ANSI/ASHRAE Addenda d, e, f, and g to
ANSI/ASHRAE Standard 55-2004

ASHRAE STANDARD

Thermal Environmental Conditions for Human Occupancy

Approved by the ASHRAE Standards Committee on January 24, 2009; by the ASHRAE Board of Directors January 28, 2009; and by the American National Standards Institute on January 29, 2009.

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FOREWORD

This addendum allows air speed to be used efficiently to cool people indoors as a way to improve comfort. In certain combinations of temperature ranges and personal factors, the preference for more air movement is greater than it is for less air movement. The standard currently allows 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 are currently allowed. In this addendum, 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).

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum d to Standard 55-2004

Add and delete the following definitions in Section 3 of the standard as shown below:

adaptive model: a model that relates indoor design temperatures or acceptable temperature ranges to outdoor meteorological or ~~climatalogical~~ climatological parameters.

~~***draft rate (DR):*** percentage of people predicted to be dissatisfied due to draft.~~

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.

~~***turbulence intensity (Tu):*** the ratio of the standard deviation of the air speed (SD_v) to the mean air speed (v). Turbulence intensity may also be expressed in percent (i.e., $Tu = [SD_v / v_a] \cdot 100$).~~

~~***velocity, standard deviation (SD_v):*** a measure of the scatter of the instantaneous air velocity around the mean air velocity in a frequency distribution, defined as the square root of the arithmetic average of a set of square values of the difference between the instantaneous air velocity and the mean air velocity. The standard deviation is based on individual values of air speed that represent an average over no more than two seconds each.~~

Revise the second and last paragraphs of Section 5.2.1.1 as shown below:

The ranges of operative temperatures presented in Figure 5.2.1.1 are for 80% occupant acceptability. This is based on a 10% dissatisfaction criterion ~~criteria~~ 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. Appendix D provides a list of inputs and outputs used in the PMV/PPD computer program to generate these graphs.

[...]

Elevated air ~~Air~~ speeds ~~greater than 0.20 m/s (40 ft/min)~~ may be used 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.

Revise Section 5.2.1.2 as shown below:

5.2.1.2 Computer Model Method for General Indoor Application. The method in this section may be applied 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 Appendix A for estimation of metabolic rates and Appendix B for estimation of clothing insulation.

[...]

Use of the PMV model in this standard is limited to air speeds below ~~not greater than~~ 0.20 m/s (40 fpm). Air speeds greater than this ~~0.20 m/s (40 ft/min)~~ may be used to increase the upper temperature limits of the comfort zone in certain circumstances. Section 5.2.3 describes the method ~~these adjustments~~ and ~~specifies the~~ criteria required for such adjustments. ~~The adjustments in Section 5.2.3 are with respect to the upper limit of the comfort zone determined with the PMV model using an air speed of 0.20 m/s (40 fpm).~~

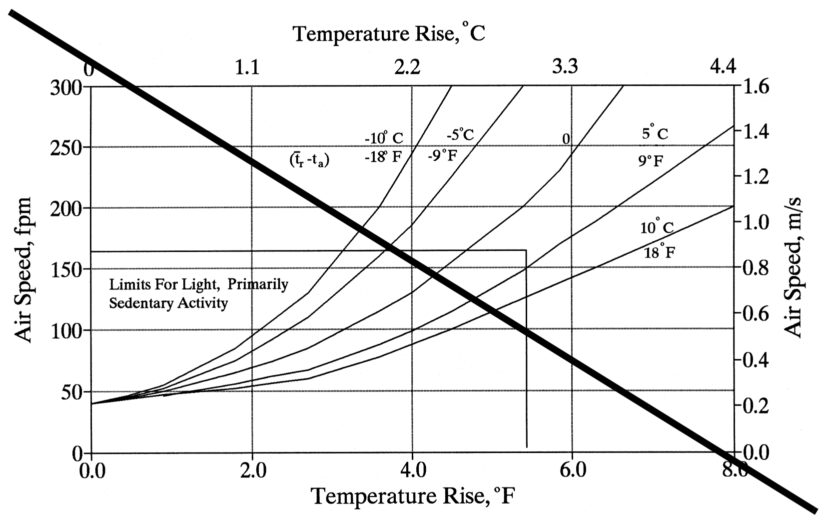
Revise Section 5.2.3 as shown below. Note that the current Figure 5.2.3 has been deleted and a new Figure 5.2.3.1 has been added:

