ANSI/ASHRAE Standard 55-2010
(Supersedes ANSI/ASHRAE Standard 55-2004)
Includes ANSI/ASHRAE addenda listed in Appendix I

ASHRAE STANDARD

Thermal Environmental Conditions for Human Occupancy

See Appendix I for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

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ANSI/ASHRAE Standard 55-2010
Thermal Environmental Conditions for Human Occupancy

NOTE

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(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process.)

FOREWORD

ANSI/ASHRAE Standard 55-2010 is the latest edition of Standard 55. The 2010 edition combines Standard 55-2004 and the ten approved and published addenda to the 2004 edition into one easy-to-use, consolidated standard. The standard outlines conditions in which a specified fraction of the occupants will find the environment thermally acceptable. The standard is intended for use in design, commissioning, and testing of buildings and other occupied spaces and their HVAC systems and for the evaluation of thermal environments. Because it is not possible to prescribe the metabolic rate of occupants, and because of variations in occupant clothing levels, operating setpoints for buildings cannot practically be 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 on a regular basis 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 Web site.

As with previous updated editions of the standard, the 2004 edition introduced significant changes. Perhaps most notable were (1) the adoption of the computer model method for general indoor application, which brought the standard into close agreement with ISO Standards 7726[1] and 7730[2], and (2) the introduction of the Adaptive Method, which relied on recent research to support natural ventilation designs for more sustainable, energy efficient, and occupant-friendly designs.

Continuing in this spirit of introducing recent research innovations into the standard, several significant improvements have been made in the years since 2004. In particular, the use of elevated air speeds to widen the acceptable range of thermal conditions has been introduced and refined.

The standard previously allowed modest increases in operative temperature beyond the PMV-PPD ("Computer Model Method" in the standard) limits as a function of air speed and turbulence intensity. But field studies, including recently published work, show that occupants, especially when neutral or slightly warm, prefer higher air speeds than were previously allowed. In certain combinations of temperature ranges and personal factors, the preference for more air movement is greater than for less air movement. Addenda since 2004 included a new method for expressing and selecting air-speed limits, and alternatives for determining the boundaries of comfort at air speeds above 0.15 m/s (30 fpm). With these changes, the standard continues to focus on defining the range of indoor thermal environmental conditions acceptable to a majority of occupants, but accommodates an ever increasing variety of design solutions intended both to provide comfort and to respect today's imperative for sustainable buildings.

The 2010 edition of the standard includes the following significant changes:

- *Clarifies that the upper humidity limit shown on the psychrometric chart in the Graphic Comfort Zone Method applies to only that method. Higher humidity limits are allowed if evaluated with the Computer Model Method and no limits are imposed on the Adaptive Model.*
- *Revises requirements and calculation methods when increased air movement is used to maintain comfort in warm conditions. Standard Effective Temperature (SET) is reintroduced into the Standard as the calculation basis for determining the cooling effect of air movement. In general, the calculation method has been simplified with the removal of turbulence intensity and draft risk calculations, and the personal control limitations have been relaxed based on the results of new research. This change is expected to give clear requirements for application of ceiling fans for comfort cooling.*
- *Significant revisions to Section 6, "Compliance" that now clearly state the mandatory minimum requirements for analysis and documentation of a design to show that it meets the requirements in the standard. Informative appendix H expands on Section 6 by providing a compliance form for documentation of design compliance.*
- *A new general satisfaction survey has been added to section 7.5.2.1 as a method to evaluate thermal comfort in occupied spaces. The previous survey in the 2004 version of the standard was meant for evaluating comfort at a point in time (e.g., "how do you feel right now?"), and the new survey is meant to evaluate the overall comfort of a space (e.g., "how do you feel in general?"). Addition of a general satisfaction survey aligns standard 55 with current practice for survey-based post occupancy evaluations (POEs).*
- *Editorial changes have been made throughout to clarify the requirements in the standard. Wherever possible, the use of informative language in the standard is avoided.*

For more specific information on the changes and on other revisions made to the standard by addenda, refer to Informative Appendix I at the end of this standard. Users of the standard are encouraged to use the continuous maintenance procedure to suggest changes for further improvements. A form for submitting change proposals is included in the back of this edition. The project committee for Standard 55 will take formal action on all change proposals received.

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.

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

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, thermal: the characteristics of the environment that affect a person's heat loss.

environment, acceptable thermal: an environment that a substantial majority of the occupants would find thermally acceptable.

garment: a single piece of clothing.

humidity ratio: the ratio of the mass of water vapor to the mass of dry air in a given volume.

humidity, relative (RH): the ratio of the partial pressure (or density) of the water vapor in the air to the saturation pressure (or density) of water vapor at the same temperature and the same total pressure.

insulation, clothing/ensemble (I_{cl}): the resistance to sensible heat transfer provided by a clothing ensemble. Expressed in clo units. ***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 clo units.

met: a unit used to describe the energy generated inside the body due to metabolic activity, defined as 58.2 W/m^2 (18.4 $Btu/h \cdot ft^2$), which is equal to the energy produced per unit surface area of an average person seated at rest. The surface area of an average person is 1.8 m^2 (19 ft^2).

metabolic rate (M): the rate of transformation of chemical energy into heat and mechanical work by metabolic activities within an organism, usually expressed in terms of unit area of the total body surface. In this standard, metabolic rate is expressed in met units.

naturally conditioned spaces, occupant controlled: those spaces where the thermal conditions of the space are regulated primarily by the opening and closing of windows by the occupants.

neutrality, thermal: the indoor thermal index value corresponding with a mean vote of neutral on the thermal sensation scale.

percent dissatisfied (PD): percentage of people predicted to be dissatisfied due to local discomfort.

predicted mean vote (PMV): an index that predicts the mean value of the votes of a large group of persons on the seven-point thermal sensation scale.

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 of the two opposite sides of a small plane element.

response time (90%): the time for a measuring sensor to reach 90% of the final value after a step change. For a measuring system that includes only one exponential time-constant function, the 90% response time equals 2.3 times the time constant.

sensation, thermal: a conscious feeling commonly graded using the categories *cold*, *cool*, *slightly cool*, *neutral*, *slightly warm*, *warm*, and *hot*; it requires subjective evaluation.

step change: an incremental change in a variable, either by design or as the result of an interval between measurement; typically, an incremental change in a control setpoint.

temperature, air (t_a): the temperature of the air surrounding the occupant.

temperature, dew point (t_{dp}): the temperature at which moist air becomes saturated (100% relative humidity) with water vapor ($p_{sdp} = p_a$) when cooled at constant pressure.

temperature, mean monthly outdoor air ($t_{a(out)}$): when used as input variable in Figure 5.3 for the adaptive model, this temperature is based on the arithmetic average of the mean daily minimum and mean daily maximum outdoor (dry-bulb) temperatures for the month in question.

temperature, mean radiant (t_r): the uniform surface temperature of an imaginary black enclosure in which an occupant would exchange the same amount of radiant heat as in the actual nonuniform space; see Section 7.2 for information on measurement positions.

temperature, operative (t_o): the uniform temperature of an imaginary black enclosure in which an occupant would exchange the same amount of heat by radiation plus convection as in the actual nonuniform environment; see Section 7.2 for information on body position within the imaginary enclosure.

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, standard effective (SET): the temperature of an imaginary environment at 50% RH, <0.1 m/s air speed, and $t_r = t_a$, 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.

time constant: the time for a measuring sensor to reach 63% of the final value after a step change.

water vapor pressure (p_a): the pressure that the water vapor would exert if it alone occupied the volume occupied by the humid air at the same temperature.

water vapor pressure, saturated dewpoint (p_{sdp}): the water vapor pressure at the saturation temperature corresponding to the reference pressure and without any liquid phase.

velocity, mean (v_a): an average of the instantaneous air velocity over an interval of time.

zone, occupied: the region normally occupied by people within a space, generally considered 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

Use of this standard is specific to the space being considered and the occupants of that space. Any application of this standard must specify the space to which it applies or the locations within that space to which it applies, if not to the entire space. Any application of this standard must identify the occupants (who must have a residency of more than 15 minutes in the space) to which it applies.

The activity and clothing of the occupants must be considered in applying this standard. When there are substantial differences in physical activity and/or clothing for occupants of a space, these differences must be considered.

In some cases it will not be possible to achieve an acceptable thermal environment for all occupants of a space due to individual differences, including activity and/or clothing. If the requirements are not met for some known set of occupants, then these occupants must be identified.

The thermal environmental conditions required for comfort are determined according to Section 5.2 or Section 5.3 of this standard. Any application of this standard must clearly state which of these sections is used. Additionally, all requirements of the applicable section, 5.2 or 5.3, must be met.

5. CONDITIONS THAT PROVIDE THERMAL COMFORT

5.1 Introduction. Thermal comfort is that condition of mind that expresses satisfaction with the thermal environment. Because there are large variations, both physiologically and psychologically, from person to person, it is difficult to satisfy everyone in a space. The environmental conditions required for comfort are not the same for everyone. Extensive laboratory and field data have been collected that provide the necessary statistical data to define conditions that a specified percentage of occupants will find thermally comfortable. Section 5 of this standard is used to determine the thermal environmental conditions in a space that are necessary to achieve acceptance by a specified percentage of occupants of that space.

There are six primary factors that must be addressed when defining conditions for thermal comfort. A number of other, secondary factors affect comfort in some circumstances. The six primary factors are listed below. Complete descriptions of these factors are presented in Section 5.4 and Normative Appendices A and B.

1. Metabolic rate
2. Clothing insulation
3. Air temperature
4. Radiant temperature
5. Air speed
6. Humidity

It is possible for all six of these factors to vary with time. This standard only addresses thermal comfort in a steady state (with some limited specifications for temperature variations with time in Section 5.2.5). ***Note:*** As a result, people entering a space that meets the requirements of this standard may not immediately find the conditions comfortable if they have experienced different environmental conditions just prior to entering the space. The effect of prior exposure or activity may affect comfort perceptions for approximately one hour.

Nonuniformity is addressed in Section 5.2.4. ***Note:*** Factors 2 through 6 may be nonuniform over an occupant's body, and this nonuniformity may be an important consideration in determining thermal comfort.

The vast majority of the available thermal comfort data pertains to sedentary or near sedentary physical activity levels typical of office work. This standard is intended primarily for these conditions. However, it is acceptable to use the standard to determine appropriate environmental conditions for moderately elevated activity. It does not apply to sleeping or bed rest. The body of available data does not contain significant information regarding the comfort requirements of children, the disabled, or the infirm. It is acceptable to apply the information in this standard to these types of occupants if it is applied judiciously to groups of occupants, such as those found in classroom situations.

Section 5.2 contains the methodology that shall be used for most applications. The conditions required for thermal comfort in spaces that are naturally conditioned are not necessarily the same as those conditions required for other indoor spaces. Field experiments have shown that in naturally conditioned spaces, where occupants have control of operable windows, the subjective notion of comfort is different because of different thermal experiences, availability of control, and resulting shifts in occupant expectations. Section 5.3 specifies criteria required for a space to be considered naturally conditioned. The methods of Section 5.3 may, as an option, be applied to spaces that meet these criteria. The methods of Section 5.3 may not be applied to other spaces.

Section 5.4 describes in some detail variables that must be clearly understood in order to use the methods of Section 5 effectively.

5.2 Method for Determining Acceptable Thermal Conditions in Occupied Spaces. When Section 5.2 is used to determine the requirements for thermal comfort, the requirements of all subsections—5.2.1, 5.2.2, 5.2.3, 5.2.4, and 5.2.5—must be met. This standard recommends a specific percentage of occupants that constitutes acceptability and values of the thermal environment associated with this percentage.

5.2.1 Operative Temperature. For given values of humidity, air speed, metabolic rate, and clothing insulation, a comfort zone may be determined. The comfort zone is defined in terms of a range of operative temperatures that provide acceptable thermal environmental conditions or in terms of the combinations of air temperature and mean radiant temperature that people find thermally acceptable.

This section describes methods that are acceptable for use in determining temperature limits for the comfort zone. Section 5.2.1.1 uses a simplified Graphic Method for determining the comfort zone that is acceptable for use for many typical applications. Section 5.2.1.2 uses a computer program based on a heat balance model to determine the comfort zone for a wider range of applications. For a given set of conditions, the results from the two methods are consistent, and either method is acceptable for use as long as the criteria outlined in the respective section are met.

See Informative Appendix C and the 2009 *ASHRAE Handbook—Fundamentals*,[3] Chapter 9, for procedures to calculate operative temperature. It is permissible to use dry-bulb temperature as a proxy for operative temperature under certain conditions described in Appendix C.

5.2.1.1 Graphic Comfort Zone Method for Typical Indoor Environments. It is permissible to apply the method in this section to spaces where the occupants have activity levels that result in metabolic rates between 1.0 and 1.3 met and where clothing is worn that provides between 0.5 and 1.0 clo of thermal insulation. See Normative Appendix A for estimation of metabolic rates and Normative Appendix B for estimation of clothing insulation. Most office spaces fall within these limitations.

The range of operative temperatures presented in Figure 5.2.1.1 are for 80% occupant acceptability. This is based on a 10% dissatisfaction criterion for general (whole body) thermal comfort based on the PMV-PPD index, plus an additional 10% dissatisfaction that may occur on average from local (partial body) thermal discomfort. Normative Appendix D provides a list of inputs and outputs used in the PMV/PPD computer program to generate these graphs.

Figure 5.2.1.1 specifies the comfort zone for environments that meet the above criteria and where the air speeds are not greater than 0.20 m/s (40 ft/min). Two zones are shown—one for 0.5 clo of clothing insulation and one for 1.0 clo of insulation. These insulation levels are typical of clothing worn when the outdoor environment is warm and cool, respectively. It is permissible to determine the operative temperature range allowed for intermediate values of clothing insulation by linear interpolation between the limits for 0.5 and 1.0 clo, using the following relationships:

$$T_{min,\,Icl} = [(I_{cl} - 0.5\text{ clo})\, T_{min,\,1.0\,clo} + (1.0\text{ clo} - I_{cl})\, T_{min,\,0.5clo}] \,/\, 0.5\text{ clo}$$

$$T_{max,\,Icl} = [(I_{cl} - 0.5\text{ clo})\, T_{max,\,1.0\,clo} + (1.0\text{ clo} - I_{cl})\, T_{max,\,0.5clo}] \,/\, 0.5\text{ clo}$$

where

$T_{max,\,Icl}$	=	upper operative temperature limit for clothing insulation I_{cl},
$T_{min,\,Icl}$	=	lower operative temperature limit for clothing insulation I_{cl}, and
I_{cl}	=	thermal insulation of the clothing in question, clo.

