Herman Miller

The Attributes of Thermal Comfort

Ergonomic criteria for the design of the Aeron® chair

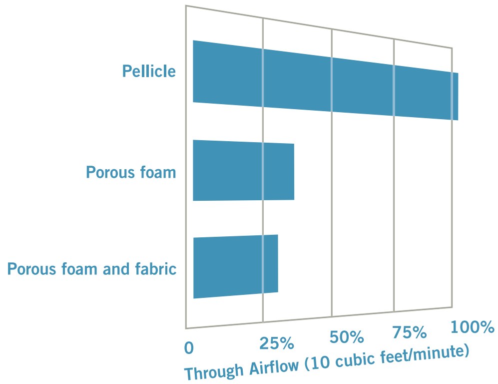
by Bill Stumpf, Don Chadwick, and Bill Dowell

A chair should breathe.

A work chair should have a neutral effect on body-surface temperatures, so that thermal comfort is not posture dependent.

Figure 1

Pellicle® material, unlike porous foam/fabric, does not restrict airflow.



What We Know: People are more comfortable when ambient temperatures are neutral, allowing the body to maintain thermal equilibrium without sweating or shivering. Increased humidity at the skin's surface can lead to sitting discomfort.

The human body is designed to maintain thermal equilibrium with its outside environment, so that body heat produced by activity and metabolism roughly equals the amount of body heat lost to the ambient air. When this equilibrium is disturbed, the body compensates by shaking to generate more heat or sweating to transfer heat away from the body surface through evaporation.

Thermal comfort, then, is relative to body temperature. One study found that its subjects' definitions of a comfortable temperature varied with the current temperature of their own bodies (Shitzer *et al.* 1978). "Ideal" ambient temperatures vary from person to person and over time as body temperature varies.

Humidity is another important aspect of thermal comfort. A seated person usually experiences humidity build-up at the skin's surface as uncomfortable because moist skin creates increased friction coefficients (Reed *et al.* 1994), causing it to stick to clothing or chair upholstery and inhibiting the small movements required to shift weight off pressure points.

Therefore: A comfortable chair will have a neutral effect on thermal comfort by not blocking the flow of heat or the dispersion of water vapor generated by the body.

Design Problem: Design a work chair that "breathes" so that its users experience the same thermal conditions when seated as they experience when standing.

Conventional approaches to office-chair upholstery have been more concerned with the requirements of the decorating scheme than with the thermal comfort of the people who spend a large portion of their work days sitting. An office chair's seat and backrest are typically upholstered with fabric over foam padding that has insulating properties that prevent conduction of heat away from the body. A study of different materials used for wheelchair seat cushions found a significant rise in skin temperatures under the thighs and sitting bones of test subjects in chairs using four-inch-thick foam rubber pads (Fisher *et al.* 1978).

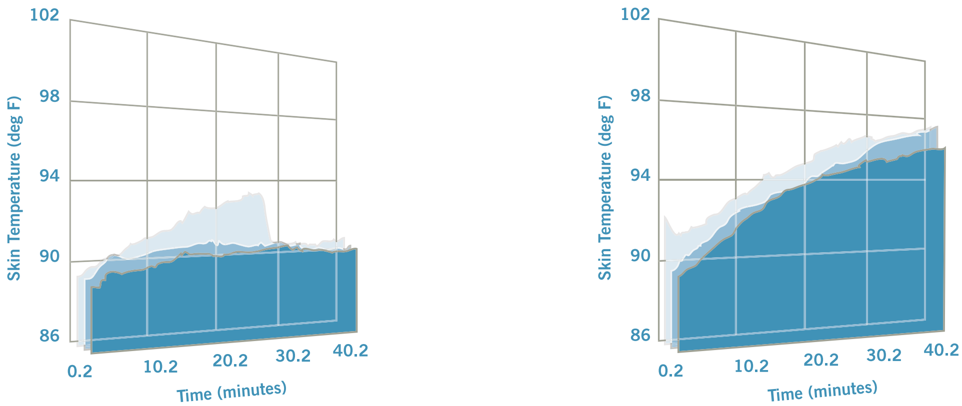
Foam padding can also impede water-vapor transfer from the skin's surface. One study found that, along with different foam compositions, permeability of seat cushions varied with compression (Diebschlag *et al.* 1988). This suggests that thermal comfort could vary for different people using the same type of work chair, depending on where and how much they compress the foam cushions of the seat pan and backrest.

