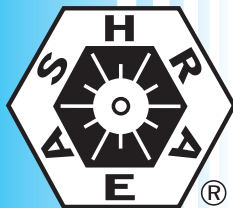


**ANSI/ASHRAE Standard 55-2004**  
**(Supersedes ANSI/ASHRAE Standard 55-1992)**



# **ASHRAE STANDARD**

# **Thermal Environmental Conditions for Human Occupancy**

This standard was approved by the ASHRAE Standards Committee on January 24, 2004; by the ASHRAE Board of Directors on January 29, 2004; and by the American National Standards Institute on April 16, 2004.

This standard is under continuous maintenance 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. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, <http://www.ashrae.org>, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: [orders@ashrae.org](mailto:orders@ashrae.org). Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada).

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**American Society of Heating, Refrigerating  
and Air-Conditioning Engineers, Inc.**

**1791 Tullie Circle NE, Atlanta, GA 30329**

**[www.ashrae.org](http://www.ashrae.org)**

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#### NOTE

**When addenda, interpretations, or errata to this standard have been approved, they can be downloaded free of charge from the ASHRAE Web site at <http://www.ashrae.org>.**

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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

Standard 55-2004, "Thermal Environmental Conditions for Human Occupancy," is a revision of Standard 55-1992. The standard specifies conditions in which a specified fraction of the occupants will find the environment thermally acceptable. The revision is a consensus standard that has undergone public and ASHRAE review; it incorporates the relevant research and experience gained since the 1992 revision. Such changes include the addition of the PMV/PPD calculation methods and the concept of adaptation. 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 be practically mandated by this standard.

The designer may choose, in agreement with the owner or owner's representative (e.g., owner's agent, developer, or equivalent), the level of thermal comfort and appropriate exceedance. The selected design criteria will influence the HVAC system design and may also influence the building design. This standard may also be used for evaluation of existing thermal environments in buildings, during experimental conditions, and for the development and testing of products.

This standard is in close agreement with ISO Standards 7726<sup>1</sup> and 7730.<sup>2</sup>

## 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<sup>2</sup> °C/W (0.88 ft<sup>2</sup>·h·°F/Btu).

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

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

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

**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<sup>2</sup> (18.4 Btu/h·ft<sup>2</sup>), 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<sup>2</sup> (19 ft<sup>2</sup>).

**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, this 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 into 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 5.3.1 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.

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

**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.,  $Tu = [SD_v / v_a] \cdot 100$ ).

**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.

**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.

**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.

It may 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.