It is acceptable to use elevated air speeds to increase the upper operative temperature limit for the comfort zone in certain circumstances. Section 5.2.3 describes these adjustments and specifies the criteria required for such adjustments.

5.2.1.2 Computer Model Method for General Indoor Application. It is permissible to apply the method in this section to spaces where the occupants have activity levels that result in average metabolic rates between 1.0 and 2.0 met and where clothing is worn that provides 1.5 clo or less of thermal insulation. See Normative Appendix A for estimation of metabolic rates and Normative Appendix B for estimation of clothing insulation.

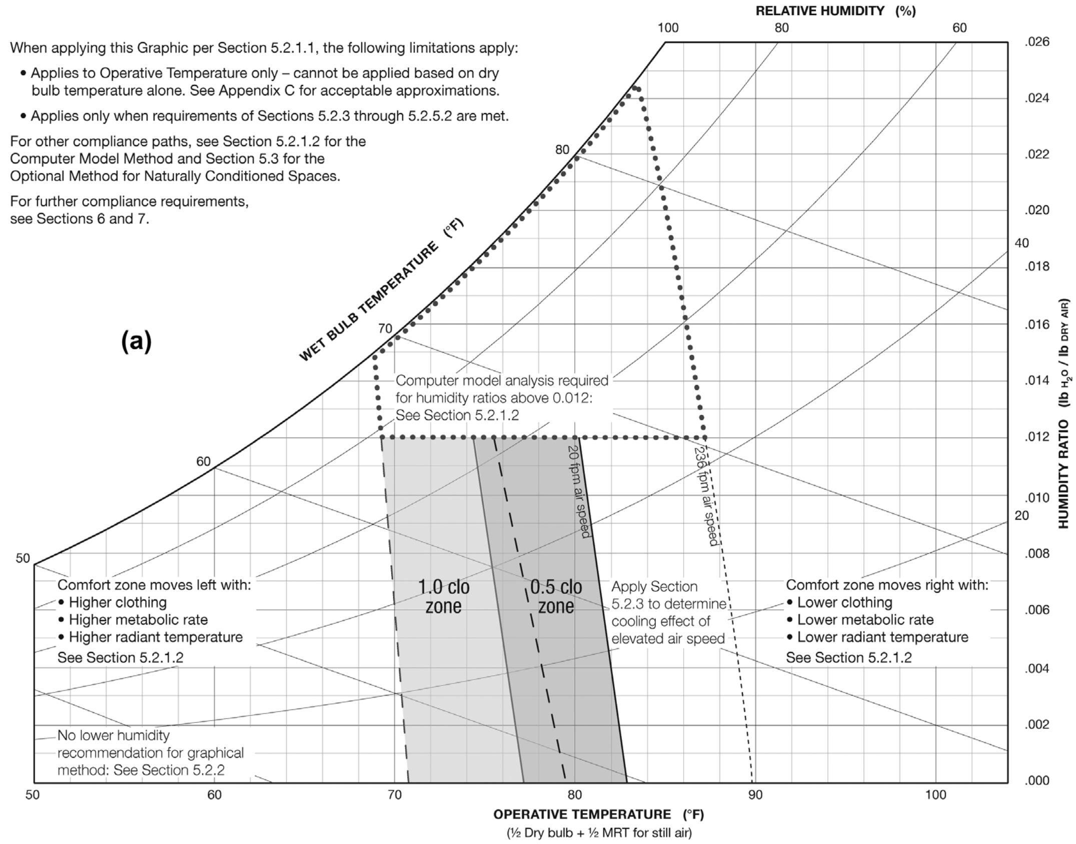
The ASHRAE thermal sensation scale, which was developed for use in quantifying people's thermal sensation, is defined as follows:

+3 hot
+2 warm
+1 slightly warm
0 neutral
–1 slightly cool
–2 cool
–3 cold

The predicted mean vote (PMV) model uses heat balance principles to relate the six key factors for thermal comfort listed in Section 5.1 to the average response of people on the above scale. The PPD (predicted percentage of dissatisfied) index is related to the PMV as defined in Figure 5.2.1.2. It is based on the assumption that people voting +2, +3, –2, or –3 on the thermal sensation scale are dissatisfied and on the simplification that PPD is symmetric around a neutral PMV.

Table 5.2.1.2 defines the recommended PPD and PMV range for typical applications. This is the basis for the Graphical Method in Section 5.2.1.1.

The comfort zone is defined by the combinations of the six key factors for thermal comfort for which the PMV is within the recommended limits specified in Table 5.2.1.2. The PMV model is calculated with the air temperature and mean



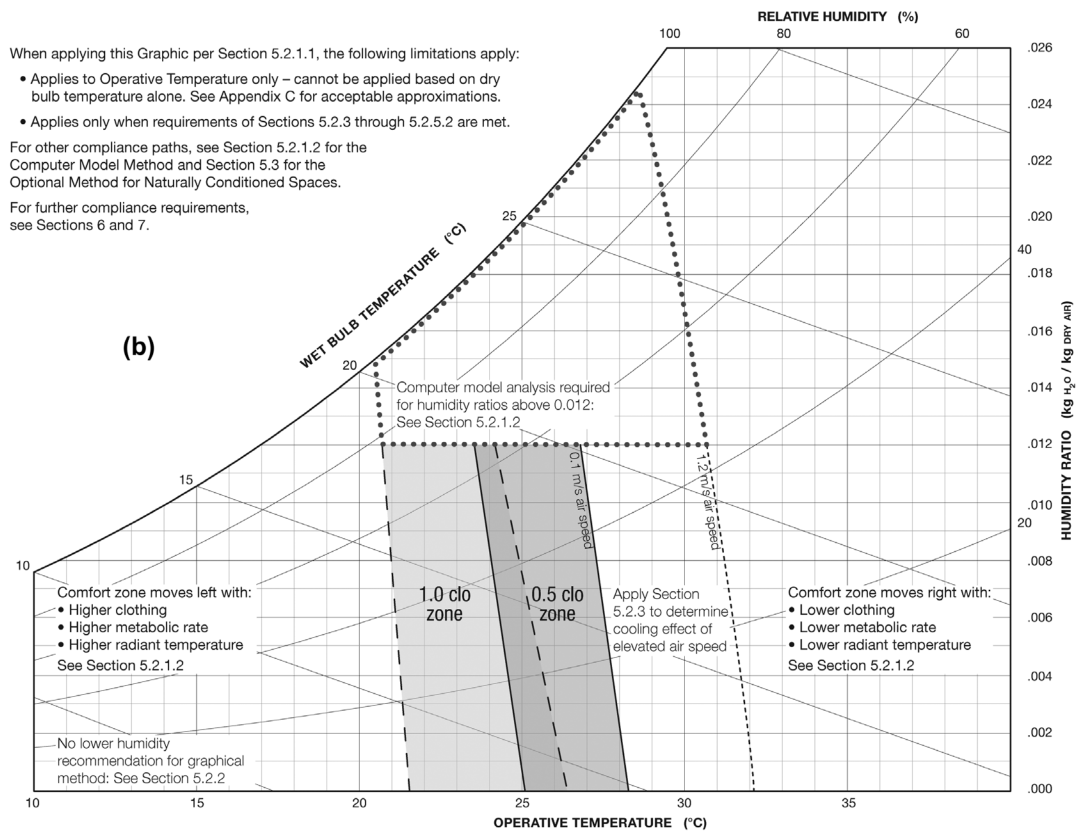


Figure 5.2.1.1 Graphic Comfort Zone Method: Acceptable range of operative temperature and humidity for spaces that meet the criteria specified in Section 5.2.1.1 (1.1 met; 0.5 and 1.0 clo)—(a) I-P and (b) SI.

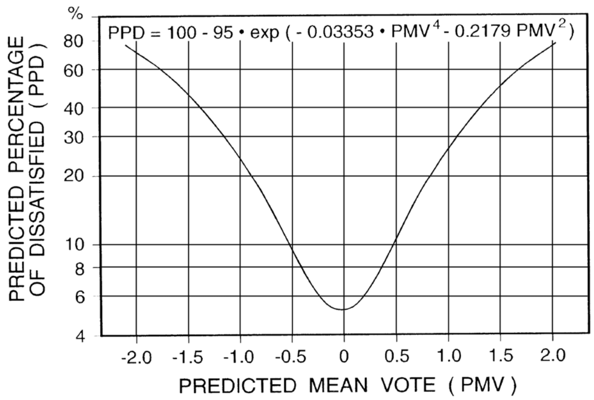


Figure 5.2.1.2 Predicted percentage dissatisfied (PPD) as a function of predicted mean vote (PMV).

TABLE 5.2.1.2
Acceptable Thermal Environment for General Comfort

PPD	PMV Range
<10	–0.5 < PMV < +0.5

radiant temperature in question along with the applicable metabolic rate, clothing insulation, air speed, and humidity. If the resulting PMV value generated by the model is within the recommended range, the conditions are within the comfort zone.

Use of the PMV model in this standard is limited to air speeds below 0.20 m/s (40 fpm). It is acceptable to use air speeds greater than this to increase the upper temperature limits of the comfort zone in certain circumstances. Section 5.2.3 describes the method and criteria required for such adjustments.

There are several computer codes available that predict PMV-PPD. The computer code in Normative Appendix D is to be used with this standard.[4] If any other version is used, it is the user's responsibility to verify and document that the version used yields the same results as the code in Appendix D for the conditions for which it is applied.

5.2.2 Humidity Limits. When the Graphic Comfort Zone Method in Section 5.2.1.1 is used, systems shall be able to maintain a humidity ratio at or below 0.012, which corresponds to a water vapor pressure of 1.910 kPa (0.277 psi) at standard pressure or a dew-point temperature of 16.8°C (62.2°F).

There are no established lower humidity limits for thermal comfort; consequently, this standard does not specify a minimum humidity level. ***Note:*** Nonthermal comfort factors, such as skin drying, irritation of mucus membranes, dryness of the eyes, and static electricity generation, may place limits on the acceptability of very low humidity environments.

5.2.3 Elevated Air Speed. This standard allows elevated air speed to be used to increase the maximum operative temperature for acceptability under certain conditions. Limits are imposed depending on environmental and personal factors and whether the occupants have local control of air speed.

5.2.3.1 Graphical Elevated Air Speed Method. The amount that the temperature may be increased is shown in Figure 5.2.3.1. The combinations of air speed and temperature defined by the lines in this figure result in equal levels of heat loss from the skin. The reference point for these curves is the upper air-speed limit of the PMV-defined comfort zone, 0.20 m/s (40 fpm), as described in Section 5.2.1.2. The figure applies to a lightly clothed person (with clothing insulation between 0.5 clo and 0.7 clo) who is engaged in near sedentary physical activity (with metabolic rates between 1.0 met and 1.3 met). The curves are generated by the SET thermophysiological model described in Section 5.2.3.2.

The indicated increase in temperature pertains to both the mean radiant temperature and the air temperature. That is, both temperatures increase by the same amount with respect to the starting point. When the mean radiant temperature is low and the air temperature is high, elevated air speed is less effective at increasing heat loss. Conversely, elevated air speed is more effective at increasing heat loss when the mean radiant temperature is high and the air temperature is low. Thus, the curve in Figure 5.2.3.1 that corresponds to the relative difference between air temperature and mean radiant temperature must be used. It is acceptable to interpolate between curves for intermediate differences.

Under the Graphical Elevated Air Speed Method, the required air speed for light, primarily sedentary activities may not be higher than 0.8 m/s (160 ft/min)—although higher air speeds are acceptable when using the SET Method in Section 5.2.3.2. Any benefits gained by increasing air speed depend on clothing and activity. Due to increases in skin wettedness, the effect of increased air speed is greater with elevated activity than with sedentary activity. Due to increased amounts of exposed skin, the effect of increased air speed is greater with lighter clothing. Thus, Figure 5.2.3.1 is conservative for activity levels above 1.3 met and/or for clothing insulation less than 0.5 clo and may be applied in these circumstances.

Due to increased body coverage, the effect of increased air speed is less with higher levels of clothing insulation. Thus, Figure 5.2.3.1 will underestimate the required air speed for clothing insulation greater than 0.7 clo and shall not be applied in these circumstances.

5.2.3.2 SET Method. Figure 5.2.3.2 represents a particular case of equal skin heat loss contours created by the Standard Effective Temperature (SET) model. The model, however, is not restricted to this particular case and it is acceptable to use it to determine the comfort zone for a broad range of applications.

The SET model uses a thermophysiological simulation of the human body to reduce any combination of real environmental and personal variables into the temperature of an imaginary standard environment in which the occupant's skin heat loss is equal to that of the person in the actual environment. This model enables air velocity effects on thermal comfort to be related across a wide range of air temperatures, radiant temperatures, and humidity ratios.

Figure 5.2.3.2 uses SET to extend the Figure 5.2.1.1 comfort zones across a range of air speeds for the example humidity ratio of 0.010. Figure 5.2.1.1 is based on PMV calculated for 0.1 m/s air speed (20 fpm). The extension in

Figure 5.2.3.2 was created in two steps. The PMV model was first used to calculate the operative temperature range of ±0.5 PMV at 0.15 m/s (30 fpm) in order to define the upper PMV comfort zone boundary, as specified in Section 5.2.3.1. After this boundary was defined, the curving comfort envelope boundaries above 0.15 m/s (30 fpm) were then defined by constant SET. The SET lines indicate temperature/air-speed combinations at which skin heat loss is the same as at the 0.15 m/s (30 fpm) PMV comfort zone boundary.

Note: The SET model is available in the ASHRAE *Thermal Comfort Tool CD*[4], as described in the Informative Appendix F of this standard.

