Thermal Comfort

Vocabulary List

Sensing

- Thermal receptors in the skin and key organs

Warmth receptors

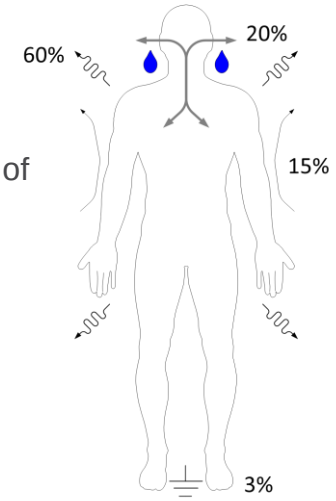
- Unmyelinated type C nerve fibers, coolth receptors - type Aδ myelinated nerve ending.

Perception

- Develops in the parietal lobe of the cerebral cortex, thus the universal definition, "**condition of mind**."

Response/adaptation to maintain homeostasis.

- **Below conscious**.
  - Thalamus → Hypothalamus → Pituitary → Thyroid (HPT axis)
  - Vasodilation → sweating → hyperthermia…vasoconstriction → shivering → hypothermia.
- **Above conscious**.
  - Actions to get warm or become cool, adjust posture and clothing, relocate, change activity, activate fans and heaters.
- **Heat Transfer Between the Body and the Built Environment**
  - Appx. 60% by radiation of sensible, appx. 40% of total.
  - Appx. 20% to 25% by respiration/evaporation.
  - Appx. 15% to 20% by convection.
  - Appx. 3% by conduction.

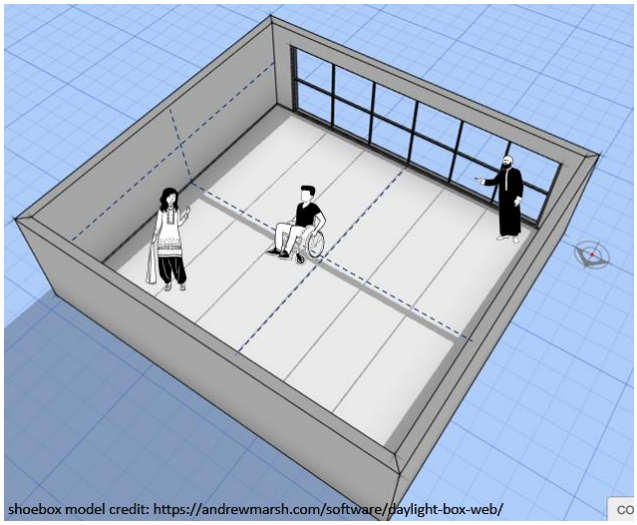


Terminology, Descriptions and Illustrations

ASHRAE Standard 55 Metrics

Clothing (CLO)

- What people are wearing has a major influence on their sensing and perceiving thermal comfort. CLO is a unit used to express the thermal insulation provided by garments and clothing ensembles; typical winter indoor clothing is appx. 1 clo = 0.155 m2·°C/W (0.88 ft2·h·°F/Btu). The less insulative the clothing the lower the CLO value. e.g., knee length skirt, long sleeve shirt, full slip = 0.67 clo.

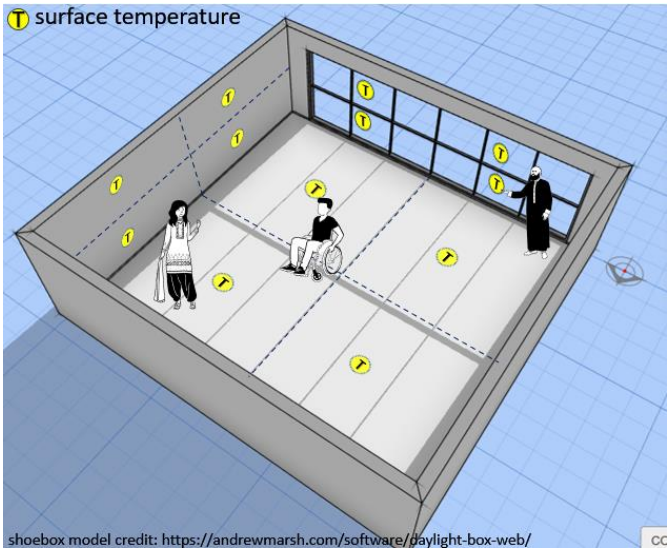


Metabolic Rate (MET)

- is the rate of transformation of chemical energy into heat and mechanical work by metabolic activities of an individual, per unit of skin surface area (expressed in units of met) equal to 58.2 W/m2 (18.4 Btu/h·ft2), which is the energy produced per unit skin surface area of an average person seated at rest. e.g., a seated quiet person writing has a MET rate of 1, cooking is 1.8.

