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FOREWORD

ANSI/ASHRAE Standard 55-2013 is the latest edition of Standard 55. This edition incorporates eighteen addenda to the 2010 edition that were written with a renewed focus on application of the standard by practitioners and use of clear, enforceable language.

The core of the standard in Sections 4 and 5 specifies methods to determine thermal environmental conditions (temperature, humidity, air speed, and radiant effects) in buildings and other spaces that a significant proportion of the occupants will find acceptable at a certain metabolic rate and clothing level. The comprehensive analytical method to determine these conditions uses calculation algorithms included in the standard and appendices, all of which are implemented in the ASHRAE Thermal Comfort Tool.[4]

The standard contains a graphical method of compliance, which is familiar to many users, yet is permitted to be used only in limited circumstances. Given the widespread and easy accessibility of computing power and third-party implementations of the analytical method, it is expected that more users will favor the comprehensive analytical methods over the graphical method.

Section 6 contains requirements for demonstrating that a design of an occupied space or building meets the comfort requirements in Sections 4 and 5. Section 7 includes requirements for the measurement and evaluation of existing thermal environments and is also applicable to commissioning.

Since the two personal characteristics of occupants (metabolic rate and clothing level) vary, operating setpoints for buildings are not mandated by this standard.

Standard 55 was first published in 1966 and republished in 1974, 1981, and 1992. Beginning in 2004, it is now updated using ASHRAE's continuous maintenance procedures. According to these procedures, Standard 55 is continuously revised by addenda that are publicly reviewed, approved by ASHRAE and ANSI, and published and posted for free on the ASHRAE website.

The eighteen addenda published since 2010 are summarized in detail in Informative Appendix M, and the most noteworthy changes are summarized here:

a. The normative body of the standard, comprising Sections 3 through 8, have been rewritten and reorganized. Requirements are more clearly stated, definitions are added to Section 3, and informative supporting information has been moved from the body to informative appendices.
b. Procedures are clarified and appear in a more sequential manner. For example, a "representative occupant" with representative "clothing insulation" and "metabolic rate" shall be defined as input into thermal comfort calculations.
c. The cooling effect of air movement now applies to naturally conditioned spaces as well as mechanically conditioned spaces, and in each case correction factors are given that adjust the comfort boundaries when air movement is present.
d. A new alternate procedure for estimating occupant clothing insulation based on outdoor weather was added. This procedure is based on extensive field research and can be used for design calculations, annual simulations, and control of occupied spaces.
e. Major revisions to Section 7 procedures for measuring comfort in existing spaces including survey and physical measurement methods and a new section on evaluating and reporting results.
f. The standard now says that two of the key comfort parameters, air speed and air temperature, must be calculated as an average that the occupant experiences at three heights across the body and over a period of time.

1. PURPOSE

The purpose of this standard is to specify the combinations of indoor thermal environmental factors and personal factors that will produce thermal environmental conditions acceptable to a majority of the occupants within the space.

2. SCOPE

2.1 The environmental factors addressed in this standard are temperature, thermal radiation, humidity, and air speed; the personal factors are those of activity and clothing.

2.2 It is intended that all of the criteria in this standard be applied together since comfort in the indoor environment is complex and responds to the interaction of all of the factors that are addressed.

2.3 This standard specifies thermal environmental conditions acceptable for healthy adults at atmospheric pressure equivalent to altitudes up to 3000 m (10,000 ft) in indoor spaces designed for human occupancy for periods not less than 15 minutes.

2.4 This standard does not address such nonthermal environmental factors as air quality, acoustics, and illumination or other physical, chemical, or biological space contaminants that may affect comfort or health.