5.2.3 Elevated Air Speed. ~~Precise relationships between increased air speed and improved comfort have not been established. However, this~~ 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 ~~if the affected~~ the occupants have local ~~are able to~~ control of~~the~~ air speed.

5.2.3.1 Graphical Method. The amount that the temperature may be increased is shown in Figure ~~5.2.3.~~ 5.2.3.1. The combinations of air speed and temperature defined by the lines in this figure result in ~~the same~~equal levels of heat loss from the skin. The reference point for these curves is the upper air-speed~~temperature~~ limit of the PMV-defined comfort zone, ~~(PMV = +0.5) and~~ 0.20 m/s (40 fpm), as described in Section 5.2.1.2. ~~of air speed. This~~ The figure applies to a lightly clothed person (with clothing insulation between 0.5 and 0.7 clo) who is engaged in near sedentary physical activity (with metabolic rates between 1.0 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.~~ 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 Method, the required air speed for light, primarily sedentary activities may not be higher than 0.8 m/s (160 ft/min)—although it may be higher when using the SET Method in Section 5.2.3.2 below.~~Elevated air speed may be used to offset an increase in the air temperature and the mean radiant temperature, but not by more than 3.0°C (5.4°F) above the values for the comfort zone without elevated air speed. The required air speed may not be higher than 0.8 m/s (160 fpm). Large individual differences exist between people with regard to the preferred air speed. Therefore, the elevated air speed must be under the direct control of the affected occupants and adjustable in steps no greater than 0.15 m/s (30 fpm).~~



~~**Figure 5.2.3 Air speed required to offset increased temperature.**~~

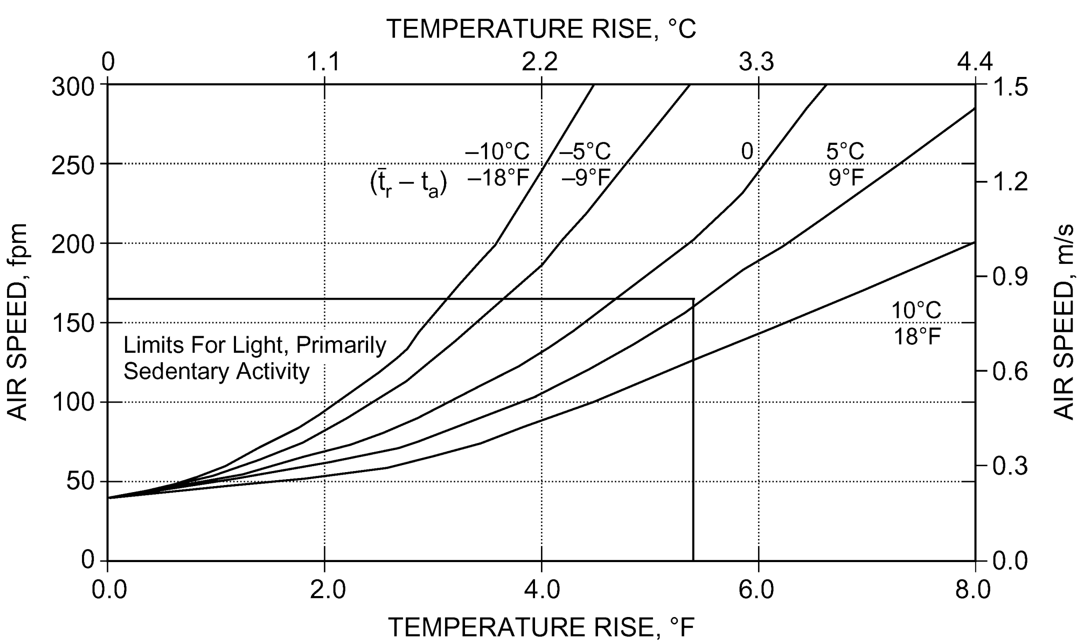


Figure 5.2.3.1 Air speed required to offset increased air and radiant temperatures.

