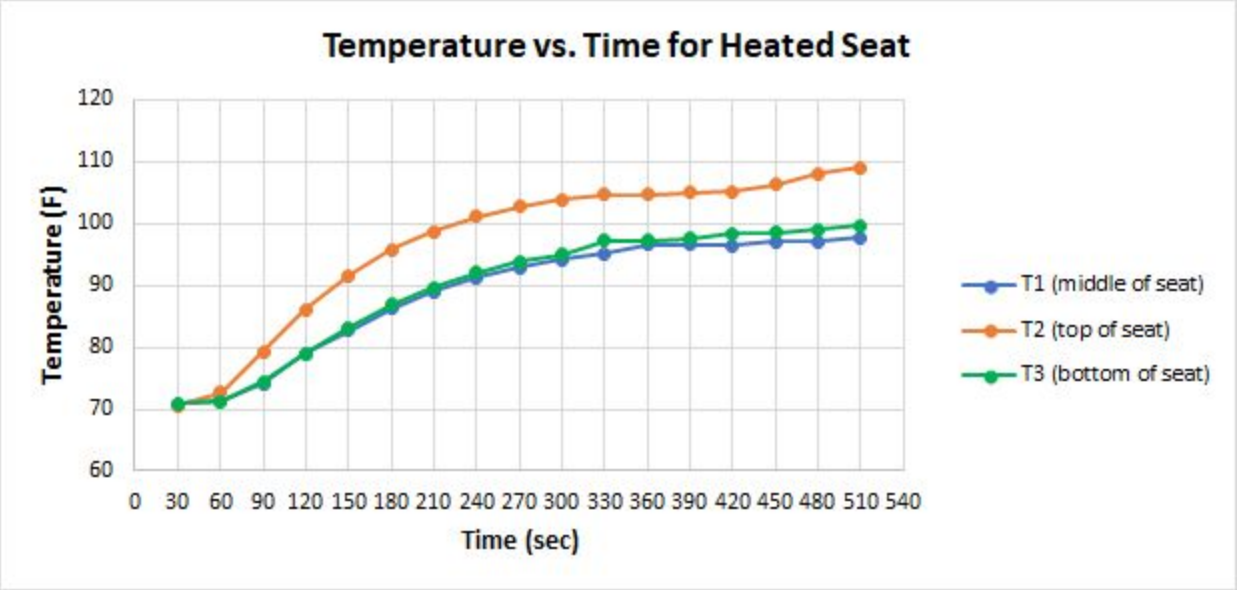

Figure 4: Time it takes for heated seat to reach maximum specified temperature (109 F)

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Figure 5 shows the time it takes for the heated seat to cool to ambient temperature from a temperature of 109 F. All three parts of the seat (top, middle, bottom) all cool at approximately the same rate. It takes approximately 420 seconds (7 minutes) for the seat to cool to 75 F from 109 F.

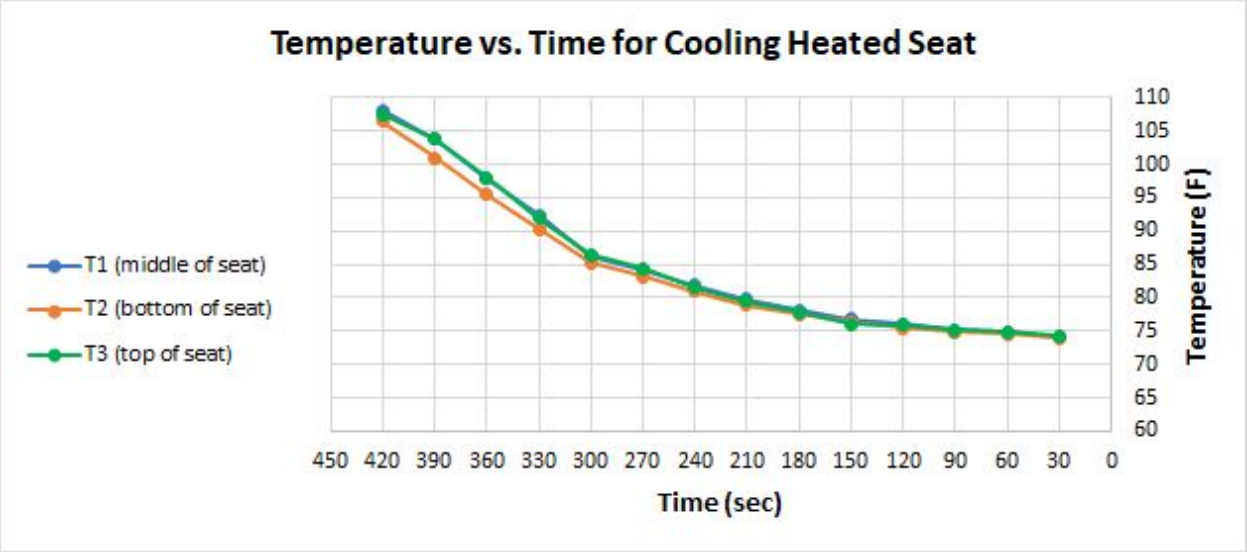

Figure 5: Time it takes for heated seat to cool at different locations from a temperature of about 109 F

Discussion:

The ambient temperature under the tray increased as the heated seat became warmer, as expected. The ambient temperature behind the visor decreased from its starting temperature. The biggest factor contributing to this was the open area on the back of the stroller that the plastic did not cover. It was predetermined that the heated seat would not become any warmer than 109 F to reduce the risk of contact burns on the baby's skin. This testing confirmed that it is possible for the heated seat to at least reach the maximum end of the determined specification. This test also has showed how much uncovered areas in the stroller can affect the ambient temperature of the stroller, even when covered. The team needs to decide whether or not extra plastic will be used to cover the hole in the back of the stroller to maintain a higher ambient temperature in the stroller.

The current plan for the heating system is to heat up the seat to a specific temperature, then have the system shut off to cool to a specific temperature, and repeat. The data from this test has affirmed that the plan for the heating system will work with our current setup. A realistic cycle time for the heating system would be 15 minutes.

From this testing, the team has decided that we will not be adding another layer of foam to the seat, because the seat does not heat evenly in all areas. To make sure the baby stays

warm enough, taking into account all of the heavy winter clothes he/she will be wearing, one sheet of foam is the best choice.

Conclusion:

A realistic cycle time for the heating system is 15 minutes. Although the heat does not heat exactly the same, the current coil design is sufficient enough to heat the seat to our standards for this prototype. Additionally, one sheet of foam at a thickness of 0.25” will keep the baby warm without getting too hot.

Improvements/Recommendations:

- Conducting the test in a cold environment to see how that affects heating and cooling time
- Add more thermocouples to measure more locations on the seat
- Measure the temperature on the back of the foam to see if the back of the seat needs to be layered with more foam to further insulate the seat