3. DEFINITIONS

adaptive model: a model that relates indoor design temperatures or acceptable temperature ranges to outdoor meteorological or climatological parameters. ***Note:*** *Adaptive model* is another name for the method described in Section 5.4, "Determining Acceptable Thermal Conditions in Occupant-Controlled Naturally Conditioned Spaces.")

air speed: the rate of air movement at a point, without regard to direction.

air speed, average (V_a): the average air speed surrounding a representative occupant. The average is with respect to location and time. The spatial average is for three heights as defined for average air temperature (t_a). The air speed is averaged over an interval not less than one and not more than three minutes. Variations that occur over a period greater than three minutes shall be treated as multiple different air speeds.

climate data: hourly, site-specific values of representative meteorological data, such as temperature, wind, speed, solar radiation, and relative humidity. (See Chapter 14 of *ASHRAE Handbook—Fundamentals*[3] for data sources.) For cities or urban regions with several climate data entries, and for locations where climate data are not available, the designer shall select available weather or meteorological data that best represents the climate at the building site.

clo: a unit used to express the thermal insulation provided by garments and clothing ensembles, where 1 clo = 0.155 $m^2 \cdot °C/W$(0.88 $ft^2 \cdot h \cdot °F$/Btu).

comfort, thermal: that condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation.

draft: the unwanted local cooling of the body caused by air movement.

environment, acceptable thermal: a thermal environment that a substantial majority (more than 80%) of the occupants find thermally acceptable.

environment, thermal: the thermal environmental conditions that affect a person's heat loss.

exceedance hours: the number of occupied hours within a defined time period in which the environmental conditions in an occupied space are outside the comfort zone.

garment: a single piece of clothing.

generally accepted engineering standard: see ASHRAE/IES Standard 90.1.[7]

humidity: a general reference to the moisture content of the air. It is expressed in terms of several thermodynamic variables, including vapor pressure, dew-point temperature, wet-bulb temperature, humidity ratio, and relative humidity. It is spatially and temporally averaged in the same manner as air temperature. ***Note:*** Any one of these humidity variables must be used in conjunction with dry-bulb temperature in order to describe a specific air condition.

insulation, clothing (I_{cl}): the resistance to sensible heat transfer provided by a clothing ensemble (expressed in units of clo). (***Note:*** The definition of *clothing insulation* relates to heat transfer from the whole body and, thus, also includes the uncovered parts of the body, such as head and hands.)

insulation, garment (I_{clu}): the increased resistance to sensible heat transfer obtained from adding an individual garment over the nude body (expressed in units of clo).

local thermal discomfort: the thermal discomfort caused by locally specific conditions such as a vertical air temperature difference between the feet and the head, by radiant temperature asymmetry, by local convective cooling (draft), or by contact with a hot or cold floor.

metabolic rate (met): 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/m^2 (18.4 $Btu/h \cdot ft^2$), which is the energy produced per unit skin surface area of an average person seated at rest.

occupant, representative: an individual or composite or average of several individuals that is representative of the population occupying a space for 15 minutes or more.

occupant-controlled naturally conditioned spaces: those spaces where the thermal conditions of the space are regulated primarily by occupant-controlled openings in the envelope.

occupant-controlled openings: openings such as windows or vents that are directly controlled by the occupants of a space. Such openings may be manually controlled or controlled through the use of electrical or mechanical actuators under direct occupant control.

outdoor design condition: the local outdoor environmental conditions represented by climate data at which a heating or cooling system is designed to maintain the specified indoor thermal conditions.

predicted mean vote (PMV): an index that predicts the mean value of the thermal sensation votes (self-reported perceptions) of a large group of persons on a sensation scale expressed from –3 to +3 corresponding to the categories "cold," "cool," "slightly cool," "neutral," "slightly warm," "warm," and "hot."

predicted percentage of dissatisfied (PPD): an index that establishes a quantitative prediction of the percentage of thermally dissatisfied people determined from PMV.

radiant temperature asymmetry: the difference between the plane radiant temperature (t_{pr}) in opposite directions. The vertical radiant temperature asymmetry is with plane radiant temperatures in the upward and downward directions. The horizontal radiant temperature asymmetry is the maximum radiant temperature asymmetry for all horizontal directions. The radiant temperature asymmetry is determined at waist level, 0.6 m (24 in.) for a seated occupant and 1.1 m (43 in.) for a standing occupant. (See Chapter 9 of *ASHRAE Handbook—Fundamentals*[3] for a more complete description of plane radiant temperature and radiant asymmetry.)