The benefits that can be 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.~~ 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.~~ 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.

Add new Section 5.2.3.2 as shown below. Note that Figure 5.2.3.2 has been added to this section.

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 can be used 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, as described in the informative Appendix F of this standard.

Add new Section 5.2.3.3 as shown below:

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

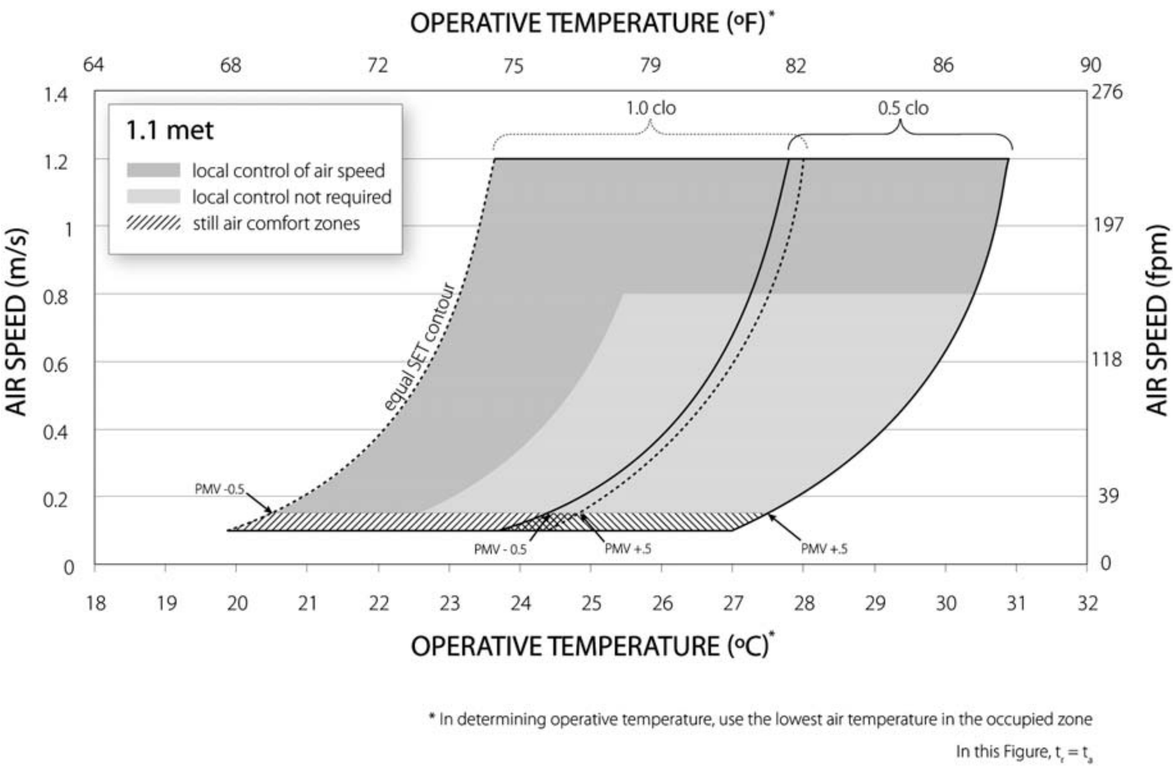


Figure 5.2.3.2 Acceptable range of operative temperature and air speeds for the comfort zone shown in Figure 5.2.1.1, at humidity ratio 0.010.

directly accessible to occupants must be provided for every six occupants (or less) or 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.

