Thermal Delight in Architecture

“This work began with the hypothesis that the thermal function of a building could be used as an effective element of design. Thermal qualities – warm, cool, humid, airy, radiant, cozy – are an important part of our experience of a space; they not only influence what we choose to do there but also how we feel about the space.”

Lisa Heschong
Comfort Criteria in the Context of the Building Acquisition Process

• Design intent – “occupants will be thermally comfortable”
• Design criteria – defines what you mean by “comfortable” … sets the target for design efforts
• Methods – develop ideas about how comfort will be achieved (HVAC, passive cooling, hybrid heating, …)
• Design Validation* – verify that the method(s) selected will actually work and meet criteria – for example, that you can passively cool an office in Phoenix in August
• Construction Validation* – check to see that the contractor is following the drawings and specifications
• Post Occupancy Evaluation** – are occupants actually experiencing comfort in the building under use (if not … fix and learn; if so, file under good lessons learned)

* part of building commissioning; ** part of ongoing commissioning
Reminder: Parameters that Affect Thermal Comfort

Design must control:
- Air temperature
- Relative humidity
- Air speed
- Radiant conditions
  - MRT or
  - Solar intensity

Design must consider:
- Clothing
- Activity level
- Mental state

environmental factors  personal factors

A Key Source for Thermal Comfort Criteria – ASHRAE Standard 55

zone of 80% "acceptable" responses
two, somewhat overlapping, zones are defined and shown in the chart; a zone for 1 clo ("winter") and another for 0.5 clo ("summer") attire; the zone boundaries define an 80% occupant acceptance of thermal conditions (representing the middle three points of the seven-point scale)

The Chart in ASHRAE Standard 55 is …

Explicit with respect to:
- Relative humidity (or humidity ratio)
- Air temperature *
- Radiant temperature *

* via operative temperature
  \[ (\text{air temp} + \text{MRT}) / 2 \]
The Chart in ASHRAE Standard 55 is

Explicit with respect to:
• Clothing (clo value) … given at 2 levels ("summer" and "winter")

a question will eventually arise … how does the chart deal with other clo values? (how is the comfort chart used in the real world of diverse clothing options?)

The Chart in ASHRAE 55 is

Silent with regard to:
• Activity level (met value) … but, the zones are plotted assuming a sedentary activity
• Air speed … but, the zones are plotted assuming air speed to be “low”

a question will eventually arise … what about other activity levels and what about other air speeds? (how is the comfort chart used in the real, complicated, world?)
“Extensions” to the Standard 55 Chart

A designer will need to read through the text of the standard to obtain adjustments for:
• Air speed (other than nominal)
• Activity level (other than sedentary)
• Clothing (other than 0.5 and 1.0 clo)
And also for limits on:
• Radiant asymmetry
• Changes in conditions over time

Spatial & Temporal Non-Uniformity

The text of ASHRAE Standard 55 addresses thermal non-uniformity:

• **Thermal asymmetry** *(e.g., hot ceiling/cold floor)*
  – Too much is considered not good (especially with respect to radiant conditions)
• **Thermal change with time** *(e.g., temperature cycling)*
  – Too much, too quickly, is considered not good
The Electronic ASHRAE Standard 55

a software implementation of comfort “zones” – easy to use

Emerging Issues – Adaptive Comfort

Standard 55-2010: provides this option for naturally ventilated spaces; the comfort zone moves with changing outdoor air temperature
Another Source for Thermal Comfort Criteria -- Olgyay

from: Design with Climate

The Olgyay Chart is:

Explicit with respect to:

• Temperature
• Relative humidity
• Air speed
• MRT and solar radiation

• and … evaporative cooling effects
The Olgyay Chart is:

Silent with regard to:
• Activity level (met value)
• Clothing level (clo value)

A question will eventually arise … what about other activity and clothing levels? (how is this comfort chart used in practice?)

Olgyay Chart “Extensions”

Read through the text of Design with Climate to find adjustments for:

• Various clothing levels
• Various activity levels
  good direction is given
ASHRAE vs. Olgyay Criteria

• Olgyay comes from an “envelope” control philosophy (passive systems)
• ASHRAE comes from an HVAC control philosophy (active systems)

• They are alternatives … not equivalents
  – Nevertheless, the two comfort zones are surprisingly similar
Other Tools – The Bioclimatic Chart

Olgyay:  
*Design with Climate*

Other Tools – The Bioclimatic Chart

Olgyay:  
*Design with Climate*

Other Tools – First Moves

Milne & Givoni:  
*Energy Conservation Through Building Design*
Other Tools – First Moves

Milne & Givoni: 
Energy Conservation Through Building Design

Other Tools – Climate Consultant

http://www2.aud.ucla.edu/energy-design-tools/

Indianapolis
Other Tools – **Climate Consultant**

**Tallahassee**

100.0% Composite of Selected Strategies

**Kuwait**

100.0% Composite of Selected Strategies