sensation, thermal: a conscious subjective expression of an occupant's thermal perception of the environment, commonly expressed using the categories "cold," "cool," "slightly cool," "neutral," "slightly warm," "warm," and "hot."

temperature, air: the temperature of the air at a point.

temperature, air average (t_a): the average air temperature surrounding a representative occupant. The average is with respect to location and time. The spatial average is the numerical average of the air temperature at the ankle level, the waist level, and the head level. These levels are 0.1, 0.6, and 1.1 m (4, 24, and 43 in.) for seated occupants and 0.1, 1.1, and 1.7 m (4, 43, and 67 in.) for standing occupants. Time averaging is over a period not less than three and not more than 15 minutes.

temperature, dew-point (t_{dp}): the air temperature at which the water vapor in air at a given barometric pressure will condense into a liquid.

temperature, floor (t_f): the surface temperature of the floor where it is in contact with the representative occupants' feet.

temperature, mean daily outdoor air ($\overline{t_{mda(out)}}$): any arithmetic mean for a 24-hour period permitted in Section 5.4 of

the standard. Mean daily outdoor air temperature is used to calculate prevailing mean outdoor air temperature ($\overline{t_{pma(out)}}$).

temperature, mean radiant ($\bar{t}_r$): the temperature of a uniform, black enclosure that exchanges the same amount of heat by radiation with the occupant as the actual enclosure. It is a single value for the entire body expressed as a spatial average of the temperature of surfaces surrounding the occupant weighted by their view factors with respect to the occupant. (See Chapter 9 of *ASHRAE Handbook—Fundamentals*[3] for a more complete description of mean radiant temperature.)

temperature, operative (t_o): the uniform temperature of an imaginary black enclosure and the air within it in which an occupant would exchange the same amount of heat by radiation plus convection as in the actual nonuniform environment; calculated in accordance with Normative Appendix A of this standard. ***Note:*** See Chapter 9 of *ASHRAE Handbook—Fundamentals*[3] for further discussion of operative temperature.)

temperature, plane radiant (t_{pr}): the uniform temperature of an enclosure in which the incident radiant flux on one side of a small plane element is the same as in the existing environment.

temperature, prevailing mean outdoor air ($\overline{t_{pma(out)}}$): when used as an input variable in Figure 5.4.2.1 for the adaptive model, this temperature is based on the arithmetic average of the mean daily outdoor temperatures over some period of days as permitted in Section 5.4.2.1.

temperature, standard effective (SET): the temperature of an imaginary environment at 50% rh, <0.1 m/s (20 fpm) average air speed (V_a), and $\bar{t}_r = t_a$, in which the total heat loss from the skin of an imaginary occupant with an activity level of 1.0 met and a clothing level of 0.6 clo is the same as that from a person in the actual environment, with actual clothing and activity level.

zone, comfort: those combinations of air temperature, mean radiant temperature ($\bar{t}_r$), and humidity that are predicted to be an acceptable thermal environment at particular values of air speed, metabolic rate, and clothing insulation (I_{cl}).

zone, occupied: the region normally occupied by people within a space. In the absence of known occupant locations, the occupied zone is to be between the floor and 1.8 m (6 ft) above the floor and more than 1.0 m (3.3 ft) from outside walls/windows or fixed heating, ventilating, or air-conditioning equipment and 0.3 m (1 ft) from internal walls.

4. GENERAL REQUIREMENTS

4.1 When information is required to be identified in this standard, it shall be documented in accordance with and in addition to the requirements in Section 6.

4.2 Identify all the space types to which the standard is being applied and any locations within a space to which it is not applied.

4.3 For each space type, at least one representative occupant shall be identified. If any known set of occupants is excluded from consideration then these excluded occupants shall be identified.