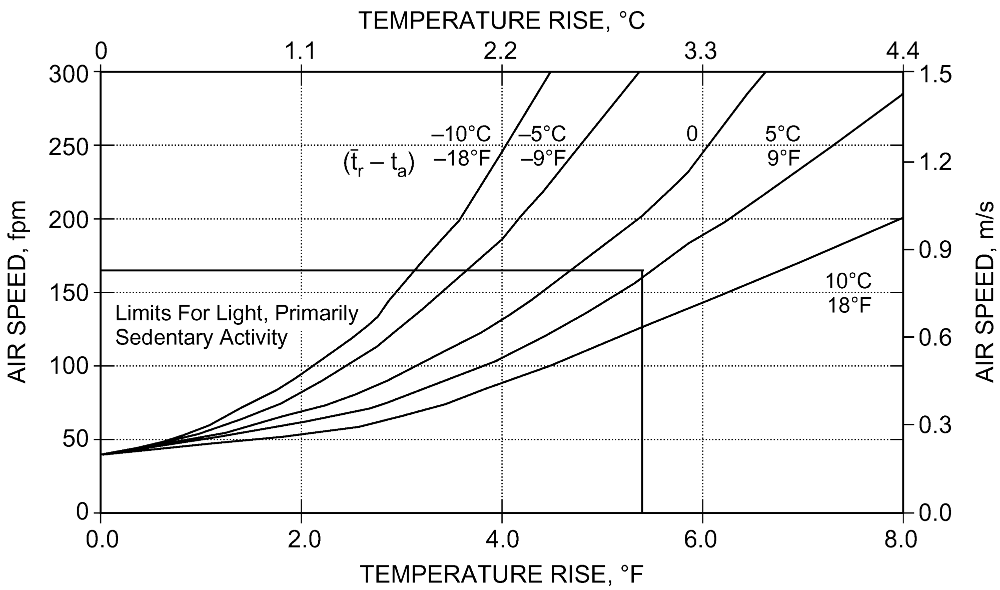


Figure 5.2.3.1 Air speed required to offset increased air and radiant temperature.

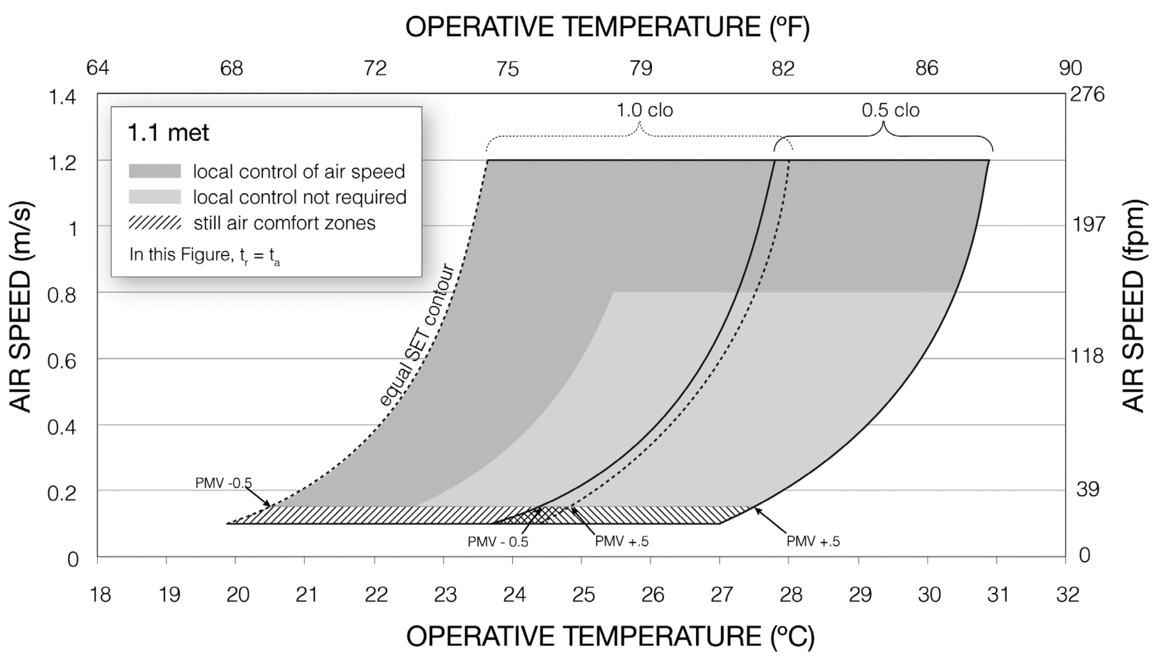


Figure 5.2.3.2 Acceptable range of operative temperature and air speeds for the comfort zone shown in Figure 5.2.1.1, at humidity ratio 0.010.

5.2.3.3 Limits to Air Speed

5.2.3.3.1 With Local Control. The full bounded area for a given clothing level in Figure 5.2.3.2 contains heat losses equal to those of the underlying PMV zone. The full bounded area applies when control of local air speed is provided to occupants. For control over their local air speed, control directly accessible to occupants must be provided either (a) for every six occupants or less or (b) for every 84 square meters (900 square feet) or less. The range of control shall encompass air speeds suitable for sedentary occupants. The air speed should be adjustable continuously or in maximum steps of 0.25 m/s (50 fpm) as measured at the occupant's location.

Exception: In multi-occupant spaces where groups gather for shared activities, such as classrooms and conference rooms, at least one control shall be provided for each space, regardless of size. Multi-occupant spaces that can be subdivided by moveable walls shall have one control for each space subdivision.

5.2.3.3.2 Without Local Control. Within the equal-heat-loss envelope, if occupants do not have control over the local air speed in their space, limits apply, as shown by the light gray area in Figure 5.2.3.2.

- For operative temperatures above 25.5°C (77.9°F), the upper limit to air speed shall be 0.8 m/s (160 fpm) for light, primarily sedentary office activities, such as in offices.
- For operative temperatures below 22.5°C (72.5°F), the limit shall be 0.15 m/s (30 ft/min) in order to avoid local cold discomfort due to draft.
- For operative temperatures between 22.5°C and 25.5°C (72.5°F and 77.9°F), the allowable speed shall follow the curve shown in Figure 5.2.3.2. This curve is an equal-SET curve for 0.6 clo and 1.1 met. It is acceptable to approximate the curve in SI and I-P units by the following equation:

$$V = 50.49 - 4.4047\, t_a + 0.096425(t_a)^2 \qquad \text{(m/s, °C)}$$

$$V = 31375.7 - 857.295\, t_a + 5.86288(t_a)^2 \qquad \text{(fpm, °F)}$$

5.2.3.4 Air Speed Measurement. At operative temperatures above 22.5°C (72.5°F), the overall heat balance of the body determines comfort. For this, the average air speed specified in Section 5.4 is used.

At operative temperatures below 22.5°C (72.5°F), however, the problem is avoiding local thermal discomfort, usually occurring on an unclothed portion of the body. The SET and PMV models do not distinguish between clothed and unclothed portions of the body, so the following conservative approach is adopted. The *maximum* mean air speed of the three measurement heights is used for the SET calculations, thereby overpredicting the whole-body cooling to a level that more closely approximates the cooling of the most affected local part. ***Note:*** To eliminate sources of air movement beyond the designer's control, the measurements should be taken without occupants present and with any nearby heat-generating equipment turned OFF.

5.2.4 Local Thermal Discomfort. The local thermal discomfort caused by a vertical air temperature difference between the feet and the head, by an asymmetric radiant field, by local convective cooling (draft), or by contact with a hot or cold floor must be considered in determining conditions for acceptable thermal comfort. Requirements for these factors are specified in this section.

The requirements specified in this section apply to a lightly clothed person (with clothing insulation between 0.5 and 0.7 clo) engaged in near sedentary physical activity (with metabolic rates between 1.0 and 1.3 met). With higher metabolic rates and/or with more clothing insulation, people are less thermally sensitive and, consequently, the risk of local discomfort is lower. Thus, it is acceptable to use the requirements of this section for metabolic rates greater than 1.3 met and with clothing insulation greater than 0.7 clo, and they will be conservative. People are more sensitive to local discomfort when the whole body is cooler than neutral and less sensitive to local discomfort when the whole body is warmer than neutral. The requirements of this section are based on environmental temperatures near the center of the comfort zone. These requirements apply to the entire comfort zone, but they may be conservative for conditions near the upper temperature limits of the comfort zone and may underestimate acceptability at the lower temperature limits of the comfort zone.

Table 5.2.4 specifies the expected percent dissatisfied (PD) for each source of local thermal discomfort described in Sections 5.2.4.1 through 5.2.4.4. The criteria for all sources of local thermal discomfort must be met simultaneously at the levels specified for an environment to meet the requirements of this standard.

5.2.4.1 Radiant Temperature Asymmetry. The thermal radiation field about the body may be nonuniform due to hot and cold surfaces and direct sunlight. This asymmetry may cause local discomfort and reduce the thermal acceptability of the space. In general, people are more sensitive to asymmetric radiation caused by a warm ceiling than that caused by hot and cold vertical surfaces. Figure 5.2.4.1 gives the predicted percentage of dissatisfied occupants as a function of the radiant temperature asymmetry caused by a warm ceiling, a cool wall, a cool ceiling, or a warm wall.

The limits for radiant temperature asymmetry are specified in Table 5.2.4.1. Alternatively, it is acceptable to use Figure 5.2.4.1 in conjunction with the PD limits from Table 5.2.4 to determine the allowable radiant asymmetry.

5.2.4.2 Draft. Draft is unwanted local cooling of the body caused by air movement. It is most prevalent when the whole body thermal sensation is cool (below neutral). Draft

TABLE 5.2.4
Percentage Dissatisfied (PD) Due to Local Discomfort from Draft or Other Sources

PD Due to Draft	PD Due to Vertical Air Temperature Difference	PD Due to Warm or Cool Floors	PD Due to Radiant Asymmetry
<20%	<5%	<10%	<5%

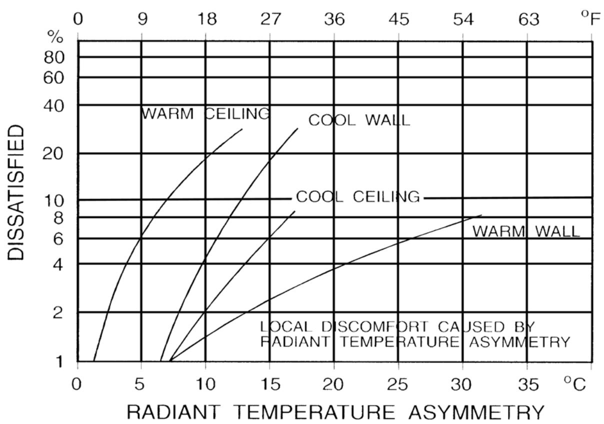


Figure 5.2.4.1 Local thermal discomfort caused by radiant asymmetry.

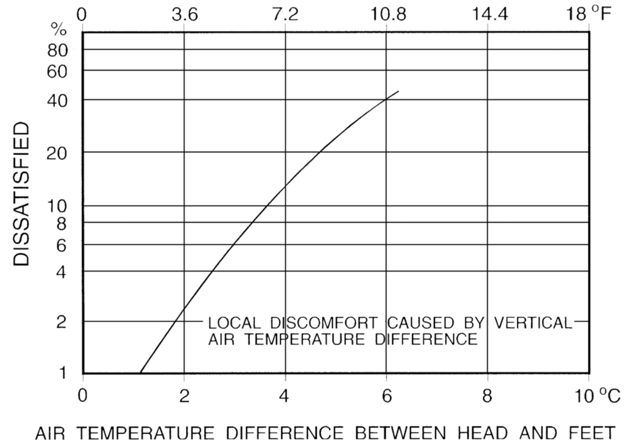


Figure 5.2.4.3 Local thermal discomfort caused by vertical temperature differences.

TABLE 5.2.4.1
Allowable Radiant Temperature Asymmetry

Radiant Temperature Asymmetry °C (°F)			
Warm Ceiling	**Cool Wall**	**Cool Ceiling**	**Warm Wall**
<5 (9.0)	<10 (18.0)	<14 (25.2)	<23 (41.4)

TABLE 5.2.4.3
Allowable Vertical Air Temperature Difference Between Head and Ankles

Vertical Air Temperature Difference, °C (°F)
<3 (<5.4)

sensation depends on the air speed, the air temperature, the activity, and the clothing. Sensitivity to draft is greatest where the skin is not covered by clothing, especially the head region comprising the head, neck, and shoulders and the leg region comprising the ankles, feet, and legs.

At operative temperatures below 22.5°C (72.5°F), air speeds within the comfort envelope of ±0.5 PMV should not exceed 0.15 m/s (30 fpm) as measured at any single height surrounding the body. This limit applies to air movement caused by the building, its fenestration, and its HVAC system and not to air movement produced by office equipment or occupants. It is acceptable for air speed to exceed this limit if it is under the occupants' local control and it is within the elevated air speed comfort envelope described in Section 5.2.3.

5.2.4.3 Vertical Air Temperature Difference. Thermal stratification that results in the air temperature at the head level being warmer than at the ankle level may cause thermal discomfort. This section specifies allowable differences between the air temperature at head level and the air temperature at ankle level. Figure 5.2.4.3 gives the predicted percentage of dissatisfied occupants as a function of the air temperature difference where the head level is warmer than the ankle level. Thermal stratification in the opposite direction is rare, is perceived more favorably by occupants, and is not addressed in this standard.

It is permissible to determine the allowable differences in air temperature from the ankle level to the head level from Table 5.2.4.3. Alternatively, it is acceptable to use Figure 5.2.4.3 in conjunction with the PD limit for vertical temperature differences in Table 5.2.4 to determine the allowable differences in air temperature from the ankle level to the head level.

5.2.4.4 Floor Surface Temperature. Occupants may feel uncomfortable due to contact with floor surfaces that are too warm or too cool. The temperature of the floor, rather than the material of the floor covering, is the most important factor for foot thermal comfort for people wearing shoes. Figure 5.2.4.4 gives the predicted percentage of dissatisfied occupants as a function of floor temperature. The criteria in this section are based on people wearing lightweight indoor shoes. It is acceptable to use these criteria for people wearing heavier footgear, but they may be conservative. This standard does not address the floor temperature required for people not wearing shoes, nor does it address acceptable floor temperatures when people sit on the floor.

The limits for floor temperature are specified in Table 5.2.4.4. Alternatively, it is acceptable to use Figure 5.2.4.4 conjunction with the PD limit from Table 5.2.4 to determine the allowable floor temperature range.