In some climates, the cost of additional air conditioning required to counteract the insulating properties of upholstered seating can be a significant expense. A technical report published by the Rocky Mountain Institute estimates that an upholstered office chair, by insulating 20 to 25 percent of the body's surface, adds $140 to $290 per worker in HVAC and utility equipment costs (Houghten *et al.* 1992). By helping to maintain neutral body temperatures, a noninsulating chair requires less cooling and no additional heating to maintain thermal comfort.

Figure 2

With Pellicle material, seated skin temperature remains essentially constant. (Three subjects represented.)

With foam, seated skin temperature rises. (Three subjects represented.)



Design Solution: Eliminate the need for foam cushions with an elastic and permeable seat and back material that provides comfort without padding and allows conduction of heat and dispersion of moisture away from the surface of the skin.

Instead of seat and back cushions of fabric-upholstered foam, the Aeron chair has a Pellicle suspension of a permeable, two-way stretch material pulled tightly across open seat and back frames. The open mesh of the Pellicle seat pan and backrest allows airflow to the parts of the body in contact with the chair that is comparable to the flow of air that reaches the more exposed parts of the seated body. An American Society for Testing of Materials airflow test (D3574-91) of the Pellicle material found no measured pressure drop from one side of the material to the other when air was directed through it at 10 cubic feet per minute, signifying that the Pellicle material is virtually porous. Using even a highly porous foam in the same test dramatically restricted the through airflow (Figure 1). Adding a completely non-porous chair shell structure would then result in total blockage.

The porous quality of the Pellicle material allows for unobstructed moisture dispersion and conduction of heat away from body surfaces that touch the backrest and seat pan. Tests of the same subjects sitting in an Aeron chair and in a chair built to corresponding dimensions but padded with foam found that buttock skin temperature increased while the subjects sat in the foam-padded chair but remained essentially unchanged in the Aeron chair. After 40 minutes of sitting in the Aeron chair, test subjects' sitting temperatures remained essentially constant and comparable to their standing temperatures. After 40 minutes in the foam chair, the same subjects recorded sitting temperatures that were higher by about 6°F (Figure 2).

Taking its cue from the porosity of classic wicker or rattan furniture, the Aeron chair is virtually "transparent" with regard to airflow and heat transfer, acting as a conduit for, rather than a barrier to, the surrounding thermal environment. People who work in an office furnished with such chairs should be able to dress for the ambient conditions and not notice temperature changes when they move between standing and seated tasks.

References

Diebschlag *et al.* (1988), "Recommendation for ergonomic and climatic physiological vehicle seat design," *Society of Automotive Engineers Technical Paper 880055.*

Fisher *et al.* (1978), "Wheelchair cushion effect on skin temperature," *Archives of Physical Medicine and Rehabilitation.*

Houghten *et al.* (1992), "The state of the art: space cooling and air handling," COMPETITEK technical report, Rocky Mountain Institute.

Reed *et al.* (1994), "Survey of auto seat design recommendations for improved comfort," technical report, University of Michigan Transportation Research Institute.

Shitzer *et al.* (1978), "Human response from heat stress with relation to comfort," *Ergonomics.*

Credits

A specialist in the ergonomics of seating design, *Bill Stumpf* has been studying behavioral and physiological aspects of sitting at work for more than 20 years. He designed the Ergon® chair introduced by Herman Miller in 1976 and, with Don Chadwick, the equally innovative Equa® and Aeron chairs.

Codesigner of two groundbreaking ergonomic work chairs for Herman Miller, *Don Chadwick* has been instrumental in exploring and introducing new materials and production methods to office seating manufacture.

Bill Dowell leads a team of researchers at Herman Miller. His recent work includes published studies of seating behaviors, seated anthropometry, the effect of computing on seated posture, the components of subjective comfort, and methods for pressure mapping. Bill is a member of the Human Factors and Ergonomic Society, the CAESAR 3-D surface antropometric survey, the work group that published the BIFMA Ergonomic Guideline for VDT Furniture, and the committee that revised the BSR/HFES 100 Standard for Human Factors Engineering of Computer Workstations.

For more information about our products and services or to see a list of dealers, please visit us at www.HermanMiller.com or call (800) 851 1196.