4.4 For each representative occupant, the metabolic rate (M) in mets and the insulation (I) in clo shall be determined.

4.5 The thermal environment required for comfort is determined according to Section 5 of this standard.

5. CONDITIONS THAT PROVIDE THERMAL COMFORT

5.1 General Requirements. Section 5 of this standard shall be used to determine the acceptable thermal environment for each representative occupant of a space. Section 5.2 is used to determine representative occupant characteristics.

Section 5.3 in its entirety or Section 5.4 in its entirety shall be identified as the approach used in determining the acceptable thermal environment. Section 5.3 shall be permitted to be used in any space, and Section 5.4 shall be permitted to be used only in those spaces that meet the applicability criteria in Section 5.4.1. Determine operative temperature (t_o) in accordance with Normative Appendix A.

This section covers the determination of the following six factors in steady state. All six factors shall be addressed when defining conditions for acceptable thermal comfort:

a. Metabolic rate
b. Clothing insulation
c. Air temperature
d. Radiant temperature
e. Air speed
f. Humidity

Notes:

1. It is possible for all six of these factors to vary with time. The first two are characteristics of the occupant and the remaining four are conditions of the thermal environment.
2. *Average air speed* and *average air temperature* have precise definitions in this standard. See Section 3 for all defined terms.

5.2 Method for Determining Occupant Characteristics

5.2.1 Metabolic Rate

5.2.1.1 Rate for Each Representative Occupant. For each representative occupant, determine the metabolic rate associated with the occupant's activities. Averaged metabolic rates shall not be used to represent multiple occupants with significantly different metabolic rates.

Example: The customers in a restaurant may have a metabolic rate near 1.0 met, while the servers may have a metabolic rate closer to 2.0 met. Each of these groups of occupants shall be considered separately in determining the conditions required for comfort. In some situations such as this, it will not be possible to provide an acceptable level or the same level of comfort to all disparate groups of occupants.

5.2.1.2 Rate Determination. Use one or a combination of the following methods to determine metabolic rate:

a. Use the data presented in Table 5.2.1.2 for the task most comparable to the activity of the representative occupant. Where a range is given, select a single value within that range based on the characteristics of the activity.

TABLE 5.2.1.2 Metabolic Rates for Typical Tasks

Activity	Metabolic Rate		
	Met Units	W/m^2	$Btu/h \cdot ft^2$
Resting			
Sleeping	0.7	40	13
Reclining	0.8	45	15
Seated, quiet	1.0	60	18
Standing, relaxed	1.2	70	22
Walking (on level surface)			
0.9 m/s, 3.2 km/h, 2.0 mph	2.0	115	37
1.2 m/s, 4.3 km/h, 2.7 mph	2.6	150	48
1.8 m/s, 6.8 km/h, 4.2 mph	3.8	220	70
Office Activities			
Reading, seated	1.0	55	18
Writing	1.0	60	18
Typing	1.1	65	20
Filing, seated	1.2	70	22
Filing, standing	1.4	80	26
Walking about	1.7	100	31
Lifting/packing	2.1	120	39
Driving/Flying			
Automobile	1.0–2.0	60–115	18–37
Aircraft, routine	1.2	70	22
Aircraft, instrument landing	1.8	105	33
Aircraft, combat	2.4	140	44
Heavy vehicle	3.2	185	59
Miscellaneous Occupational Activities			
Cooking	1.6–2.0	95–115	29–37
House cleaning	2.0–3.4	115–200	37–63
Seated, heavy limb movement	2.2	130	41
Machine work			
sawing (table saw)	1.8	105	33
light (electrical industry)	2.0–2.4	115–140	37–44
heavy	4.0	235	74
Handling 50 kg (100 lb) bags	4.0	235	74
Pick and shovel work	4.0–4.8	235–280	74–88
Miscellaneous Leisure Activities			
Dancing, social	2.4–4.4	140–255	44–81
Calisthenics/exercise	3.0–4.0	175–235	55–74
Tennis, single	3.6–4.0	210–270	66–74
Basketball	5.0–7.6	290–440	90–140
Wrestling, competitive	7.0–8.7	410–505	130–160