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°), 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 can be approximated in SI and I-P units by the following equation:

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

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

Add new Section 5.2.3.4 as shown below:

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. 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.

Revise Table 5.2.4 in Section 5.2.4 as shown at the bottom of this page.

Correct the figure number in the second paragraph of Section 5.2.4.1 as shown at the bottom of page 5.

The limits for radiant temperature asymmetry are specified in Table 5.2.4.1. Alternatively, Figure 5.2.4.1 ~~Figure 5.4.2.1~~ may be used in conjunction with the PD limits from Table 5.2.4 to determine the allowable radiant asymmetry.

Revise Section 5.2.4.2 as shown below. Note that Figure 5.2.4.2 is shown as being deleted.

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 sensation depends on the air speed, the air temperature, ~~the turbulence intensity,~~ the activity, and the clothing. Sensitivity to draft is greatest where the skin is not covered by clothing, especially the head region composed of the head, neck, and shoulders, and the leg region composed of the ankles, feet, and legs. ~~The requirements in this section are based on sensitivity to draft in the head region with airflow from behind and may be conservative for some locations on the body and for some directions of airflow.~~

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. Air speed may 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.

~~The maximum allowable air speed is specified in Figure 5.2.4.2 as a function of air temperature and turbulence intensity. Alternatively, the following equation may be used for determining the maximum allowable air speed. The predicted percentage of people dissatisfied due to annoyance by draft (DR) is given by~~

~~$DR = ([34 - ta] \times [v - 0.05]0.62) \times (0.37 \times v \times Tu + 3.14)$,~~

~~where~~

~~DR~~	=	~~predicted percentage of people dissatisfied due to draft;~~
~~*ta*~~	=	~~local air temperature, °C;~~
~~*v*~~	=	~~local mean air speed, m/s, based on *va*, the mean velocity; and~~
~~*Tu*~~	=	~~local turbulence intensity, %.~~

~~For *ta* (°F), *v* in fpm, and *Tu* (%),~~

~~$DR = ([93.2 - ta] \times [v - 10]0.62) \times (0.00004 \times v \times Tu + 0.066)$.~~

~~For $v < 0.05$ m/s (10 fpm), use $v = 0.05$ m/s (10 fpm).~~
~~For DR > 100%, use DR = 100%.~~

~~The values of DR predicted from this equation must be within the limits specified for draft in Table 5.2.4. On average, the turbulence intensity in a large part of the occupied zone of~~

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

PD ~~DR~~ 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%

~~rooms with mixing ventilation is around 35%, and it is 20% in rooms with displacement ventilation or without mechanical ventilation. These values may be used in the above equation when the turbulence intensity is not measured.~~

~~The criteria specified in this section do not apply to the use of elevated air speed in Section 5.2.3. However, when occupants choose to turn off the elevated air speed, these criteria apply.~~

Delete the following paragraph from Section 5.4 as shown below:

~~*Turbulence intensity* is the ratio of the standard deviation of the air speed with respect to time and the time-averaged air speed. The turbulence intensity is primarily for the head/shoulder portions of the body—the 1.1 m (43 in.) level for seated occupants and the 1.7 m (67 in.) level for standing occupants. It may also apply to the ankle/lower leg areas if they are not covered with clothing—the 0.1 m (4 in.) level for both standing and seated occupants.~~

Revise the following paragraph of Section 7.2.1 as shown below:

A measure of absolute ~~Absolute~~ humidity (such as humidity ratio) is required to ~~need~~ 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.