5.2.5 Temperature Variations with Time. Fluctuations in the air temperature and/or mean radiant temperature may affect the thermal comfort of occupants. Those fluctuations under the direct control of the individual occupant do not have a negative impact on thermal comfort, and the requirements of this section do not apply to these fluctuations. Fluctuations that occur due to factors not under the direct control of the individual occupant (e.g., cycling from thermostatic control) may have a negative effect on comfort, and the requirements of this section apply to these fluctuations. Fluctuations that occupants experience as a result of moving between locations

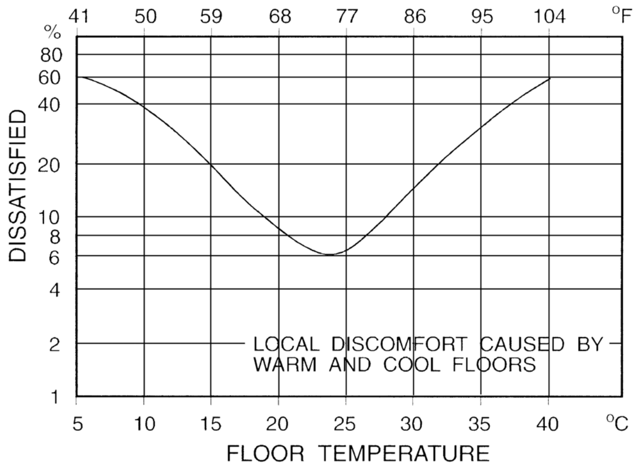


Figure 5.2.4.4 Local discomfort caused by warm and cool floors.

TABLE 5.2.4.4 Allowable Range of the Floor Temperature

Range of Surface Temperature of the Floor, °C (°F)
19–29 (66.2–84.2)

with different environmental conditions are allowed as long as the conditions at all of these locations are within the comfort zone for these moving occupants.

5.2.5.1 Cyclic Variations. Cyclic variations refer to those situations where the operative temperature repeatedly rises and falls, and the period of these variations is not greater than 15 minutes. If the period of the fluctuation cycle exceeds 15 minutes, the variation is treated as a drift or ramp in operative temperature, and the requirements of Section 5.2.5.2 apply. In some situations, variations with a period not greater than 15 minutes are superimposed on variations with a longer period. In these situations, the requirements of Section 5.2.5.1 apply to the component of the variation with a period not greater than 15 minutes, and the requirements of Section 5.2.5.2 apply to the component of the variation with a period greater than 15 minutes.

Table 5.2.5.1 specifies the maximum allowable peak-to-peak cyclic variation in operative temperature.

5.2.5.2 Drifts or Ramps. Temperature drifts and ramps are monotonic, noncyclic changes in operative temperature. The requirements of this section also apply to cyclic variations with a period greater than 15 minutes. Generally, drifts refer to passive temperature changes of the enclosed space, and ramps refer to actively controlled temperature changes. The requirements of this section are the same for drifts and ramps.

Table 5.2.5.2 specifies the maximum change in operative temperature allowed during a period of time. For any given time period, the most restrictive requirements from

TABLE 5.2.5.1 Allowable Cyclic Operative Temperature Variation

Allowable Peak-to-Peak Variation in Operative Temperature, °C (°F)
1.1 (2.0)

TABLE 5.2.5.2 Limits on Temperature Drifts and Ramps

Time Period, h	0.25	0.5	1	2	4
Maximum Operative Temperature Change Allowed, °C (°F)	1.1 (2.0)	1.7 (3.0)	2.2 (4.0)	2.8 (5.0)	3.3 (6.0)

Table 5.2.5.2 apply. For example, the operative temperature may not change more than 2.2°C (4.0°F) during a 1.0 h period, and it also may not change more than 1.1°C (2.0°F) during any 0.25 h period within that 1.0 h period. If variations are created as a result of control or adjustments by the user, higher values may be acceptable.

5.3 Optional Method for Determining Acceptable Thermal Conditions in Naturally Conditioned Spaces. For the purposes of this standard, occupant-controlled naturally conditioned spaces are those spaces where the thermal conditions of the space are regulated primarily by the occupants through opening and closing of windows. Field experiments have shown that occupants' thermal responses in such spaces depend in part on the outdoor climate and may differ from thermal responses in buildings with centralized HVAC systems primarily because of the different thermal experiences, changes in clothing, availability of control, and shifts in occupant expectations. This optional method is intended for such spaces.

In order for this optional method to apply, the space in question must be equipped with operable windows that open to the outdoors and can be readily opened and adjusted by the occupants of the space. There must be no mechanical cooling system for the space (e.g., refrigerated air conditioning, radiant cooling, or desiccant cooling). It is permissible to use mechanical ventilation with unconditioned air, but opening and closing of windows must be the primary means of regulating the thermal conditions in the space. It is permissible for the space to be provided with a heating system, but this optional method does not apply when the heating system is in operation. It applies only to spaces where the occupants are engaged in near-sedentary physical activities, with metabolic rates ranging from 1.0 to 1.3 met. See Normative Appendix A for estimation of metabolic rates. This optional method applies only to spaces where the occupants are free to adapt their clothing to the indoor and/or outdoor thermal conditions.

For spaces that meet these criteria, it is acceptable to determine the allowable indoor operative temperatures from Figure 5.3. This figure includes two sets of operative temperature limits—one for 80% acceptability and one for 90% acceptability. The 80% acceptability limits are for typical applications and shall be used when other information is not available. It is acceptable to use the 90% acceptability limits

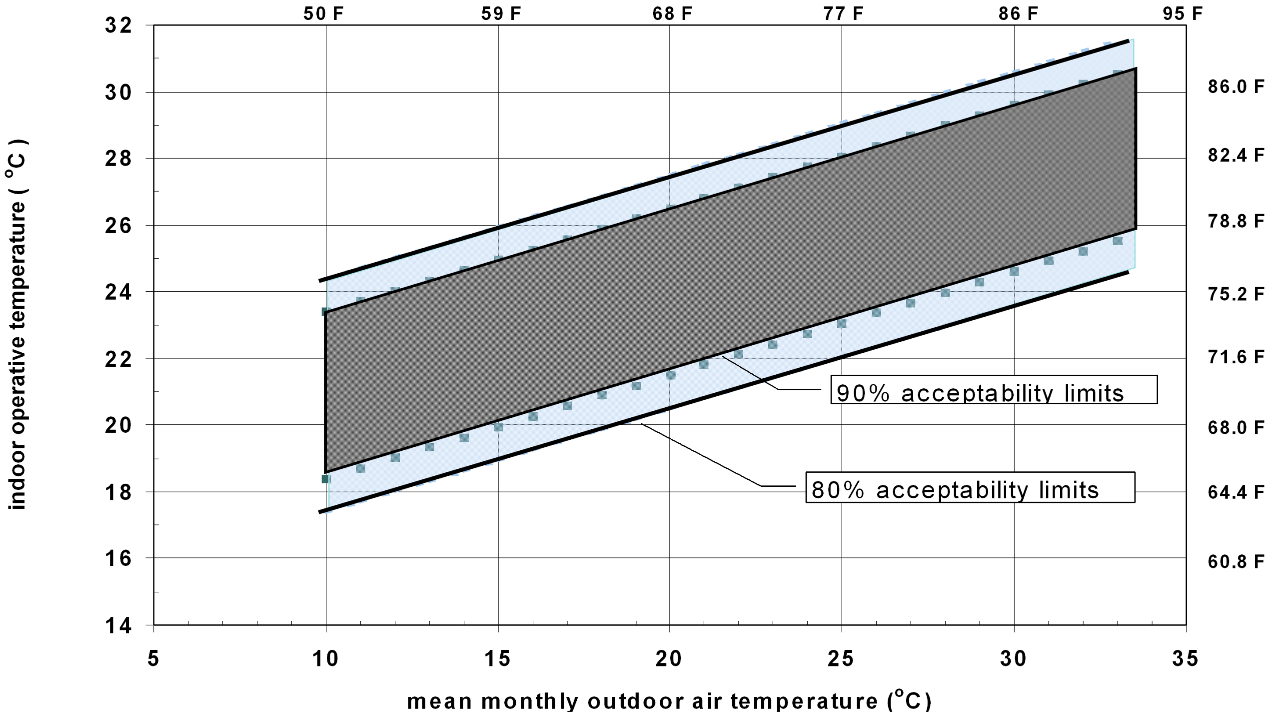


Figure 5.3 Acceptable operative temperature ranges for naturally conditioned spaces.

when a higher standard of thermal comfort is desired. Figure 5.3 is based on an adaptive model of thermal comfort that is derived from a global database of 21,000 measurements taken primarily in office buildings.

The allowable operative temperature limits in Figure 5.3 may not be extrapolated to outdoor temperatures above and below the end points of the curves in this figure. If the mean monthly outdoor temperature is less than 10°C (50°F) or greater than 33.5°C (92.3°F), this option may not be used, and no specific guidance for naturally conditioned spaces is included in this standard.

Figure 5.3 accounts for local thermal discomfort effects in typical buildings, so it is not necessary to address these factors when using this option. If there is reason to believe that local thermal comfort is a problem, it is acceptable to apply the criteria in Section 5.2.4.

Figure 5.3 also accounts for people's clothing adaptation in naturally conditioned spaces by relating the acceptable range of indoor temperatures to the outdoor climate, so it is not necessary to estimate the clothing values for the space.

No humidity or air-speed limits are required when this option is used.

5.4 Description of Thermal Environmental Variables. The following description of the environmental variables is provided for the purpose of understanding their use in Section 5. It is not intended to be a measurement specification. Section 7 specifies measurement requirements. If there is a discrepancy between the descriptions in this section and the requirements in Section 7, then the requirements in Section 7 supersede the descriptions in this section for the purpose of measurement.

For the purposes of Section 5, the thermal environment is defined with respect to the occupant.

Air temperature is the average temperature of the air surrounding an occupant. The average is with respect to location and time. As a minimum, 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.), respectively, for seated occupants, and 0.1, 1.1, and 1.7 m (4, 43, and 67 in.) for standing occupants. Intermediate, equally spaced locations may also be included in the average. When the occupant is located in a directed airflow, the air temperature on the upstream side shall be used. As a minimum, the temporal average is a three-minute average with at least 18 equally spaced points in time. If necessary, it is acceptable to extend the period up to 15 minutes to average cyclic fluctuations. The temporal average applies to all locations in the spatial average.

Local air temperature is defined in the same way as the air temperature except that it refers to a single level (e.g., head level). At least one location is required at this level. To determine a better average, it is acceptable to include multiple locations around the body.

Mean radiant temperature is defined as the temperature of a uniform, black enclosure that exchanges the same amount of thermal radiation with the occupant as the actual enclosure.

It is a single value for the entire body and may be considered a spatial average of the temperature of surfaces surrounding the occupant weighted by their view factors with respect to the occupant. See Chapter 9 in the 2009 *ASHRAE Handbook—Fundamentals*[3] for a more complete description of mean radiant temperature. For the purposes of Section 5, mean radiant temperature is also a time-averaged value. As a minimum, the temporal average is a three-minute average with at least 18 equally spaced points in time. If necessary, it is acceptable to extend the period up to 15 minutes to average cyclic fluctuations.

Operative temperature is the average of the air temperature and the mean radiant temperature weighted, respectively, by the convective heat transfer coefficient and the linearized radiant heat transfer coefficient for the occupant. See Chapter 9 in the 2009 *ASHRAE Handbook—Fundamentals*[3] for a more complete description of operative temperature. For occupants engaged in near sedentary physical activity (with metabolic rates between 1.0 and 1.3 met), not in direct sunlight, and not exposed to air velocities greater than 0.20 m/s (40 fpm), it is acceptable to approximate the relationship with acceptable accuracy by

$$t_o = (t_a + t_r) / 2$$

where

t_o = operative temperature,

t_a = air temperature, and

t_r = mean radiant temperature.

Radiant asymmetry is the difference between the plane radiant temperature in opposite directions. The plane radiant temperature is defined similarly to mean radiant temperature, except that it is with respect to a small planar surface element exposed to the thermal radiation from surfaces from one side of that plane. The vertical radiant asymmetry is with plane radiant temperatures in the upward and downward direction. The horizontal radiant asymmetry is the maximum difference between opposite plane radiant temperatures for all horizontal directions. The radiant 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. Time averaging for radiant asymmetry is the same as for mean radiant temperature. See Chapter 9 in the 2009 *ASHRAE Handbook—Fundamentals*[3] for a more complete description of plane radiant temperature and radiant asymmetry.

Floor temperature (t_f) is the surface temperature of the floor when it is in contact with the occupants' shoes. Since floor temperatures seldom change rapidly, time averaging does not need to be considered.

Mean monthly outdoor temperature is the arithmetic average of the mean daily minimum and mean daily maximum outdoor (dry-bulb) temperature for the month in question.

Air speed is the average speed of the air to which the body is exposed. The average is with respect to location and time. Time averaging is the same as for air temperature. However, the time-averaging period extends only to three minutes. Variations that occur over a period greater than three minutes shall be treated as multiple different air speeds. As to spatial averaging, the SET thermophysiological model described in Section 5.2.3.2 is based on the assumption that the body is exposed to a uniform air speed. However, spaces with passive or active systems that provide strongly nonuniform air velocity fields cause skin heat losses that cannot be simply related to those of uniform velocity fields. Therefore, the designer shall decide the proper averaging for air speed for use in the Graphical Method (Figure 5.2.3.1) and Informative Appendix F "Procedure for Evaluating Cooling Effect of Elevated Air speed Using SET." The proper averaging shall include air speeds incident on unclothed body parts (e.g., head) that have greater cooling effect and potential for local discomfort than unclothed parts.

Humidity is 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, and humidity ratio. It is spatially and temporally averaged in the same manner as air temperature.

6. COMPLIANCE

6.1 Design. Building systems (i.e., combinations of mechanical systems, control systems, and thermal envelopes) shall be designed so that at design conditions they are able to maintain the space at conditions within the range specified by one of the methods in this standard. This standard does not include specific guidance regarding mechanical systems, control systems, or the thermal envelopes for spaces as part of its scope.

In addition, the mechanical systems, control systems, and thermal envelopes shall be designed so that they are able to maintain the space at conditions within the range specified in this standard at all combinations of conditions that are expected to occur, with the exception of extreme conditions. The expected conditions shall include variations in both internal loads and the external environment. The system shall have controls that enable it to meet comfort requirements at less than full system capacity.

