The Science Behind THERMAVANCE Cooled and Heated Seat Technology

The Body's Response to Warming & Cooling:

Thermoreceptors are located immediately under the skin and are distributed throughout the human body. They determine absolute and relative changes in temperature and communicate the level of thermal comfort to the brain. The thermal sensitivity in the skin ranges from 77 – 86°F for cool thermoreceptors, and 90 – 108°F for warm thermoreceptors. For example, when a surface of 77°F is in contact with skin, the thermoreceptors send signals to the brain of an overall cooling sensation.

Reference Figure 1 which illustrates the thermal receptor performance.

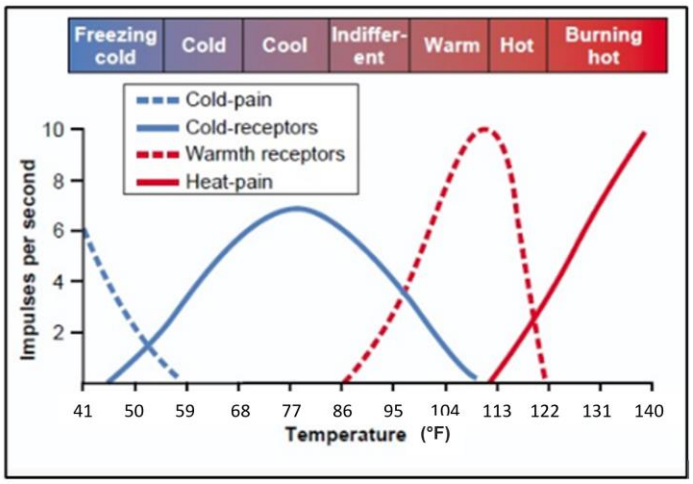

Figure 1: The temperature range and subjective response for warming and cooling.
Source: Guyton and Hall Textbook of Medical Physiology 12th Edition.

The information below summarizes the data:

The Human Body	
Body core temperature	99°F
Skin temperature	91°F
Warming	
Warm thermoreceptors firing	90 – 108°F
Feeling warm	99 – 108°F
Too hot / pain	> 109°F
Not Too Warm or Cool	86 – 99°F
Cooling	
Cool thermoreceptors firing	77 – 86°F
Feeling cool	59 – 86°F
Too cold / pain	< 59°F

THERMAVANCE Thermal Engine Performance:

The THERMAVANCE thermal engine can deliver a seat surface temperature of 65 – 86°F for cooling and 91 – 109°F for warming.

Figure 2 depicts the thermal engine cooling performance at an elevated ambient temperature of 95°F (35°C). Over the span of a 15-minute test of an occupied seat, the average cover temperature of the cushion attains a temperature of 78°F (25°C).

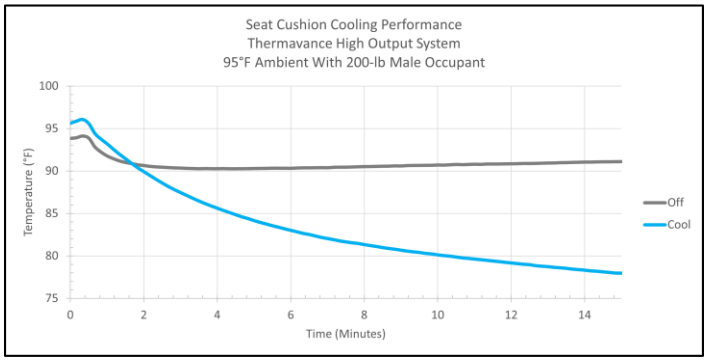

Figure 2: Seat Cushion Average Surface Temperature Comparison With and Without Seat Cooling at an Ambient Temperature of 95°F (35°C)

Figure 3 depicts the thermal engine heating performance at an ambient temperature of 73°F (22°C). Over the span of a 15-minute test of an occupied seat, the average cover temperature of the cushion attains a temperature of 109°F (43°C) at which point the system limits heating using pulse width modulation.

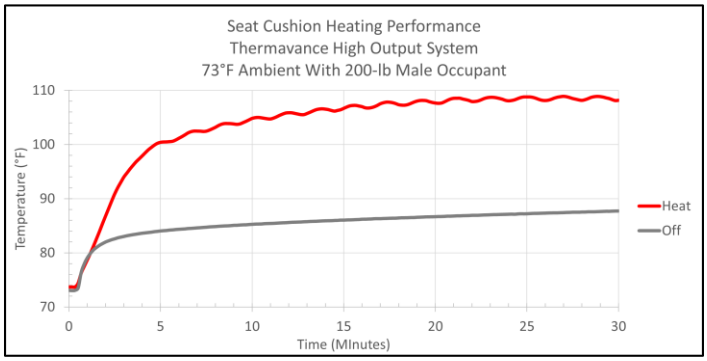

Figure 3: Seat Cushion Average Surface Temperature Comparison With and Without Seat Heating at an Ambient Temperature of 73°F (22°C)

Subjective Evaluation:

The Berkeley Thermal Sensation and Comfort Scale for the subjective assessment of thermal comfort may be used to compliment objective temperature data to validate thermal performance. It is important to include subjective assessments given significant potential differences in the perception of thermal comfort due to variation in age,

physical makeup, and other attributes of seat occupants. As with any heated or cooled seat, perception may also vary with the insulative properties of the clothing worn by the occupant.