Revise Section 7.3.1 as shown below:

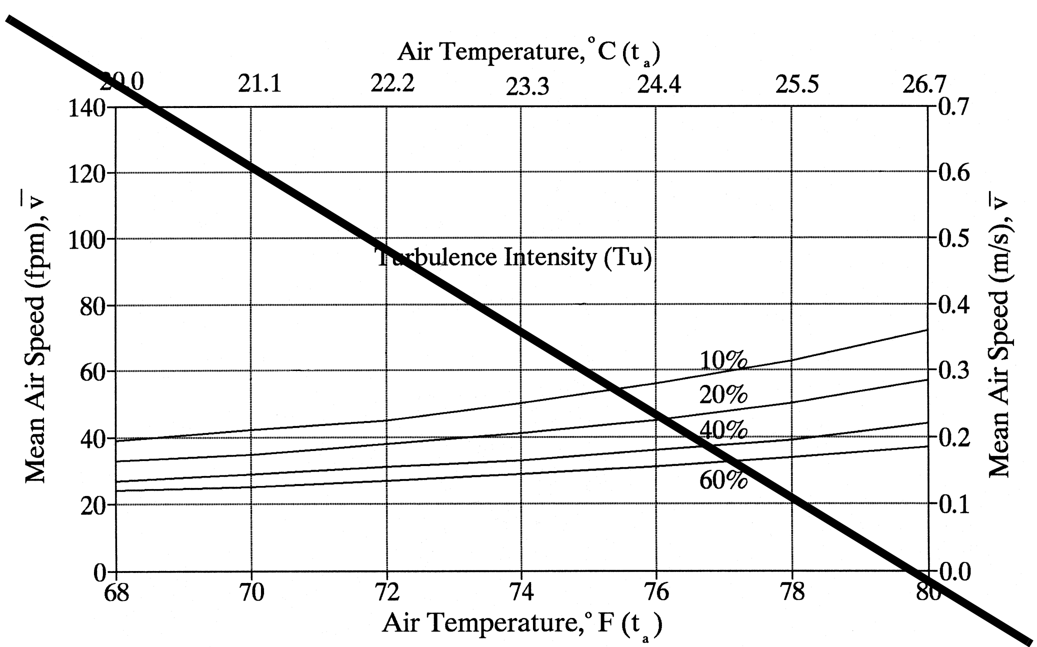
7.3.1 Air Speed. The measuring period for determining the average air speed at any location shall be three minutes. ~~Turbulence intensity is measured in the same period by calculating the ratio of the standard deviation for the period for the period to the average air speed. (See Section 3 for the definition of response time and its relation to the time constant.)~~

Make the following correction to the table at the end of Appendix C as shown below.

Add the following items to the bibliography in Appendix G as shown below.

Arens, E., T. Xu, K. Miura, H. Zhang, M. Fountain, and F. Bauman. 1998. A study of occupant cooling by personally controlled air movement. *Energy and Buildings* 27:45–59.

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) ~~m/s)~~
A	0.5	0.6	0.7



~~**Figure 5.2.4.2 Allowable mean air speed as a function of air temperature and turbulence intensity.**~~

Fang, L., G. Clausen, and P.O. Fanger. 1998. Impact of temperature and humidity on the perception of indoor air quality during immediate and longer whole-body exposure. *Indoor Air* 8:276–284.

Fanger, P.O., A.K. Melikov, H. Hanzawa, and J. Ring. 1988. Air turbulence and sensation of draught. *Energy and Buildings* 12:21–9.

Fountain, M., and E. Arens. 1993. Air movement and thermal comfort. *ASHRAE Journal* August:26–30.

Fobelets, A.P.R., and A.P. Gagge. 1988. Rationalization of the effective temperature, ET*,~~ET,~~ as a measure of the enthalpy of the human indoor environment. *ASHRAE Transactions* 94(1):12–31.

Gong, N., K.W. Tham, A.K. Melikov, D.P. Wyon, S.C. Sekhar, and D.K.W Cheong. 2005. Human perception of local air movement and the acceptable air velocity range for local air movement in the tropics. *Proceedings of Indoor Air 2005, Beijing, China,* pp. 452–56.