Because of differences in metabolic rates between individuals and the resultant differences in response to the environment, actual operating building temperatures cannot be specified in this standard.

6.2 Documentation. The method and design conditions appropriate for the intended use of the building shall be selected and documented as follows.

Note: Some of the requirements in items 1–4 below may not be applicable to naturally conditioned buildings.

1. The design operative temperature and humidity (including any tolerance or range), the design outdoor conditions (see 2009 *ASHRAE Handbook—Fundamentals*,[3] Chapter 14, "Climatic Design Information"), and total indoor loads shall be stated. The design exceedance level (the number of hours per year where conditions exceed Section 5 criteria) shall be documented based on the design conditions used in design. At a minimum, the hours of each seasonal exceedance associated with the outdoor weather percent design conditions (see 2009 *ASHRAE Handbook—Fundamentals*,[3] Chapter 14) used in design shall be stated. In complex and/or passive

systems, hours of exceedance may need to be calculated using a dynamic thermal simulation that predicts indoor conditions for every hour of the year.

2. Values assumed for comfort parameters used in the calculation of design temperatures, including clothing, metabolic rate, and indoor-air speed, shall be clearly stated. The clo level for the clothing of occupants intended to be satisfied shall be documented, including different clo levels for different seasons. The metabolic rate of occupants intended to be satisfied shall be documented. Where different clo levels or metabolic rates are anticipated in different spaces or at different times, these assumptions shall be documented.
3. Local discomfort effects are difficult to calculate due to limitations in thermal modeling tools, but can be estimated with simplified assumptions. Local discomfort shall be addressed by, at a minimum, a narrative explanation of why an effect is not likely to exceed Section 5 limits. When a design has asymmetric thermal conditions (e.g., radiant heating/cooling, areas of glazing that are above 50% window-to-wall ratio, additional air movement, stratified displacement cooling), a calculation of related local discomfort effects shall be included. At a minimum, documentation shall identify the design condition analyzed for each local discomfort effect and any simplifying assumptions used in the calculation.
4. The system input or output capacities necessary to attain the design indoor thermal comfort conditions stated in Item 1 above at design outdoor conditions shall be stated.

Note: See Informative Appendix G for sample compliance documentation.

7. EVALUATION OF THE THERMAL ENVIRONMENT

At the design stage, it is permissible to evaluate the thermal environment by calculations. Simple hand calculations and computer models of buildings and systems are available for this purpose. Use this section to evaluate existing thermal environments with respect to this standard. ***Note:*** Full-scale laboratory testing may provide a more controlled validation, however.

7.1 Measuring Device Criteria. The measuring instrumentation used shall meet the requirements for measuring range and accuracy given in ASHRAE Standard 70[5] or Standard 113[6] or in ISO 7726,[1] and the referenced source shall be so identified.

7.2 Measurement Positions

7.2.1 Location of Measurements. Measurements shall be made in occupied zones of the building at locations where the occupants are known to or are expected to spend their time.

Such locations might be workstation or seating areas, depending on the function of the space. In occupied rooms, measurements shall be taken at a representative sample of occupant locations spread throughout the occupied zone. In unoccupied rooms, the evaluator shall make a good-faith estimate of the most significant future occupant locations within the room and make appropriate measurements.

If occupancy distribution cannot be estimated, then the measurement locations shall be as follows:

a. In the center of the room or zone.
b. 1.0 m (3.3 ft) inward from the center of each of the room's walls. In the case of exterior walls with windows, the measurement location shall be 1.0 m (3.3 ft) inward from the center of the largest window.

In either case, measurements shall be taken in locations where the most extreme values of the thermal parameters are estimated or observed to occur. Typical examples might be near windows, diffuser outlets, corners, and entries. Measurements are to be made sufficiently away from the boundaries of the occupied zone and from any surfaces to allow for proper circulation around measurement sensors with positions as described below.

A measure of absolute humidity (such as humidity ratio) is required to be determined at only one location within the occupied zone in each occupied room or HVAC-controlled zone, provided it can be demonstrated that there is no reason to expect large humidity variations within that space. Otherwise, absolute humidity shall be measured at all locations defined above.

7.2.2 Height Above Floor of Measurements. Air temperature and air speed shall be measured at the 0.1, 0.6, and 1.1 m (4, 24, and 43 in.) levels for sedentary occupants at the locations specified in Section 7.2.1. Standing activity measurements shall be made at the 0.1, 1.1, and 1.7 m (4, 43, and 67 in.) levels. Operative temperature or PMV-PPD shall be measured or calculated at the 0.6 m (24 in.) level for seated occupants and the 1.1 m (43 in.) level for standing occupants.

Radiant asymmetry shall be measured at the 0.6 m (24 in.) level for seated occupants and the 1.1 m (43 in.) level for standing occupants. If desk-level furniture (that is in place) blocks the view of strong radiant sources and sinks, the measurements are to be taken above desktop level. Floor surface temperatures are to be measured with the anticipated floor coverings installed. Humidity shall be measured at any level within the occupied zone if only one measurement location is required. Otherwise it shall be measured at the 0.6 m (24 in.) level for seated occupants and the 1.1 m (43 in.) level for standing occupants.

7.3 Measurement Periods

7.3.1 Air Speed. The measuring period for determining the average air speed at any location shall be three minutes.

7.3.2 Temperature Cycles and Drifts. For determining compliance with the non-steady-state requirements of Section 5, the rate of change of operative temperature is used. It is the difference between maximum and minimum operative temperatures measured during the same cycle, divided by the elapsed time in minutes.

$$\text{Rate of change (degrees/h)} \\ = 60\,(t_{o,\,max} - t_{o,\,min}) \,/\, \text{time (minutes)}$$

The measurements shall be made every five minutes or less for at least two hours to establish the nature of the temperature cycle. The use of an automatic recorder is the preferred method of measurement; however, it is possible to make the measurements required in this section without the use of recording equipment.

7.3.3 Clothing and Activity. In buildings, it may be appropriate to measure the clothing and activity levels of the occupants. These shall be estimated in the form of mean values over a period of 0.5 to 1.0 hour immediately prior to measuring the thermal parameters.

7.4 Measuring Conditions. In order to determine the effectiveness of the building system at providing the environmental conditions specified in this standard, measurements shall be made under the following conditions.

To test during the heating period (winter conditions), the measurements required shall be made when the indoor-outdoor temperature difference is not less than 50% of the difference used for design and with cloudy to partly cloudy sky conditions. If these sky conditions are rare and not representative of the sky conditions used for design, then sky conditions representative of design conditions are acceptable.

To test during the cooling period (summer conditions), the measurements required shall be made when the outdoor-indoor temperature difference and humidity difference are not less than 50% of the differences used for design and with clear to partly cloudy sky conditions. If these sky conditions are rare and not representative of the sky conditions used for design, then sky conditions representative of design conditions are acceptable.

To test interior zones of large buildings, the measurements required shall be made with the zone loaded to at least 50% of the design load for at least one complete cycle of the HVAC system if the system is not proportionally controlled. Simulation of heat generated by occupants is recommended.

7.5 Validating the Thermal Environment for New Buildings and Installations

7.5.1 Define Criteria. Before validating a thermal environment that meets the requirements of this standard, the original design conditions specified shall be defined. From this definition, the validation team will evaluate the system's ability to meet and maintain the desired comfort level(s). The comfort criteria definition shall include but not be limited to the following:

- Temperature (air, radiant, surface)
- Humidity
- Air speed

The environmental conditions that were originally specified shall be defined as well to ensure that measurements taken correspond correctly to the design parameters. Environmental conditions shall include but are not limited to the following:

- Outdoor temperature design conditions
- Outdoor humidity design conditions
- Clothing (seasonal)
- Activity expected

7.5.2 Select Validation Method. In order to determine the thermal environment's ability to meet the defined criteria as outlined in Section 7.5.1 above, there are two methods (one described in Section 7.5.2.1 and the other in Section 7.5.2.2) that can be implemented. The first method of validating the thermal environment is to statistically determine occupant satisfaction through the evaluation of survey results. The second is to technically establish comfort conditions through the analysis of environment variables.

7.5.2.1 Survey Occupants. Since the purpose of this standard is to ensure that thermal environmental conditions in a room, building, etc., are acceptable to a majority of the occupants within the space, an effective way to evaluate the environmental conditions is to survey the occupants.

It is important, however, that the results of the survey be properly interpreted and used. Because space design conditions might differ from actual operating conditions, survey results are not a definitive means of determining whether the design engineer has succeeded in incorporating the requirements of this standard. In addition, occupant psychosocial conditions can impose a strong influence on subjective assessments of the environment, assumed design variables might be no longer valid, and operating control modules might be different from those the design engineer had anticipated.

But when properly used, occupant surveys are a direct method of assessing thermal comfort under operating conditions and, thus, the acceptability of the thermal environment. Survey results can also help designers enhance design protocols and help building operators identify and address reasons for discomfort.

Note: Related information and sample survey forms are provided in Informative Appendix E.

7.5.2.2 Analyze Environment Variables. The second method for evaluating the comfort conditions is to analyze specific environmental data for compliance with the requirements of this standard. Each application of validating the thermal environment is unique. A specific test plan will be required to accommodate the project scope.

Assess the environment for which comfort conditions are going to be verified. Determine the need to verify floor surface temperature, vertical temperature difference, and radiant temperature asymmetry. When this need exists, it is important to ensure the maximum potential for variance is exploited (e.g., take radiant asymmetry temperature reading on a sunny day with the blinds open).

Under all expected operating conditions, air speed (nondirectional), air temperature, and humidity shall be verified.

- Verify satisfactory air speed with a group of readings taken at a strategic location within the space. For VAV systems, readings shall be taken at maximum flow with minimum supply-air temperature.
- Determine the best location for providing accurate air temperature and humidity readings. Proof of performance for both air temperature and humidity shall require trended data.

Where variables are going to be trended, successful comfort control shall be a function of steady-state performance. Steady state shall require that the trended variable remain within a specified range without cycling. Cycling is defined as fluctuation over 50% of the permitted range every 15 minutes or more frequently. This verification shall include trending variables for at least one occupied cycle during each seasonal condition. When thermal conditions in the occupied zone have a high sensitivity to time of day and weather conditions, the measurement shall be made such that the high and low extremes of the thermal parameters are determined. ASHRAE Standard 113[6] offers a procedure for determining air speed and temperature variations in building spaces and provides additional guidance for the measurement of mechanical equipment parameters.

7.5.3 Provide Documentation. The effort of validation also involves ensuring a thoroughly documented process. Whichever method of validating the thermal environment is chosen, the process shall be well documented.

7.5.3.1 Documenting Surveys. When the occupants of a building are surveyed as outlined in Section 7.5.2.1, the survey method shall be developed, written, and turned over with the sample survey sheets to the appropriate parties for review and approval.

7.5.3.2 Documenting Variable Analysis. For analysis of the environmental variables outlined in Section 7.5.2, the trend logs and data analysis shall be prepared. Again, the method of trending must be included with this submission for approval if it has not been provided prior to validation.

8. REFERENCES

1. *ISO 7726:1998, Ergonomics of the thermal environment—Instruments for measuring physical quantities.*
2. *ISO 7730:2005, Ergonomics of the Thermal Environment—Analytical Determination and Interpretation of Thermal Comfort using Calculation of the PMV and PPD Indices and Local Thermal Comfort Criteria.*
3. *2009 ASHRAE Handbook—Fundamentals.*
4. *Thermal Comfort Tool CD* (ASHRAE Item Code 94030).
5. *ASHRAE Standard 70-2006, Method of Testing for Rating the Performance of Air Outlets and Inlets.*
6. *ASHRAE Standard 113-2009, Method of Testing for Room Air Diffusion.*

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX A ACTIVITY LEVELS

Use of Metabolic Rate Data

These data presented in Table A1 are reproduced from Chapter 9 of the 2009 *ASHRAE Handbook—Fundamentals*[3]. The values in the table represent typical metabolic rates per unit of skin surface area for an average adult (DuBois area = 1.8 m^2, or 19.6 ft^2) for activities performed continuously. This handbook chapter provides additional information for estimating and measuring activity levels. General guidelines for the use of these data follow.

Every activity that may be of interest is not included in this table. Users of this standard should use their judgment to match the activities being considered to comparable activities in the table. Some of the data in this table are reported as a range and some as a single value. The format for a given entry is based on the original data source and is *not* an indication of when a range of values should or should not be utilized. For all activities except sedentary activities, the metabolic rate for a given activity is likely to have a substantial range of variation that depends on the individual performing the task and the circumstances under which the task is performed.

It is permissible to use a time-weighted average metabolic rate for individuals with activities that vary over a period of one hour or less. For example, a person who typically spends 30 minutes out of each hour "lifting/packing," 15 minutes "filing, standing," and 15 minutes "walking about" has an average metabolic rate of $0.50 \times 2.1 + 0.25 \times 1.4 + 0.25 \times 1.7 = 1.8$ met. Such averaging should not be applied when the period of variation is greater than one hour. For example, a person who is engaged in "lifting/packing" for one hour and then "filing, standing" the next hour should be treated as having two distinct metabolic rates.

As metabolic rates increase above 1.0 met, the evaporation of sweat becomes an increasingly important factor for thermal comfort. The PMV method does not fully account for this factor, and this standard should not be applied to situations where the time-averaged metabolic rate is above 2.0 met. ***Note:*** Rest breaks (scheduled or hidden) or other operational factors (get parts, move products, etc.) combine to limit time-weighted metabolic rates to about 2.0 met in most applications.

Time averaging of metabolic rates only applies to an individual. The metabolic rates associated with the activities of various individuals in a space may *not* be averaged to find a single, average metabolic rate to be applied to that space. The range of activities of different individuals in the space, and the environmental conditions required for those activities, should be considered in applying this standard. For 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 should be considered separately in determining the conditions required for comfort. In some situations, it will not be possible to provide an acceptable level or the same level of comfort to all disparate groups of occupants (e.g., restaurant customers and servers).

The metabolic rates in this table were determined when the subjects' thermal sensation was close to neutral. It is not yet known the extent to which people may modify their metabolic rate to decrease warm discomfort.

TABLE A1 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)

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX B CLOTHING INSULATION

The amount of thermal insulation worn by a person has a substantial impact on thermal comfort and is an important variable in applying this standard. Clothing insulation is expressed in a number of ways. In this standard, the clothing insulation of an ensemble expressed as a clo value (I_{cl}) is used. Users not familiar with clothing insulation terminology are referred to Chapter 9 of the 2009 *ASHRAE Handbook—Fundamentals*[3] for more information.