Table 1 displays the Berkeley Scale used for thermal comfort subjective assessments.

	Scale
4	Very Hot
3	Hot
2	Warm
1	Slightly Warm
0	Neutral
-1	Slightly Cool
-2	Cool
-3	Cold
-4	Very Cold

Table 1: Berkeley Scale for Subjective Assessment of Thermal Sensation
Source: Partial- and Whole-Body Thermal Sensation and Comfort, Part I: Uniform Environmental Conditions. Arens, Zhang, Huizenga; Center for the Built Environment, University of California, Berkeley

Table 2 reflects a comparative jury assessment of two different THERMAVANCE system configurations. Average assessments of cooling sensed in the front and rear sections of the cushion and upper and lower sections of the seat back are compiled over the course of the 15-minute evaluation conducted in a thermal chamber at an ambient temperature of 95°F (35°C). In each case, the cooling system was activated at t=0 minutes after the seat itself attained ambient temperature.

Time (Minutes)	Standard System			
	Cushion		Back	
	Front	Rear	Lower	Upper
1	2.50	2.25	2.75	2.50
2	1.75	1.25	1.00	2.00
3	0.25	0.00	-0.25	0.50
4	-0.75	-1.00	-1.00	-0.50
5	-1.25	-1.50	-1.75	-0.75
6	-1.50	-2.25	-1.75	-1.00
7	-1.50	-2.25	-2.00	-0.75
8	-1.75	-2.50	-2.25	-1.25
9	-1.75	-2.50	-2.00	-1.25
10	-1.75	-2.50	-1.75	-0.75
11	-1.75	-2.75	-2.25	-1.00
12	-2.00	-2.75	-2.25	-1.25
13	-2.25	-2.75	-2.00	-1.25
14	-2.25	-2.75	-2.25	-1.25
15	-2.25	-2.75	-2.25	-1.25

Time (Minutes)	High Output System			
	Cushion		Back	
	Front	Rear	Lower	Upper
1	2.67	2.33	2.67	2.67
2	2.00	0.67	0.67	1.33
3	1.33	-0.67	-1.00	-0.33
4	0.67	-1.67	-2.00	-1.00
5	-0.67	-2.67	-3.00	-1.33
6	-1.67	-3.00	-3.00	-1.67
7	-2.00	-3.00	-3.00	-1.67
8	-2.00	-3.67	-3.33	-2.00
9	-2.33	-3.67	-3.33	-2.00
10	-2.67	-3.67	-3.33	-2.00
11	-2.67	-3.67	-3.33	-2.00
12	-2.67	-3.67	-3.33	-2.00
13	-2.67	-3.67	-3.33	-2.00
14	-2.67	-3.67	-3.33	-2.00
15	-3.00	-4.00	-3.33	-2.00

Table 2: Subjective Assessment Comparing Baseline Conductive Cooling (left) versus High Output Cooling System at an Ambient Temperature of 95°F (35°C)

Data from the jury assessment indicates a clear difference in perceived cooling with the higher output cooling system depicted in the righthand table.

Qualitatively, conductive cooling and heating system operation may be visualized with infrared imaging technology. Figure 4 depicts an infrared image of a seat with a THERMAVANCE system operating in cooling mode. The dark areas indicate lower surface temperatures resulting from conductive cooling.

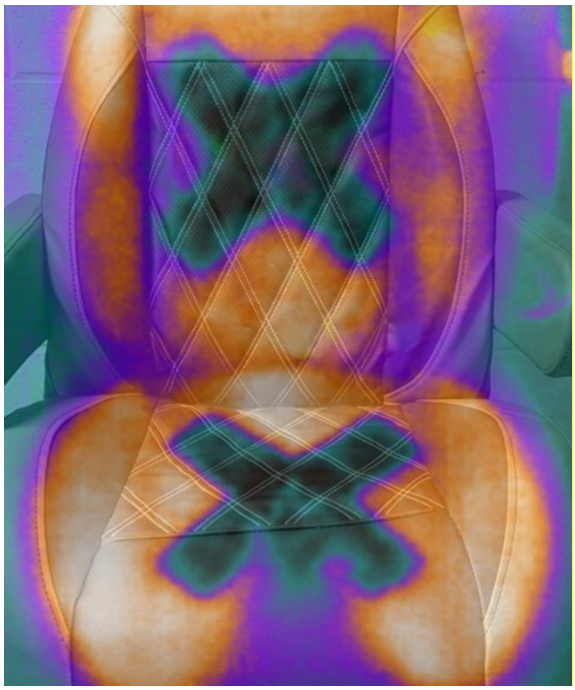

Figure 4: Infrared Image of a THERMAVANCE Cooling System Operating in a Seat

Conclusion:

The following overlay of thermal receptor and Thermavance thermal engine performance illustrates the Thermavance thermal engine capability to deliver both warm and cool comfort.

Warming	
Warm thermoreceptors firing	90 – 108°F
Feeling warm	99 – 108°F
Thermavance Heating	**91 – 109°F**
Too hot / pain	> 109°F
Not Too Warm or Cool	86 – 99°F
Cooling	
Cool thermoreceptors firing	77 – 86°F
Feeling cool	84 – 86°F
Thermavance Cooling	**65 – 86°F**
Too cold / pain	< 59°F