Kubo, H., N. Isoda, and H. Enomoto-Koshimizu. 1997. Cooling effect of preferred air velocity in muggy conditions. *Building and Environment* 32(3):211–18.

Tanabe, S., and K. Kimura. 1989. Thermal comfort requirements under hot and humid conditions. *Proceedings of the First ASHRAE Far East Conference on Air Conditioning in Hot Climates, Singapore,* pp. 3–21.

Toftum, J. 1997. Effect of airflow direction on human perception of draught. *Proceedings of CLIMA 2000, Brussels, Belgium*.

Toftum, J. 2004. Air movement—Good or bad? *Indoor Air* 14:40–5.

Zhang, H., E. Arens, S. Abbaszadeh Fard, C. Huizenga, G. Paliaga, G. Brager, and L. Zagreus. 2007. Air movement preferences observed in office buildings. *International Journal of Biometeorology* 51:349–60.

Zhao, R., S. Sun, and R. Ding. 2004. Conditioning strategies of indoor environment in warm climates. *Energy and Buildings* 36:1281–86.

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FOREWORD

This addendum clarifies and simplifies Section 6, which contains the design and documentation requirements for compliance with this standard. Fewer requirements are listed in the proposed version, and each of them is intended to be a clear and quantifiable requirement that can be met by designers and other HVAC professionals. The use of subjective compliance and documentation requirements and the use of informative language have been eliminated throughout the section.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum e to Standard 55-2004

Delete the current Section 6 as shown, and replace it with the revised Section 6 that follows.

~~6. COMPLIANCE~~

~~6.1 Design~~

~~The scope of this standard does not include specific guidance regarding mechanical systems, control systems, or the thermal envelopes for spaces. Building systems (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. Additionally, 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 less extreme conditions that are expected to occur. The less extreme conditions can include 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.~~

~~The method and design conditions, including the design exceedance level, appropriate for the intended use of the building shall be selected and should be documented in accordance with Section 6.1.1.~~

~~Design weather data are statistically based and established to explicitly acknowledge certain percentages of exceedance (e.g., 1% design, 4 month summer basis, 29 hours of exceedance). This recognizes the impracticality of providing an HVAC system that can meet all loads under all weather or operating conditions encountered in its lifetime. Thus, in practice, the requirements of Section 5 may not be met during excursions from the design conditions. Also, weather-based exceedance will usually be less than indicated by the exceedance percentage because other design loads will seldom be concurrent.~~

~~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.~~

~~**6.1.1 Documentation.** Complete plans, descriptions, component literature, and operation and maintenance instructions for the building systems should be provided and maintained. These should include, but not be limited to, building system design specifications and design intent as follows.~~

~~***Note:*** Some of the sections below may not be applicable to naturally conditioned buildings.~~

1. ~~The design criteria of the system in terms of indoor temperature and humidity, including any tolerance or range, based on stated design outdoor ambient conditions and total indoor loads, should be stated. Values assumed for comfort parameters used in calculation of design temperatures, including clothing and metabolic rate, should be clearly stated.~~
2. ~~The system input or output capacities necessary to attain the design indoor conditions at design outdoor ambient conditions should be stated, as well as the full input or output capacities of the system as supplied and installed.~~
3. ~~The limitations of the system to control the environment of the zone(s) should be stated whether based on temperature, humidity, ventilation, time of week, time of day, or seasonal criteria.~~
4. ~~The overall space supplied by the system should be shown in a plan view layout, with all individual zones within it identified. All registers or terminal units should be shown and identified with type and flow or radiant value.~~
5. ~~Significant structural and decor items should be shown and identified if they affect indoor comfort. Notes should be provided to identify which areas within a space and which locations relative to registers, terminal units, relief grilles, and control sensors should not be obstructed in order to avoid negatively affecting indoor comfort.~~
6. ~~Areas within any zone that lie outside the comfort control areas, where people should not be permanently located, should be identified.~~
7. ~~Locations of all occupant adjustable controls should be identified, and each should be provided with a legend describing which zone(s) it controls, which function(s) it controls, how it is to be adjusted, the range of effect it can have, and the recommended setting for various times of day, season, or occupancy load.~~
8. ~~A block-diagram control schematic should be provided with sensors, adjustable controls, and actuators accurately identified for each zone. If zone control systems are independent but identical, one diagram is sufficient if identified for which zones it applies. If zones are interdependent or interactive, their control diagram should be shown in total on one block diagram with the point(s) of interconnection identified.~~