Mean Radiant Temperature

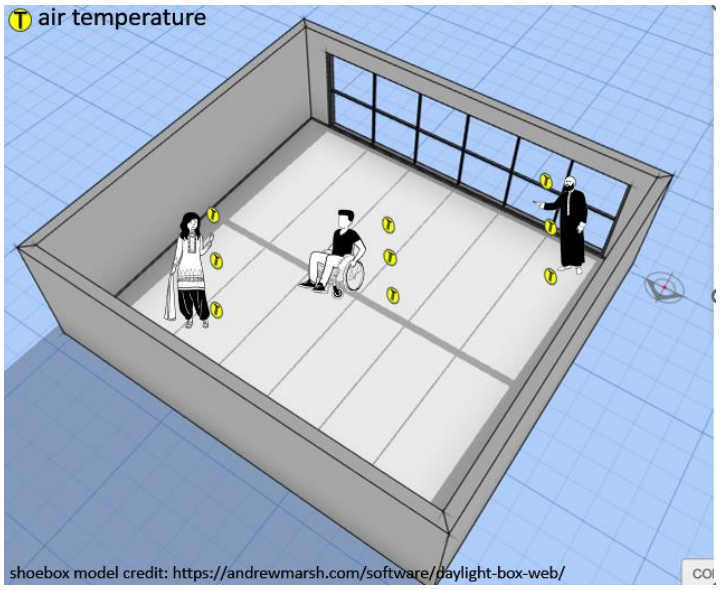
- (MRT) Represents the thermal experience occupants have as a function of all the surface temperatures around them. The MRT depends on the temperatures and emissivity of the surrounding surfaces and the person's geometric proximity to those surfaces. MRT has no specific target value (see thermal comfort tool), though calculated or measured extremes from 22°C/70°F indicate poor architectural and enclosure design, a major contributor to occupant dissatisfaction.



- Notes on MRT.
    - The closer a person is to surfaces with more influence, the more their experience changes. For example, sitting or standing next to a cold or hot window will cause them to experience the space differently than if they were away from the window.
    - There are several online tools and software that can calculate this value.

Air Temperature (dry bb)

- t_{db}, represents the average air temperature around the person measured along the seated or standing occupant's body.
- It is not the thermostat reading nor the air temperature reading at the control sensor location, though it might represent the occupant's location in high-performance buildings.



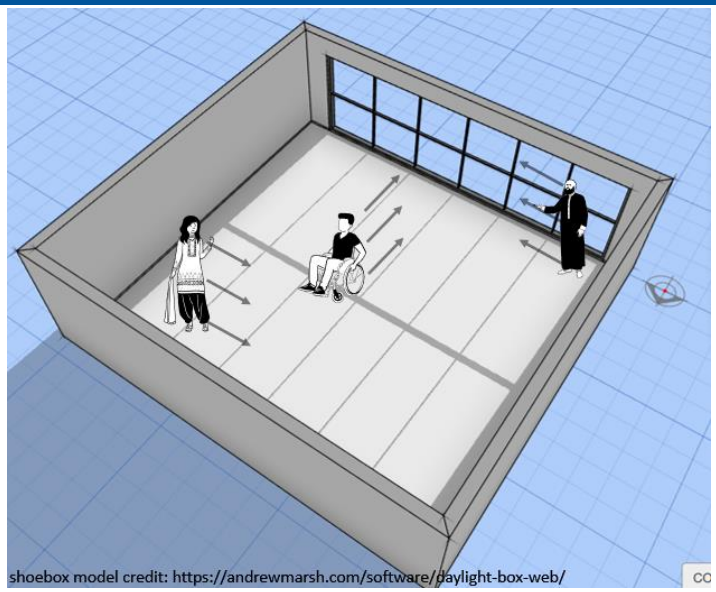
Operative Temperature

- t_{op}, represents the thermal experience from the mean radiant temperature (MRT) and the dry bulb (t_{db}) temperature…it is what people actually sense.
- t_{db} has no specific value (see thermal comfort tool), though calculated extremes from 22°C/70°F indicate poor architectural and enclosure design, which is a major contributor to occupant dissatisfaction.

Air Velocity/Speed

- Represents the average speed of the air without regard to direction and measured/calculated along the seated or standing occupant's body.

- The default value of 20 fpm in the thermal comfort tool represents a comparative measurement; persons adjacent to a diffuser or a poorly designed system may experience higher values. Good duct design, diffuser selection and location minimize risks and would be represented by lower values.



