ADDENDA

ANSI/ASHRAE Addendum d to
ANSI/ASHRAE Standard 55-2020

Thermal Environmental Conditions for Human Occupancy

Approved by ASHRAE and the American National Standards Institute on October 29, 2021.

This addendum was approved 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. Instructions for how to submit a change can be found on the ASHRAE® website (https://www.ashrae.org/continuous-maintenance).

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FOREWORD

Addendum d to Standard 55-2020 makes changes to the ERF code. The new code allows the user to calculate ERF and delta mean radiant temperature for an additional body position: horizontal.

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 55-2020

Revise Section 3 as shown. The remainder of Section 3 is unchanged.

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

Revise Section 7.3.2(b) as shown. The remainder of Section 7.3.2 is unchanged.

7.3.2 Physical Measurement Positions within the Building

[. . .]

b. **Height above floor.** Air temperature and average air speed V_a shall be measured at the 0.1, 0.6, and 1.1 m (4, 24, and 43 in.) levels for seated occupants at the plan locations specified in Section 7.3.2(a)(1) and 7.3.2(a)(2). Measurements for standing occupants shall be made at the 0.1, 1.1, and 1.7 m (4, 43, and 67 in.) levels, and measurements for horizontal occupants shall be made at the mean height of the body. Operative temperature t_o or PMV 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, and the mean height of the body for horizontal occupants. Floor temperature that may cause local discomfort shall be measured at the surface by contact thermometer or infrared thermometer (Section 5.3.3.5).

[. . .]

Revise Section C1 in Normative Appendix C as shown. The remainder of Section C1 is unchanged.

C1. CALCULATION PROCEDURE

[. . .]

where f_{eff} is the fraction of the body surface exposed to radiation from the environment (= 0.696 for a seated person and 0.725 for a standing or a horizontal person), h_r is the radiation heat transfer coefficient (W/m^2·K [Btuh/ft^2·°F]), and t_a is the air temperature (°C [°F]).

[. . .]

Direct radiation is incident only on the projected fraction of the body f_p, which depends on solar altitude β, the sun's horizontal angle relative to the front of the person (SHARP), and posture (seated, standing, horizontal). The f_p values are tabulated in the computer program in Section C4.

[. . .]

Revise Section C2 in Normative Appendix C as shown. The remainder of Section C1 is unchanged.

C2. INPUTS TO CALCULATION PROCEDURE

[. . .]

h. **Posture.** Inputs are "seated," ~~and~~ "standing," or "horizontal."

[. . .]

Revise Table C-1 as shown. The remainder of the table is unchanged.

Table C-1 Symbols and Units

Symbol	Description	Unit
[. . .]		
SHARP	Solar horizontal angle relative to front of person	deg
R_{floor}	Floor reflectance (fixed at 0.6)	—
	Posture (seated, standing, horizontal)	

Revise Table C-2 as shown. The remainder of the table is unchanged.

Table C-2 Input Variables and Ranges for Calculation Procedure

Symbol	Description	Unit	Allowable Default Value	Range of Inputs Min to Max
α_{SW}	Short-wave radiation absorptivity	—	0.7	0.2 to 0.9
f_{svv}	Fraction of sky vault exposed to body	—	N/A	0 to 1
T_{sol}	Window system glazing unit plus shade solar transmittance	—	N/A	0 to 1
I_{dir}	Direct solar beam intensity	W/m^2	900	200 to 1000
f_{bes}	Fraction of the possible body surface exposed to sun	—	N/A	0 to 1
β	Solar altitude angle	deg	N/A	0 to 90
SHARP	Solar horizontal angle relative to person	deg	N/A	0 to 180
	Posture (seated, standing, horizontal)		N/A	Seated/standing/horizontal

Revise Section C3 of Normative Appendix C as shown.