The insulation provided by clothing can be determined by a variety of means, and if accurate data are available from other sources—such as measurement with thermal manikins—these data are acceptable for use. When such information is not available, it is permissible to use tables in this appendix to estimate clothing insulation using one of the methods described below. Regardless of the source of the clothing insulation value, this standard shall not be used with clothing ensembles with more than 1.5 clo of insulation. This standard should not be used with clothing that is highly impermeable to moisture transport (e.g., chemical protective clothing or rain gear).

Three methods for estimating clothing insulation are presented. The methods are listed in order of accuracy and should be used in this order of preference.

- **Method 1:** Table B1 lists the insulation provided by a variety of common clothing ensembles. If the ensemble in question matches reasonably well with one of the ensembles in this table, then the indicated value of I_{cl} should be used.
- **Method 2:** Table B2 presents the thermal insulation of a variety of individual garments. It is acceptable to add or subtract these garments from the ensembles in Table B1 to estimate the insulation of ensembles that differ in garment composition from those in Table B1. For example, if long underwear bottoms are added to Ensemble 5 in Table B1, the insulation of the resulting ensemble is estimated as $I_{cl} = 1.01 + 0.15 = 1.16$ clo.
- **Method 3:** It is acceptable to define a complete clothing ensemble using a combination of the garments listed in Table B2. The insulation of the ensemble is estimated as the sum of the individual values listed in Table B2. For example, the estimated insulation of an ensemble consisting of overalls worn with a flannel shirt, T-shirt, briefs, boots, and calf-length socks is $I_{cl} = 0.30 + 0.34 + 0.08 + 0.04 + 0.10 + 0.03 = 0.89$ clo.

Tables B1 and B2 are for a standing person. A sitting posture results in a decreased thermal insulation due to compression of air layers in the clothing. This decrease may be offset by insulation provided by the chair. Table B3 shows the net effect on clothing insulation for typical indoor clothing ensembles that result from sitting in a chair. It is acceptable to use these data to adjust clothing insulation calculated using any of the above methods. For example, the clothing insulation for a person wearing Ensemble 3 from Table B1 and sitting in an executive chair is 0.96 + 0.15 = 1.11 clo. For many chairs, the net effect of sitting is a minimal change in clothing insulation. For this reason, it is recommended that no adjustment be made to clothing insulation if there is uncertainty as to the type of chair and/or if the activity for an individual includes both sitting and standing.

Tables B1 and B2 are for a person that is not moving. Body motion decreases the insulation of a clothing ensemble by pumping air through clothing openings and/or causing air motion within the clothing. This effect varies considerably depending on the nature of the motion (e.g., walking versus lifting) and the nature of the clothing (stretchable and snug fitting versus stiff and loose fitting). Because of this variability, accurate estimates of clothing insulation for an active person are not available unless measurements are made for the specific clothing under the conditions in question (e.g., with a walking manikin). A rough estimate of the clothing insulation for an active person is

$$I_{cl,\ active} = I_{cl} \times (0.6 + 0.4 / M) \qquad 1.2 \text{ met} < M < 2.0 \text{ met}$$

where M is the metabolic rate in met units and I_{cl} is the insulation without activity. For metabolic rates less than or equal to 1.2 met, no adjustment is recommended.

When a person is sleeping or resting in a reclining posture, the bed and bedding may provide considerable thermal insulation. It is not possible to determine the thermal insulation for most sleeping or resting situations unless the individual is immobile. Individuals will adjust the bedding to suit individual preferences. Provided adequate bedding materials are available, the thermal environmental conditions desired for sleeping and resting vary considerably from person to person and cannot be determined by the methods included in this standard.

Clothing variability among occupants in a space is an important consideration in applying this standard. This variability takes two forms. In the first form, different individuals wear different clothing due to factors unrelated to the thermal conditions. Examples include different clothing style preferences for men and women and offices where managers are expected to wear suits while other staff members may work in shirtsleeves. In the second form, the variability results from adaptation to individual differences in response to the thermal environment. For example, some individuals may wear sweaters, while others wear short-sleeve shirts in the same environment if there are no constraints limiting what is worn. The first form of variability may result in differences in the requirements for thermal comfort between the different occupants, and these differences should be addressed in applying this standard. In this situation, it is *not* acceptable to determine the average clothing insulation of various groups of occupants to determine the thermal environmental conditions needed for all occupants. Each group must be considered separately. Where the variability within a group of occupants is of the second form and is a result only of individuals freely making adjustments in clothing to suit their individual thermal preferences, it is acceptable to use a single representative average clothing insulation value for everyone in that group.

TABLE B1
Clothing Insulation Values for Typical Ensembles*

Clothing Description	Garments Included†	I_{cl}, (clo)
Trousers	1) Trousers, short-sleeve shirt	0.57
	2) Trousers, long-sleeve shirt	0.61
	3) #2 plus suit jacket	0.96
	4) #2 plus suit jacket, vest, T-shirt	1.14
	5) #2 plus long-sleeve sweater, T-shirt	1.01
	6) #5 plus suit jacket, long underwear bottoms	1.30
Skirts/Dresses	7) Knee-length skirt, short-sleeve shirt (sandals)	0.54
	8) Knee-length skirt, long-sleeve shirt, full slip	0.67
	9) Knee-length skirt, long-sleeve shirt, half slip, long-sleeve sweater	1.10
	10) Knee-length skirt, long-sleeve shirt, half slip, suit jacket	1.04
	11) Ankle-length skirt, long-sleeve shirt, suit jacket	1.10
Shorts	12) Walking shorts, short-sleeve shirt	0.36
Overalls/Coveralls	13) Long-sleeve coveralls, T-shirt	0.72
	14) Overalls, long-sleeve shirt, T-shirt	0.89
	15) Insulated coveralls, long-sleeve thermal underwear tops and bottoms	1.37
Athletic	16) Sweat pants, long-sleeve sweatshirt	0.74
Sleepwear	17) Long-sleeve pajama tops, long pajama trousers, short 3/4 length robe (slippers, no socks)	0.96

* Data are from Chapter 9 in the 2009 *ASHRAE Handbook—Fundamentals*.[3]
† All clothing ensembles, except where otherwise indicated in parentheses, include shoes, socks, and briefs or panties. All skirt/dress clothing ensembles include pantyhose and no additional socks.

For near-sedentary activities where the metabolic rate is approximately 1.2 met, the effect of changing clothing insulation on the optimum operative temperature is approximately 6°C (11°F) per clo. For example, Table B2 indicates that adding a thin, long-sleeve sweater to a clothing ensemble increases clothing insulation by approximately 0.25 clo. Adding this insulation would lower the optimum operative temperature by approximately 6°C/clo × 0.25 clo = 1.5°C (11°F/clo × 0.25 clo = 2.8°F). The effect is greater with higher metabolic rates.

TABLE B2
Garment Insulation*

Garment Description†	I_{clu}, clo	Garment Description[b]	I_{clu}, clo
Underwear		**Dress and Skirts****	
Bra	0.01	Skirt (thin)	0.14
Panties	0.03	Skirt (thick)	0.23
Men's briefs	0.04	Sleeveless, scoop neck (thin)	0.23
T-shirt	0.08	Sleeveless, scoop neck (thick), i.e., jumper	0.27
Half-slip	0.14	Short-sleeve shirtdress (thin)	0.29
Long underwear bottoms	0.15	Long-sleeve shirtdress (thin)	0.33
Full slip	0.16	Long-sleeve shirtdress (thick)	0.47
Long underwear top	0.20	**Sweaters**	
Footwear		Sleeveless vest (thin)	0.13
Ankle-length athletic socks	0.02	Sleeveless vest (thick)	0.22
Pantyhose/stockings	0.02	Long-sleeve (thin)	0.25
Sandals/thongs	0.02	Long-sleeve (thick)	0.36
Shoes	0.02	**Suit Jackets and Vests††**	
Slippers (quilted, pile lined)	0.03	Sleeveless vest (thin)	0.10
Calf-length socks	0.03	Sleeveless vest (thick)	0.17
Knee socks (thick)	0.06	Single-breasted (thin)	0.36
Boots	0.10	Single-breasted (thick)	0.44
Shirts and Blouses		Double-breasted (thin)	0.42
Sleeveless/scoop-neck blouse	0.12	Double-breasted (thick)	0.48
Short-sleeve knit sport shirt	0.17	**Sleepwear and Robes**	
Short-sleeve dress shirt	0.19	Sleeveless short gown (thin)	0.18
Long-sleeve dress shirt	0.25	Sleeveless long gown (thin)	0.20
Long-sleeve flannel shirt	0.34	Short-sleeve hospital gown	0.31
Long-sleeve sweatshirt	0.34	Short-sleeve short robe (thin)	0.34
Trousers and Coveralls		Short-sleeve pajamas (thin)	0.42
Short shorts	0.06	Long-sleeve long gown (thick)	0.46
Walking shorts	0.08	Long-sleeve short wrap robe (thick)	0.48
Straight trousers (thin)	0.15	Long-sleeve pajamas (thick)	0.57
Straight trousers (thick)	0.24	Long-sleeve long wrap robe (thick)	0.69
Sweatpants	0.28		
Overalls	0.30		
Coveralls	0.49		

* Data are from Chapter 9 in the *2009 ASHRAE Handbook—Fundamentals*[3].
† "Thin" refers to garments made of lightweight, thin fabrics often worn in the summer; "thick" refers to garments made of heavyweight, thick fabrics often worn in the winter.
** Knee-length dresses and skirts.
†† Lined vests.

TABLE B3
Typical Added Insulation when Sitting on a Chair
(Valid for Clothing Ensembles with Standing Insulation Values of 0.5 clo < I_{cl} < 1.2 clo)

Net chair*	0.00 clo
Metal chair	0.00 clo
Wooden side arm chair†	0.00 clo
Wooden stool	+0.01 clo
Standard office chair	+0.10 clo
Executive chair	+0.15 clo

* A chair constructed from thin, widely spaced cords that provide no thermal insulation. Included for comparison purposes only.
† Chair used in most of the basic studies of thermal comfort that were used to establish the PMV-PPD index.

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX C ACCEPTABLE APPROXIMATION FOR OPERATIVE TEMPERATURE

The assumption that operative temperature equals air temperature is acceptable when these four conditions exist:

1. There is no radiant and/or radiant panel heating or radiant panel cooling system;
2. The average U-factor of the outside window/wall is determined by the following equation:

$$U_W < \frac{50}{t_{d,i} - t_{d,e}} \quad \text{(SI)}$$

$$U_W < \frac{15.8}{t_{d,i} - t_{d,e}} \quad \text{(IP)}$$

where

U_w = average U-factor of window/wall, $W/m^2 \cdot K$ ($Btu/h \cdot ft^2 \cdot °F$)
$t_{d,i}$ = internal design temperature, °C (°F)
$t_{d,e}$ = external design temperature, °C (°F);

3. Window solar heat gain coefficients (SHGC) are less than 0.48; and
4. There is no major heat generating equipment in the space.

Calculation of the Operative Temperature Based on Air and Mean-Radiant Temperature

In most practical cases where the relative air speed is small (<0.2 m/s, 40 fpm) or where the difference between mean radiant and air temperature is small (<4°C, 7°F), the operative temperature can be calculated with sufficient approximation as the mean value of air temperature and mean radiant temperature.

For higher precision and other environments, the following formula may be used:

$$t_{op} = A\, t_a + (1 - A)\, t_r$$

where

t_{op} = operative temperature,
t_a = air temperature, and
t_r = mean radiant temperature.

The value of A can be found from the values below as a function of the relative air speed, v_r.

v_r	<0.2 m/s (<40 fpm)	0.2 to 0.6 m/s (40 to 120 fpm)	0.6 to 1.0 m/s (120 to 200 fpm)
A	0.5	0.6	0.7