Representative Occupant

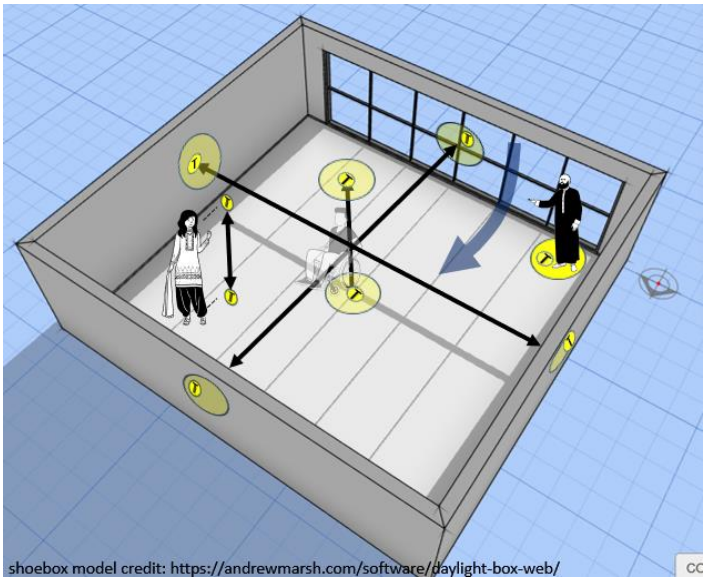
- Where the person goes, so goes the operative temperature, humidity and air speed.
- Regardless of the thermostat location, the metrics in Standard 55 ALWAYS follow the person.

Air Distribution Performance Index (ADPI)

- Is not a requirement in Standard 55 but is recommended as good practice.

Stratification

- Represents the differential temperature measured between the ankles and head.



Radiant Asymmetry

- Represents the surface-to-surface temperature differential vertically and surface-to-surface (or air) horizontally across the body

Floor Temperature

- Represent the temperature under the person below their normal footwear.

General Draft

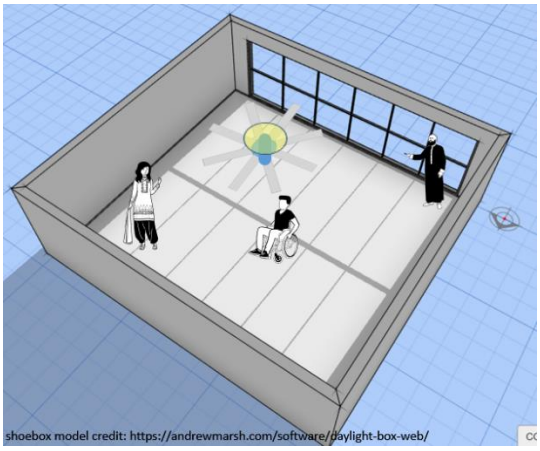
- Draft is the unwanted flow of air across a body, specifically across exposed areas such as the head, hands, neck, and ankles. It is considered unwanted when a person wants to be warm and wanted when a person wants to be cool.

Ankle Draft

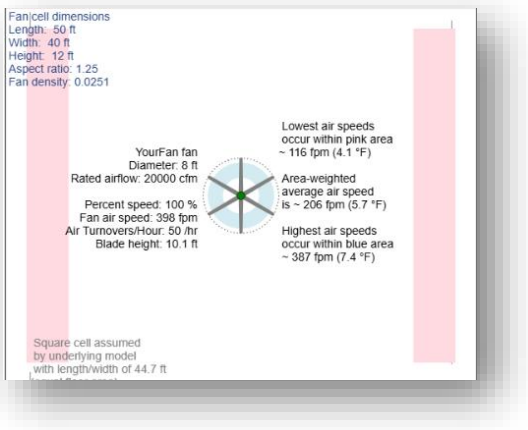
- Is airflow specifically across the ankles and is usually caused by downdrafts or poorly designed floor distribution systems.

Elevated Air Speed

- Is a strategy to enable the perception of cooling and can be created with fans.
- Often, elevated air speeds are all that is needed instead of more refrigerant-based cooling and dehumidification.
- The fan's characteristics, number and layout are all important elements.
- Elevated air speeds can be modelled with the CBE Fan Tool.



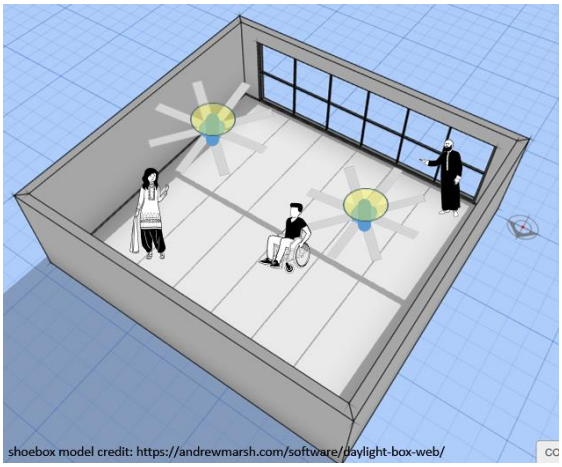
Single Fan Layout



Screenshot from ceiling fan performance tool.

Dual Fan Layout

- Additional Benefits:
  - For some locations around the world, the operating range of adaptive/naturally ventilated spaces can be extended using ceiling fans.
  - This reduces the hours needed for refrigerant based cooling resulting in energy preservation. This should be considered in light of future changes in climate.



Quad Fan Layout

- Additional Benefits:
- When using a combination of radiant cooling systems with fans the heat transfer coefficient is increased.