C3. COMPUTER PROGRAM FOR CALCULATING COMFORT IMPACT OF SOLAR GAIN ON OCCUPANTS

The following code is one implementation of the solar calculation using JavaScript in SI units.

```
function find_span(arr, x){
/* for ordered array arr and value x, find the left index of the closed interval that
   the value falls in. */

   for (var i = 0; i < arr.length - 1; i++){ if (x <= arr[i+1] && x >= arr[i]){
   return i;
      }
   }
   return -1;
}

function radians_to_degrees(radians) {
  const pi = Math.PI;
  return radians * (180 / pi);
}

function degrees_to_radians(degrees) {
  const pi = Math.PI;
  return degrees * (pi / 180);
}

function get_fp(alt, sharp, posture){
/*
   This function calculates the projected sunlit fraction (fp) given a seated or
standing posture, a solar altitude, and a solar horizontal angle relative to
   the person (SHARP). fp values are taken from Thermal Comfort, Fanger 1970, Danish
Technical Press.

   alt : altitude of sun in degrees [0, 90] (beta) Integer
   sharp : sun's horizontal angle relative to person in degrees [0, 180] Integer
*/

  if (posture == "horizontal") {
    // transpose alt and sharp for a horizontal person
    const altitude_new = radians_to_degrees(
      Math.asin(
        Math.sin(degrees_to_radians(Math.abs(sharp - 90))) *
          Math.cos(degrees_to_radians(alt))
      )
    );
    sharp = radians_to_degrees(
      Math.atan(
        Math.sin(degrees_to_radians(sharp)) *
          Math.tan(degrees_to_radians(90 - alt))
      )
    );
    alt = altitude_new;
  }

var fp;
var alt_range = [0, 15, 30, 45, 60, 75, 90];
var sharp_range = [0, 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, 165, 180];
```

```
var alt_i = find_span(alt_range, alt);
var sharp_i = find_span(sharp_range, sharp);
if (posture == 'standing'|| posture == 'horizontal'){
   var fp_table = [[0.35,0.35,0.314,0.258,0.206,0.144,0.082],
      [0.342,0.342,0.31,0.252,0.2,0.14,0.082],
      [0.33,0.33,0.3,0.244,0.19,0.132,0.082],
      [0.31,0.31,0.275,0.228,0.175,0.124,0.082],
      [0.283,0.283,0.251,0.208,0.16,0.114,0.082],
      [0.252,0.252,0.228,0.188,0.15,0.108,0.082],
      [0.23,0.23,0.214,0.18,0.148,0.108,0.082],
      [0.242,0.242,0.222,0.18,0.153,0.112,0.082],
      [0.274,0.274,0.245,0.203,0.165,0.116,0.082],
      [0.304,0.304,0.27,0.22,0.174,0.121,0.082],
      [0.328,0.328,0.29,0.234,0.183,0.125,0.082],
      [0.344,0.344,0.304,0.244,0.19,0.128,0.082],
      [0.347,0.347,0.308,0.246,0.191,0.128,0.082]];
} else if (posture == 'seated'){
   var fp_table = [[0.29,0.324,0.305,0.303,0.262,0.224,0.177],
      [0.292,0.328,0.294,0.288,0.268,0.227,0.177],
      [0.288,0.332,0.298,0.29,0.264,0.222,0.177],
      [0.274,0.326,0.294,0.289,0.252,0.214,0.177],
      [0.254,0.308,0.28,0.276,0.241,0.202,0.177],
      [0.23,0.282,0.262,0.26,0.233,0.193,0.177],
      [0.216,0.26,0.248,0.244,0.22,0.186,0.177],
      [0.234,0.258,0.236,0.227,0.208,0.18,0.177],
      [0.262,0.26,0.224,0.208,0.196,0.176,0.177],
      [0.28,0.26,0.21,0.192,0.184,0.17,0.177],
      [0.298,0.256,0.194,0.174,0.168,0.168,0.177],
      [0.306,0.25,0.18,0.156,0.156,0.166,0.177],
      [0.3,0.24,0.168,0.152,0.152,0.164,0.177]];
   }

var fp11 = fp_table[sharp_i][alt_i];
var fp12 = fp_table[sharp_i][alt_i+1];
var fp21 = fp_table[sharp_i+1][alt_i];
var fp22 = fp_table[sharp_i+1][alt_i+1];
var sharp1 = sharp_range[sharp_i];
var sharp2 = sharp_range[sharp_i+1]; var alt1 = alt_range[alt_i];
var alt2 = alt_range[alt_i+1];

// Bilinear interpolation
fp = fp11 * (sharp2 - sharp) * (alt2 - alt);
fp += fp21 * (sharp - sharp1) * (alt2 - alt);
fp += fp12 * (sharp2 - sharp) * (alt - alt1);
fp += fp22 * (sharp - sharp1) * (alt - alt1);
fp /= (sharp2 - sharp1) * (alt2 - alt1);

return fp;
}

function ERF(alt, sharp, posture, Idir, tsol, fsvv, fbes, asa){
/*
   ERF function to estimate the impact of solar radiation on occupant comfort INPUTS:
   alt : altitude of sun in degrees [0, 90]
   sharp : sun's horizontal angle relative to person in degrees [0, 180] posture: posture of
      occupant ('seated', or 'standing', or 'horizontal')
   Idir : direct beam intensity (normal)
   tsol: total solar transmittance (SC * 0.87)
```

```
   fsvv : sky vault view fraction : fraction of sky vault in occupant's view [0, 1]
fbes : fraction body exposed to sun [0, 1]
   asa : average shortwave absorptivity of body [0, 1] (alpha_sw)
*/

   var DEG_TO_RAD = 0.0174532925;
   var hr = 6;
   var Idiff = 0.2 * Idir;
   var fp = get_fp(alt, sharp, posture);
if (posture== 'standing' || posture == 'horizontal') {
   var feff = 0.725;
else if (posture=='seated'){ var feff = 0.696;
else {
   console.log("Invalid posture (choose seated or seated)"); return;

}
var sw_abs = asa;
var lw_abs = 0.95;
var E_diff = 0.5 * feff * fsvv * tsol * Idiff;
var E_direct = fp * feff * fbes * tsol * Idir;
var E_refl = 0.5 * feff * fsvv * tsol * (Idir * Math.sin(alt * DEG_TO_RAD) + Idiff) * 0.6;
var E_solar = E_diff + E_direct +E_refl;
var ERF = E_solar * (sw_abs / lw_abs);
var trsw = ERF / (hr * feff);

return {"ERF": ERF, "trsw": trsw};
}
```