9. ~~The general maintenance, operation, and performance of the building systems should be stated, followed by more specific comments on the maintenance and operation of the automatic controls and manually adjustable controls and the response of the system to each. Where necessary, specific seasonal settings of manual controls should be stated, and major system changeovers that are required to be performed by a professional service agency should be identified.~~
10. ~~Specific limits in the adjustment of manual controls should be stated. Recommendations for seasonal settings on these controls should be stated, along with the degree of manual change that should be made at any one time, and the waiting time between adjustments when trying to fine-tune the system. A maintenance and inspection schedule for all thermal environmental-related building systems should be provided.~~
11. ~~Assumed electrical load for lighting and equipment in occupied spaces (including diversity considerations) used in HVAC load calculations should be documented, along with any other significant thermal and moisture loads assumed in HVAC load calculations and any other assumptions upon which HVAC and control design is based.~~

~~6.2 Validation~~

~~Validation should be performed as described in Section 7 to demonstrate that the building systems can be operated to meet the requirements of Section 5 according to the design intent and under design conditions inclusive of less severe conditions, as documented in Section 6.1.1.~~

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 *ASHRAE Handbook—Fundamentals*,[3] Chapter 27, "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 *ASHRAE Handbook—Fundamentals*,[3] Chapter 27) 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.

(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. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

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.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum f to Standard 55-2004

(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 concensus process.)

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

The cooling effect of elevated air speed 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 *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

(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. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This addendum revises Section 7.6.2.1 and Informative Appendix E to clarify and improve the requirements for thermal comfort surveys and to offer better guidance on surveys. Updated sample survey forms are provided in Appendix E.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum g to Standard 55-2004

Modify existing Section 7.6.2.1 as shown immediately following this note, and delete the existing informative Appendix E and replace it in its entirety as explained on the following page.

7.6.2.1 Survey Occupants. Since the purpose of this standard is to ensure that ~~a room, building, etc., is~~ thermal environmental conditions in a room, building, etc., are acceptable to a majority of the occupants within the space, ~~comfortable for a substantial majority (at least 80%) of the occupants~~ an effective way to evaluate the environmental conditions is to survey the occupants. ~~This survey should be performed for every operating mode, in every design condition.~~

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.

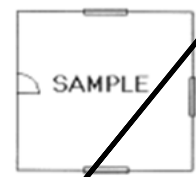
~~This would require a survey check sheet to be provided by the team responsible for validating the thermal environment of the space. The sheet shall have, as a minimum, the following data for the occupant to fill in:~~

- ~~Occupant's name, date, and time~~
- ~~Approximate outside air temperature~~
- ~~Clear sky/overcast (if applicable)~~
- ~~Seasonal conditions~~
- ~~Occupant's clothing~~
- ~~Occupant's activity level~~
- ~~Applicable equipment~~
- ~~General thermal comfort level~~
- ~~Occupant's location~~

~~In addition to the occupant's data, space shall be provided for the surveyor to number the survey, summarize the results, and sign his/her name. A sample check sheet and clothing table are provided in Appendix E.~~ Related information and sample survey forms are provided in Appendix E.

Delete the existing informative Appendix E in Standard 55-2004, which is shown below, in its entirety, including the Thermal Environment Survey on the following page. Replace it with the new Appendix E that immediately follows the deleted Appendix E.