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX D
COMPUTER PROGRAM FOR CALCULATION OF PMV-PPD

(Reference Annex D of ISO 7730. Used with permission from ISO. For additional technical information and an I-P version of the equations in this appendix, refer to the ASHRAE *Thermal Comfort Tool CD* referenced in Section 8 of this standard. The Thermal Comfort Tool allows for I-P inputs and outputs, but the algorithm is implemented in SI units.)

```
10   REM    ' Computer program (BASIC) for calculation of
20   REM    ' Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfaction (PPD)
30   REM    ' in accordance with ISO 7730
40   CLS:   Print "Data Entry"                                   : 'data entry
50   INPUT  "  Clothing                              (clo)"      ; CLO
60   INPUT  "  Metabolic rate                        (met)"      ; MET
70   INPUT  "  External work, normally around 0      (met)"      ; WME
80   INPUT  "  Air Temperature                       ( C )"      ; TA
90   INPUT  "  Mean radiant temperature              ( C )"      ; TR
100  INPUT  "  Relative air velocity                 (m/s)"      : VEL
110  PRINT  "  ENTER EITHER RH OR WATER VAPOR PRESSURE BUT NOT BOTH"
120  INPUT  "  Relative humidity                     ( % )"      ; RH
130  INPUT  "  Water vapor pressure                  (Pa)"       ; PA
140  DEF  FNPS (T) = exp(16.6536-4030.183/(TA+235))              : ' saturated vapor pressure KPa
150  IF PA=0 THEN PA=RH*10*FNPS  (TA)                            : ' water vapor pressure, Pa
160  ICL = .155 * CLO                                            : ' thermal insulation of the clothing in m^2K/W
170  M  =  MET * 58.15                                           : ' metabolic rate in W/m^2
180  W  =  WME * 58.15                                           : ' external work in W/m^2
190  MW  =  M – W                                                : ' internal heat production in the human body
200  IF ICL < .078 THEN FCL = 1 + 1.29 * ICL ELSE FCL = 1.05+645*ICL
205                                                              : ' clothing area factor
210  HCF = 12.1*SQR (VEL)                                        : ' heat transf. coefficient by forced convection
220  TAA =  TA + 273                                             : ' air temperature in Kelvin
230  TRA =  TR + 273                                             : ' mean radiant temperature in Kelvin
240  ' - - - - - - - - -  CACULATE SURFACE TEMPERATURE OF CLOTHING BY ITERATION - - - - - - - - - - - - - - -
250  TCLA =  TAA + (35.5-TA) / (3.5*(6.45*ICL+.1))
255  ' first guess for surface temperature of clothing
260  P1  =  ICL * FCL                                            : ' calculation term
270  P2  =  P1 * 3.96                                            : ' calculation term
280  P3  =  P1 * 100                                             : ' calculation term
290  P4  =  P1 * TAA                                             : ' calculation term
300  P5  =  308.7 – .028 * MW +P2 * (TRA/100) ^ 4                : ' calculation term
310  XN  =  TCLA / 100
320  XF  =  XN
330  N =0                                                        : ' N: number of iterations
340  EPS = .00015                                                : ' stop criteria in iteration
350  XF  =  (XF+XN) / 2
355  ' heat transf. coeff. by natural convection
360  HCN=2.38*ABS(100*XF-TAA)^.25
370  IF HCF<HCN THEN HC=HCF ELSE HC=HCN
380  XN=(P5+P4*HC-P2*XF^4) / (100+P3*HC)
390  N=N+1
400  IF N > 150 then goto 550
410  IF ABS(XN-XF) . EPS then goto 350
```

```
420   TCL=100*XN-273                                  :  ' surface temperature of the clothing
430   ' - - - - - - - - - - - - - - - - - - - HEAT LOSS COMPONENTS - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
435   " heat loss diff. through skin
440   HL1 = 3.05*.001*(5733-6.99*MW-PA)
445   ' heat loss by sweating (comfort)
450   IF MW > 58.15 THEN HL2 = .42 * (MW-58.15)
      ELSE HL2 = 0!
455   ' latent respiration heat loss
460   HL3 = 1.7 * .00001 * M * (5867-PA)
465   ' dry respiration heat loss
470   HL4 = .0014 * M * (34-TA)
475   ' heat loss by radiation
480   HL5 = 3.96*FCL*(XN^4-(TRA/100)^4)
485   ' heat loss by convection
490   HL6 = FCL * HC * (TCL-TA)
500   ' - - - - - - - - - - - - - - - - - CALCULATE PMV AND PPD - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
505   ' thermal sensation trans. Coeff.
510   TS  =  .303 * EXP(-.036*M) + 0.28
515   ' predicted mean vote
520   PMV = TS * (MW-HL1-HL2-HL3-HL4-HL5-HL6)
525   ' predicted percentage dissat.
530   PPD=100-95*EXP(-.03353*PMV^4-.2179*PMV^2)
540   goto 570
550   PMV = 99999!
560   PPD-100
570   PRINT: PRINT "OUTPUT"
580   PRINT " Predicted Mean Vote                          (PMV)              :  "
                ;: PRINT USING "###.###"; PMV
590   PRINT " Predicted Percentage of Dissatisfied         (PPD)              :  "
                ;: PRINT USING ###.###": PPD
600   PRINT: INPUT "NEXT RUN (Y/N) "  ;  R$
610   If (R$="Y" or R$="y") THEN RUN
620   END
```

EXAMPLE—Values used to generate the comfort envelope in Figure 5.2.1.1.

Run	Air Temp.		RH	Radiant Temp.		Air Speed		Met.	CLO	PMV	PPD
#	°F	C	%	°F	C	FPM	m/s				%
1	67.3	19.6	86	67.3	19.6	20	0.10	1.1	1	–0.5	10
2	75.0	23.9	66	75.0	23.9	20	0.10	1.1	1	0.5	10
3	78.2	25.7	15	78.2	25.7	20	0.10	1.1	1	0.5	10
4	70.2	21.2	20	70.2	21.2	20	0.10	1.1	1	–0.5	10
5	74.5	23.6	67	74.5	23.6	20	0.10	1.1	0.5	–0.5	10
6	80.2	26.8	56	80.2	26.8	20	0.10	1.1	0.5	0.5	10
7	82.2	27.9	13	82.2	27.9	20	0.10	1.1	0.5	0.5	10
8	76.5	24.7	16	76.5	24.7	20	0.10	1.1	0.5	–0.5	10

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX E
THERMAL ENVIRONMENT SURVEY

The use of occupant thermal environment surveys is an acceptable way of assessing comfort conditions for the acceptability ranges discussed in this standard.

All surveys should strive for a meaningful sample size and a high response rate. If the objective of the survey is a broad-brush assessment of a building or installation, an adequate sample size and high response rate help lower the risk of generalizing a limited observation to the entire occupant population. While no specific response rate is specified in the standard, the most important consideration is whether the survey responses are an accurate representation of the entire occupant population. Without representative responses, the results will have unknown value in representing a general assessment of the building or installation.

Note that thermal environment surveys are invaluable tools for diagnostic purposes in existing buildings and facilities. As a diagnostic tool, the goal is not a broad-brush conclusion but rather a detailed insight into the building's day-to-day operation through occupant feedback. For such purposes, each response is valuable regardless of the size or response rate of the survey.

There are two types of thermal environment surveys. In either type of survey, the essential questions relate to thermal comfort, but additional questions can help identify problems and formulate possible responses.

1. "Right-now" or "point-in-time" surveys are used to evaluate thermal sensations of occupants at a single point in time. Thermal comfort researchers have used these point-in-time surveys to correlate thermal comfort with environmental factors, such as those included in the PMV/PPD model: metabolic rate, clothing insulation, air temperature, radiant temperature, air speed, and humidity.

   A sample point-in-time survey is included in Section E1. This is a thermal sensation survey that asks occupants to rate their sensation (from "hot" to "cold") on the ASHRAE seven-point thermal sensation scale. Comfort, or predicted percentage dissatisfied (PPD), is extrapolated from occupant sensation votes, not surveyed directly.

   In order to use the results of a point-in-time survey to assess comfort conditions with respect to the acceptability ranges discussed in this standard over time, the survey would ideally be implemented in multiple conditions and in multiple operating modes. This may limit the feasibility or applicability of the point-in-time survey or its results.

   Note that a point-in-time survey, if repeated a month or a year apart with the same individuals and thermal environmental conditions, may give somewhat different results. Thus, such surveys should not be coupled with each other and interpreted as evidence of changes in the performance of the building's environmental control systems.
2. A second form of thermal environment survey—a "satisfaction" survey—is used to evaluate thermal comfort response of the building occupants in a certain span of time. Instead of evaluating thermal sensations and environmental variables indirectly to assess percentage dissatisfied, this type of survey directly asks occupants to provide satisfaction responses.

A sample thermal satisfaction survey has been included in Section E2 of this annex. It asks occupants to rate their satisfaction with their thermal environment (from "very satisfied" to "very dissatisfied") on a seven-point satisfaction scale. Acceptability is determined by the percentage of occupants who have responded "neutral" or "satisfied" (0, +1, +2, or +3) with their environment.

The basic premise of this survey method is that occupants by nature can recall instances or periods of thermal discomfort, identify patterns in building operation, and provide "overall" or "average" comfort votes on their environment. The surveyor must identify a span of time for the respondents to consider.

Since the survey results encompass a larger timeframe, the survey can be made every six months or repeated in heating and/or cooling seasons. It is recommended that the first thermal satisfaction survey be done at least six months after a new building has been occupied in order to identify and help avoid typical new-building problems/complaints. Since satisfaction may vary under different operational modes (i.e., seasons, weather), a survey conducted in one mode should not be generalized to other modes of operation.

The thermal satisfaction survey can be used by researchers, building operators, and facility managers to provide acceptability assessments of building systems' performance and operations in new buildings, in addition to periodic post-occupancy evaluation in existing facilities.

Note that the longer the time period covered—that is, the longer the period the respondents are asked to recall their thermal satisfaction—the less representative the survey may be of the entire time period. Recall accuracy decreases sharply as the time period recalled increases. Responses will generally be unintentionally weighted by respondents toward more recent experience.

E1. THERMAL ENVIRONMENT POINT-IN-TIME SURVEY

1. Record the approximate outside-air temperature _____ and seasonal conditions:

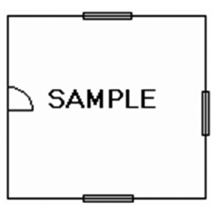
☐ Winter ☐ Spring ☐ Summer ☐ Fall

2. What is your general thermal sensation? (Check the one that is most appropriate)

*(**Note to survey designer:** This scale must be used as-is to keep the survey consistent with ASHRAE Standard 55.)*

- ☐ Hot
- ☐ Warm
- ☐ Slightly Warm
- ☐ Neutral
- ☐ Slightly Cool
- ☐ Cool
- ☐ Cold

3. Either (a) place an "X" in the appropriate place where you are located now:



*(**Note to survey designer:** Provide appropriate sketch for your space or building.)*

or (b) place an "X" in the check box that best describes the area of the building where you are located now.

- ☐ North
- ☐ East
- ☐ South
- ☐ West
- ☐ Core
- ☐ Don't know

4. On which floor of the building are you located now?

- ☐ 1st
- ☐ 2nd
- ☐ 3rd
- ☐ Other (provide the floor number):

5. Are you near an exterior wall (within 15 ft)?

- ☐ Yes
- ☐ No

6. Are you near a window (within 15 ft)?

- ☐ Yes
- ☐ No

7. Using the list below, please check each item of clothing that you are wearing right now. (Check all that apply):

*(**Note to survey designer:** This list can be modified at your discretion.)*

☐ Short-Sleeve Shirt	☐ Dress	☐ Nylons
☐ Long-Sleeve Shirt	☐ Shorts	☐ Socks
☐ T-shirt	☐ Athletic Sweatpants	☐ Boots
☐ Long-Sleeve Sweatshirt	☐ Trousers	☐ Shoes
☐ Sweater	☐ Undershirt	☐ Sandals
☐ Vest	☐ Long Underwear Bottoms	
☐ Jacket	☐ Long Sleeve Coveralls	
☐ Knee-Length Skirt	☐ Overalls	
☐ Ankle-Length Skirt	☐ Slip	

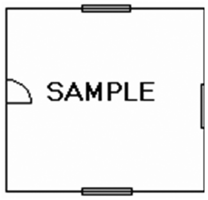
☐ Other: (Please note if you are wearing something not described above, or if you think something you are wearing is especially heavy.) ___________________

8. What is your activity level right now? (Check the one that is most appropriate)

- ☐ Reclining
- ☐ Seated
- ☐ Standing relaxed
- ☐ Light activity standing
- ☐ Medium activity standing
- ☐ High activity

E2. THERMAL ENVIRONMENT SATISFACTION SURVEY[1]

1. Either (a) place an "X" in the appropriate place where you spend most of your time:



*(**Note to survey designer:** Provide appropriate sketch for your space or building.)*

or (b) place an "X" in the check box that best describes the area of the building where your space is located.

☐ North
☐ East
☐ South
☐ West
☐ Core
☐ Don't know

2. On which floor of the building is your space located?

☐ 1st
☐ 2nd
☐ 3rd
☐ Other (provide the floor number)__________________

3. Are you near an exterior wall (within 15 ft)?

☐ Yes
☐ No

4. Are you near a window (within 15 ft)?

☐ Yes
☐ No

5. Which of the following do you personally adjust or control in your space? (Check all that apply.)

*(**Note to survey designer:** This list can be modified at your discretion.)*

☐ Window blinds or shades
☐ Room air-conditioning unit
☐ Portable heater
☐ Permanent heater
☐ Door to interior space
☐ Door to exterior space
☐ Adjustable air vent in wall or ceiling
☐ Ceiling fan
☐ Adjustable floor air vent (diffuser)
☐ Portable fan
☐ Thermostat
☐ Operable window
☐ None of these
☐ Other: _________________________

Please respond to the following questions based on your overall or average experience in the past [six] months.

(***Note to survey designer:*** The above statement can be modified for a different span of time.)

6. How satisfied are you with the temperature in your space? (Check the one that is most appropriate)

Very Satisfied  **Very Dissatisfied**

7. If you are dissatisfied with the temperature in your space, which of the following contribute to your dissatisfaction:

a. In warm/hot weather, the temperature in my space is (check the most appropriate box):

*(**Note to survey designer:** Include a scale or, as shown below, check boxes.)*

☐ Always too hot
☐ Often too hot
☐ Occasionally too hot
☐ Occasionally too cold
☐ Often too cold
☐ Always too cold

b. In cool/cold weather, the temperature in my space is (check the most appropriate box):

*(**Note to survey designer:** Include a scale or, as shown below, check boxes.)*

☐ Always too hot
☐ Often too hot
☐ Occasionally too hot
☐ Occasionally too cold
☐ Often too cold
☐ Always too cold

c. When is this most often a problem? (check all that apply):

☐ Morning (before 11am)
☐ Midday (11am–2pm)
☐ Afternoon (2pm–5pm)
☐ Evening (after 5pm)
☐ Weekends/holidays
☐ Monday mornings
☐ No particular time
☐ Always
☐ Other:

---

[1] This survey has been adapted from the CBE occupant IEQ survey developed by the Center for the Built Environment at the University of California at Berkeley.

d. How would you best describe the source of this discomfort? (Check all that apply):

*(**Note to survey designer:** This list can be modified at your discretion.)*

- ☐ Humidity too high (damp)
- ☐ Humidity too low (dry)
- ☐ Air movement too high
- ☐ Air movement too low
- ☐ Incoming sun
- ☐ Heat from office equipment
- ☐ Drafts from windows
- ☐ Drafts from vents
- ☐ My area is hotter/colder than other areas
- ☐ Thermostat is inaccessible
- ☐ Thermostat is adjusted by other people
- ☐ Clothing policy is not flexible
- ☐ Heating/cooling system does not respond quickly enough to the thermostat
- ☐ Hot/cold surrounding surfaces (floor, ceiling, walls, or windows)
- ☐ Deficient window (not operable)
- ☐ Other: ________________________

e. Please describe any other issues related to being too hot or too cold in your space:

____
____
____
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INFORMATIVE APPENDIX F PROCEDURE FOR EVALUATING COOLING EFFECT OF ELEVATED AIR SPEED USING SET

The cooling effect of elevated air speed, as specified in Section 5.4, in warmer thermal environments at various combinations of metabolism and convective, radiant, and evaporative heat exchange can be estimated using the calculated difference in SET. The 2009 *ASHRAE Handbook—Fundamentals* defines SET as the equivalent air temperature of an isothermal environment at 50% RH in which a subject, wearing clothing standardized for the activity concerned, has the same heat stress (skin temperature) and thermoregulatory strain (skin wettedness) as in the actual environment.