Revise Table C4-1 as shown below.

C4. COMPUTER CODE VALIDATION TABLE

Table C-5 Computer Code Validation Table

alt	sharp	posture	Idir	tsol	fsvv	fbes	asa	ERF	~~trsw~~	trsw
0	120	Seated	800	0.5	0.5	0.5	0.7	~~42.9~~43.3	~~10.3~~	10.4
60	120	Seated	800	0.5	0.5	0.5	0.7	63.~~7~~2	~~15.3~~	15.1
90	120	Seated	800	0.5	0.5	0.5	0.7	~~64.9~~65.3	~~15.5~~	15.6
30	0	Seated	800	0.5	0.5	0.5	0.7	~~62.7~~63.1	~~15.0~~	15.1
30	30	Seated	800	0.5	0.5	0.5	0.7	~~62.7~~62.4	~~15.0~~	14.9
30	60	Seated	800	0.5	0.5	0.5	0.7	~~59.8~~60.5	~~14.3~~	14.5
30	90	Seated	800	0.5	0.5	0.5	0.7	~~56.8~~57.2	~~13.6~~	13.7
30	150	Seated	800	0.5	0.5	0.5	0.7	~~52.4~~51.7	~~12.6~~	12.4
30	180	Seated	800	0.5	0.5	0.5	0.7	49.0~~.5~~	~~11.8~~	11.7
30	120	Standing	800	0.5	0.5	0.5	0.7	~~59.6~~59.3	~~13.7~~	13.6
30	120	Seated	400	0.5	0.5	0.5	0.7	~~27.7~~27.4	~~6.6~~	6.6
30	120	Seated	600	0.5	0.5	0.5	0.7	~~41.5~~41.1	~~9.9~~	9.8
30	120	Seated	1000	0.5	0.5	0.5	0.7	~~69.2~~68.5	~~16.6~~	16.4
30	120	Seated	800	0.1	0.5	0.5	0.7	~~11.1~~11.0	~~2.7~~	2.6
30	120	Seated	800	0.3	0.5	0.5	0.7	~~33.2~~32.9	~~8.0~~	7.9
30	120	Seated	800	0.7	0.5	0.5	0.7	~~77.5~~76.7	~~18.6~~	18.4
30	120	Seated	800	0.5	0.1	0.5	0.7	~~29.9~~29.3	~~7.2~~	7.0
30	120	Seated	800	0.5	0.3	0.5	0.7	~~42.7~~42.1	~~10.2~~	10.1
30	120	Seated	800	0.5	0.7	0.5	0.7	~~68.1~~67.5	~~16.3~~	16.2
30	120	Seated	800	0.5	0.5	0.1	0.7	~~36.5~~36.4	~~8.7~~	8.7
30	120	Seated	800	0.5	0.5	0.3	0.7	~~45.9~~45.6	~~11.0~~	10.9
30	120	Seated	800	0.5	0.5	0.7	0.7	~~64.8~~64.0	~~15.5~~	15.3
30	120	Seated	800	0.5	0.5	0.5	0.3	~~23.7~~23.5	~~5.7~~	5.6
30	120	Seated	800	0.5	0.5	0.5	0.5	~~39.6~~39.1	~~9.5~~	9.4
30	120	Seated	800	0.5	0.5	0.5	0.9	~~71.2~~70.4	~~17.0~~	16.9
30	120	Seated	800	0.5	0.5	0.5	0.7	~~55.4~~54.8	~~13.3~~	13.1
45	0	Horizontal	700	0.8	0.2	0.5	0.7	60.9		14.0
45	45	Horizontal	700	0.8	0.2	0.5	0.7	65.8		15.1
45	45	Horizontal	800	0.5	0.5	0.5	0.7	70.9		16.3

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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.

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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.

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