~~INFORMATIVE APPENDIX E~~
~~THERMAL ENVIRONMENT SURVEY~~

THERMAL ENVIRONMENT SURVEY		Survey Number:
WHITE SECTIONS TO BE FILLED IN BY OCCUPANT		Surveyor's Name:
1. Occupant's Name:		**11. Occupant Location in Area** (Place an "X" in the approximate place where you most often work.) 
2. Date:		
3. Time:		
4. Approx. Outside Air Temperature (°F or °C):		
5. Sky: ❑ Clear ❑ Mixed (Sun & Clouds) ❑ Overcast		
6. Seasonal Conditions ❑ Winter ❑ Spring ❑ Summer ❑ Fall		
7. Occupant's Clothing Please refer to the attached Table 1. Place a check mark next to the articles of clothing that you are currently wearing as you fill out this sheet. If you are wearing articles of clothing not listed in the table, please enter them into the space provided below. Article:		**SURVEYOR'S USE ONLY** Clothing Insulation Summary: Total I_{cl} = ___________ clo
Article:		
8. Occupant Activity Level (Check the one that is most appropriate) 1. ❑ Reclining 2. ❑ Seated Quite 3. ❑ Office, school 4. ❑ Standing Relaxed 5. ❑ Light Activity Standing 6. ❑ Medium Activity, Standing 7. ❑ High Activity		**Metabolic Rates (met)** 1. 0.8 met 2. 1.0 met 3. 1.2 met 4. 1.2 met 5. 1.6 met 6. 2.0 met 7. 3.0 met
9. Equipment (Equipment adding or taking away from the heat load.)		
Item (computers, copiers, lighting, fans, etc.)	**Quantity**	**Total Heat Added/ Subtracted**
10. General Thermal Comfort (Check the one that is most appropriate) 1. ❑ Hot 2. ❑ Warm 3. ❑ Slightly Warm 4. ❑ Neutral 5. ❑ Slightly Cool 6. ❑ Cool 7. ❑ Cold		Thermal Sensation Scale 1. + 3 2. + 2 3. + 1 4. 0 5. – 1 6. – 2 7. – 3
General Environment Comments:		**Area Summary:**
		Room/Building Type:
		Outside Relative Humidity: %
		Thermostat Setting: °F or °C
		Humidity setpoint: %
		Total Number of Occupants:

~~TABLE 1 Clothing Ensembles~~

~~Description~~
~~Trousers, short-sleeve shirt~~
~~Trousers, long-sleeve shirt~~
~~Trousers, long-sleeve shirt plus suit jacket~~
~~Trousers, long-sleeve shirt plus suit jacket, vest, T-shirt~~
~~Trousers, long-sleeve shirt plus long sleeve sweater, T-shirt~~
~~Trousers, long-sleeve shirt plus long sleeve sweater, T-shirt plus suit jacket, long underwear bottoms~~
~~Knee-length skirt, short-sleeve shirt (sandals)~~
~~Knee-length skirt, long-sleeve shirt, full slip~~
~~Knee-length skirt, long-sleeve shirt, half slip, long-sleeve sweater~~
~~Ankle-length skirt, long-sleeve shirt, suit jacket~~
~~Walking shorts, short-sleeve shirt~~
~~Long-sleeve coveralls, T-shirt~~
~~Overalls, long-sleeve shirt, T-shirt~~
~~Insulated coveralls, long-sleeve thermal underwear tops and bottoms~~
~~Athletic sweat pants, long-sleeve sweatshirt~~

Add the new Appendix E as shown below.

(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 rates 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 has been included in Section E1. This survey 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 satisfied (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)
☐ Mid-day (11am–2pm)
☐ Afternoon (2pm–5pm)
☐ Evening (after 5pm)
☐ Weekends/holidays

[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.

- ☐ Monday mornings
- ☐ No particular time
- ☐ Always
- ☐ Other:

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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____

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.