The calculated values of SET can be obtained using the ASHRAE Thermal Comfort Tool or similar software.

1. Enter the air temperature, radiant temperature, relative humidity, clo value, and met rate.
2. Set your elevated air velocity in the range from above 0.15 to 3 m/s.
3. Note the calculated value for SET in the output data.
4. Reduce the air speed to 0.15 m/s.
5. The SET will be different from the previous value.
6. Calculate the difference between the two SET values.
7. This difference is the cooling effect of the elevated air speed.

The resulting temperature difference calculated in Step 6, the change in SET from increasing the air speed above 0.15 m/s, is the extent to which operative temperatures determined by PMV-PPD calculations can be increased with elevated air speed. This approach can be used where humidity or clo levels are not addressed by Figure 5.2.3.1. Occupants of a space may be subjected to significant heat stress if air movement is curtailed when temperature and humidity are high.

Example

Input settings at elevated air speed:

Air T	MRT	Air V	RH	Season	Met	Clo
28	28	1.0	50	Summer	1.3	0.8
SET = 27.5, slightly uncomfortable						

Input settings at reduced air speed:

Air T	MRT	Air V	RH	Season	Met	Clo
28	28	0.15	50	Summer	1.3	0.8
SET = 29.9, slightly uncomfortable						

Cooling effect of the elevated air speed:
Difference 29.9 – 27.5 = 2.4°C

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INFORMATIVE APPENDIX G
SAMPLE COMPLIANCE DOCUMENTATION

[Forms are located on the following pages.]

SAMPLE COMPLIANCE DOCUMENTATION TEMPLATE

Based on Standard 55-2010 without addenda.

SECTION ONE

COMPLETE SECTION ONE FOR ALL PROJECTS

Assumptions for personal factors in each space type category & season

Space Type (i.e.. Office, Lobby, Gym)	Clothing Level (CLO)				Metabolic Rate (MET)
	Spring	Summer	Fall	Winter	

SECTION TWO

COMPLETE SECTION TWO FOR PROJECTS USING THE PMV/PPD METHOD

Weather data used for design calculations

Weather design conditions used for peak load calculations (0.5%, 1%, etc.)

Cooling Heating

Hours per typical year that outdoor temperature exceeds design conditions

Cooling Heating

	Space Type (i.e.. Office, Lobby, Gym)	Design Operative Temperature (degF)*				Maximum Design Humidity (RH)				Design Air Speed (ft/min)			
		Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
Cooling Mode													
Heating Mode													

* Operative temperature includes radiant effects. See Standard 55.

Verify that the combinations of assumed personal factors, operative temperature, air speed, and humidity above are predicted to limit the percentage of dissatisfied people to less than 10% per Standard 55. (Include supporting documentation with PMV/PPD calculation, ASHRAE comfort tool results, and/or psychrometric comfort zone chart from Standard 55).

Cooling Effect of Air Movement

When air speed is used to offset increased temperature using Figure 5.2.3.1 or the SET method (Figure 5.2.3.2) the appropriate section below shall be completed.

Figure 5.2.3.1 method

Verify that air speed is less than 0.8m/s (160 ft/min) and CLO is less than 0.7

Figure 5.2.3.2 method

Verify that air speeds are withing specified limits of Figure 5.2.3.2 when occupants do not have local control over air speed.

Verify that air speeds are within specified limits of Figure 5.2.3.2 when occupants have local control and that there are separate controls for every 84 sq. meters (900 sq.ft.)

Local Discomfort Effects

Verify that local discomfort effects have been considered and are not likely to exceed Standard 55 limits. When local discomfort effects are likely to occur, verify that calculations were performed to demonstrate that local discomfort effects are predicted to be within Standard 55 Section 5.2.4 limits.

Local Discomfort Effect	Not Likely	Calculations Performed
Radiant Temperature Asymmetry		
Vertical Air Temperature Difference		
Floor Surface Temperature		
Draft		

SECTION THREE

COMPLETE SECTION THREE FOR SPACES USING THE ADAPTIVE METHOD

Standard 55.
a) The spaces have operable windows open to the outdoors readily adjustable by occupants.
b) No mechanical cooling systems serve the space.
c) any heating system is not in operation when this method is used, d) Metabolic rates are expected to be from 1.0 to 1.3 MET.

Weather data used for mean monthly outdoor temperature calculations

Verify that mean monthly outdoor temperature is within the limits of Figure 5.3 for all months where the adaptive method is used.

Verify that operative temperature is predicted to be within the 80% acceptability limits on Figure 5.3 from ASHRAE 55. (Provide supporting documentation with inputs and results of calculations or simulations. Include mean monthly outdoor conditions and worst case predicted indoor conditions for each month. Show predicted worst case indoor conditions for each month on Figure 5.3 of ASHRAE 55.)

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(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX I
ADDENDA DESCRIPTION

ANSI/ASHRAE Standard 55-2010 incorporates ANSI/ASHRAE Standard 55-2004 and Addenda a, b, d, e, f, g, h, i, j, and k to ANSI/ASHRAE Standard 55-2004. Table I1 lists each addendum and describes the way in which the standard is affected by the change. It also lists the ASHRAE and ANSI approval dates for each addendum.

TABLE I1
Addenda to ANSI/ASHRAE Standard 55-2004

Addendum	Section(s) Affected	Description of Changes*	Approval Dates • Standards Committee • ASHRAE BOD • ANSI
a	7.5 Mechanical Equipment Operating Conditions	This addendum deletes the requirements to simultaneously observe the mechanical equipment operating conditions described in Section 7.5 when conducting evaluations of thermal environments under Section 7.	January 19, 2008 January 23, 2008 February 27, 2008
b	5.2.2 Humidity Limits	This addendum clarifies that the upper humidity limit in Section 5.2.2 only applies to the Graphic Comfort Zone Method in Section 5.2.1.1. Higher humidity levels are allowed when evaluated using the Computer Model Method in Section 5.2.1.2 and no humidity limit is imposed on the Adaptive Model.	January 19, 2008 January 23, 2008 February 27, 2008
d	3. Definitions; 5.2 Method for Determining Acceptable Thermal Conditions in Occupied Spaces; 7.3.1 Air Speed; Informative Appendix G—Bibliography	This addendum allows air speed to be used efficiently to cool people indoors as a way to improve comfort. Research shows that in certain combinations of temperature ranges and personal factors, the preference for more air movement is greater than it is for less air movement. New bases for selecting these limits are provided, and alternatives are given for determining the boundaries of comfort at air speeds above 0.15 m/s (30 fpm).	January 24, 2009 January 28, 2009 January 29, 2009
e	6. Compliance	This addendum clarifies and simplifies Section 6, which contains the minimum calculation and documentation requirements to show that a design is in compliance with this standard.	January 24, 2009 January 28, 2009 January 29, 2009
f	Informative Appendix F—Procedures for Evaluating Cooling Effect of Elevated Air Speed Using Set	This new informative appendix provides guidance on the cooling effect of elevated air speed at humidity and clo levels that are not addressed in Figure 5.2.3. This method may be of particular use in environments where passive cooling is utilized or in hot and humid climates.	January 24, 2009 January 28, 2009 January 29, 2009
g	7.6.2.1 Survey Occupants; Informative Appendix E—Thermal Environment Survey	This addendum clarifies and improves the requirements for thermal comfort surveys and to offer better guidance on surveys. Updated sample survey forms are provided in Informative Appendix E.	January 24, 2009 January 28, 2009 January 29, 2009
h	5.2.3.3.1 With Local Control	This addendum clarifies the requirements for local control of air speed in Section 5.2.3.3.1 and provides an exception for classrooms and conference rooms where only one control is required. (Reference Addendum d to 55-2004)	June 26, 2010 June 30, 2010 July 1, 2010

* These descriptions may not be complete and are provided for information only.

TABLE I1
Addenda to ANSI/ASHRAE Standard 55-2004 *(Continued)*

Addendum	Section(s) Affected	Description of Changes*	Approval Dates • Standards Committee • ASHRAE BOD • ANSI
i	Informative Appendix H— Sample Compliance Documentation	This new Informative Appendix H provides a sample compliance form to supplement Section 6 of the standard. Section 6 was modified in Addendum e to 55-2004. Section 6 of the standard and this sample compliance form document design compliance.	June 26, 2010 June 30, 2010 July 1, 2010
j	5.4 Description of Thermal Environmental Variables	This addendum clarifies and adds to the description of the environmental variables, which is presented in the Standard for the purpose of understanding their use in Section 5. Since the Standard now allows the designer to choose the appropriate average air speed for use in design calculations, this language clarifies that the designer is to make these choices within the context of specific temporal, spatial, and clothing restraints that are not otherwise stipulated in the standard.	June 26, 2010 June 30, 2010 July 23, 2010
k	5.1 Operative Temperature; 5.4 Description of Thermal Environmental Variables; 6.2 Documentation; 7.1 Measuring Device Criteria; 7.6.2.2 Analyze Environment Variables; 8. References; Normative Appendix A—Activity Levels; Normative Appendix B—Clothing Insulation; Informative Appendix F—Bibliography	This addendum updates references in the standard to reflect updated publications since 2004.	June 26, 2010 June 30, 2010 July 1, 2010

* These descriptions may not be complete and are provided for information only.

NOTICE

INSTRUCTIONS FOR SUBMITTING A PROPOSED CHANGE TO THIS STANDARD UNDER CONTINUOUS MAINTENANCE

This standard is maintained under continuous maintenance procedures by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. SSPC consideration will be given to proposed changes within 13 months of receipt by the manager of standards (MOS).

Proposed changes must be submitted to the MOS in the latest published format available from the MOS. However, the MOS may accept proposed changes in an earlier published format if the MOS concludes that the differences are immaterial to the proposed change submittal. If the MOS concludes that a current form must be utilized, the proposer may be given up to 20 additional days to resubmit the proposed changes in the current format.

ELECTRONIC PREPARATION/SUBMISSION OF FORM FOR PROPOSING CHANGES

An electronic version of each change, which must comply with the instructions in the Notice and the Form, is the preferred form of submittal to ASHRAE Headquarters at the address shown below. The electronic format facilitates both paper-based and computer-based processing. Submittal in paper form is acceptable. The following instructions apply to change proposals submitted in electronic form.

Use the appropriate file format for your word processor and save the file in either a recent version of Microsoft Word (preferred) or another commonly used word-processing program. Please save each change proposal file with a different name (for example, "prop01.doc," "prop02.doc," etc.). If supplemental background documents to support changes submitted are included, it is preferred that they also be in electronic form as word-processed or scanned documents.

ASHRAE will accept the following as equivalent to the signature required on the change submittal form to convey non-exclusive copyright:

Files attached to an e-mail:	Electronic signature on change submittal form (as a picture; *.tif, or *.wpg).
Files on a CD:	Electronic signature on change submittal form (as a picture; *.tif, or *.wpg) or a letter with submitter's signature accompanying the CD or sent by facsimile (single letter may cover all of proponent's proposed changes).

Submit an e-mail or a CD containing the change proposal files to:
Manager of Standards
ASHRAE
1791 Tullie Circle, NE
Atlanta, GA 30329-2305
E-mail: change.proposal@ashrae.org
(Alternatively, mail paper versions to ASHRAE address or fax to 404-321-5478.)

The form and instructions for electronic submittal may be obtained from the Standards section of ASHRAE's Home Page, www.ashrae.org, or by contacting a Standards Secretary, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
Phone: 404-636-8400. Fax: 404-321-5478. E-mail: standards.section@ashrae.org.

FORM FOR SUBMITTAL OF PROPOSED CHANGE TO AN ASHRAE STANDARD UNDER CONTINUOUS MAINTENANCE

NOTE: Use a separate form for each comment. Submittals (Microsoft Word preferred) may be attached to e-mail (preferred), submitted on a CD, or submitted in paper by mail or fax to ASHRAE, Manager of Standards, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: change.proposal@ashrae.org. Fax: +1-404/321-5478.

1. Submitter:

Affiliation:

Address: City: State: Zip: Country:

Telephone: Fax: E-Mail:

I hereby grant the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this or other analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

Submitter's signature: ____ Date: ____________________________

All electronic submittals must have the following statement completed:

I *(insert name)* ____, through this electronic signature, hereby grant the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this or other analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

2. Number and year of standard:

3. Page number and clause (section), subclause, or paragraph number:

4. I propose to: *(check one)*

[ ] Change to read as follows
[ ] Delete and substitute as follows
[ ] Add new text as follows
[ ] Delete without substitution

Use underscores to show material to be added (<u>added</u>) and strike through material to be deleted (~~deleted~~). Use additional pages if needed.

5. Proposed change:

6. Reason and substantiation:

7. Will the proposed change increase the cost of engineering or construction? If yes, provide a brief explanation as to why the increase is justified.

[ ] Check if additional pages are attached. Number of additional pages: _______

[ ] Check if attachments or referenced materials cited in this proposal accompany this proposed change. Please verify that all attachments and references are relevant, current, and clearly labeled to avoid processing and review delays. *Please list your attachments here:*

Rev. 3-9-2007

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

About ASHRAE

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), founded in 1894, is an international organization of some 50,000 members. ASHRAE fulfills its mission of advancing heating, ventilation, air conditioning, and refrigeration to serve humanity and promote a sustainable world through research, standards writing, publishing, and continuing education.

For more information or to become a member of ASHRAE, visit www.ashrae.org.

To stay current with this and other ASHRAE standards and guidelines, visit www.ashrae.org/standards.

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ASHRAE has two collections of standards and guidelines available on CD that include one year of unlimited access to download monthly updates, including addenda, errata, and interpretations. *ASHRAE Standards and Guidelines* contains the complete library, and *Essential Standards* contains ASHRAE's 12 most referenced standards and guidelines. Both include the User's Manuals for Standard 90.1 and Standard 62.1. For more information on these products, visit the Standards and Guidelines section of the ASHRAE bookstore at www.ashrae.org/bookstore.

IMPORTANT NOTICES ABOUT THIS STANDARD

To ensure that you have all of the approved addenda, errata, and interpretations for this standard, visit www.ashrae.org/standards to download them free of charge.

Addenda, errata, and interpretations for ASHRAE standards and guidelines will no longer be distributed with copies of the standards and guidelines. ASHRAE provides these addenda, errata, and interpretations only in electronic form in order to promote more sustainable use of resources.

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