ADDENDA

ANSI/ASHRAE Addendum b to
ANSI/ASHRAE Standard 55-2017

Thermal Environmental Conditions for Human Occupancy

Approved by ASHRAE and the American National Standards Institute on May 31, 2019.

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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ISSN 1041-2336

Approved American National Standard
ANSI
www.ansi.org

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FOREWORD

Addendum b updates the computer code for calculation of PMV-PPD using the JavaScript language to ease use of the code in modern software applications. The updated code also includes errata previously published for Standard 55-2013 and aligns the code with requirements in Standard 55-2017.

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

Addendum b to Standard 55-2017

Revise Normative Appendix B as shown.

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

NORMATIVE APPENDIX B
COMPUTER PROGRAM FOR CALCULATION OF PMV-PPD

~~(Reference Annex D of ISO 7730[4]. 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[3] 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.)~~

The following code is one implementation of the PMV-PPD calculation using JavaScript in SI units. This calculation does not include discomfort risk due to local discomfort factors.

```
pmv = function(ta, tr, vel, rh, met, clo, wme) {
    // returns [pmv, ppd]
    // ta, air temperature (°C)
    // tr, mean radiant temperature (°C)
    // vel, relative air velocity (m/s)
    // rh, relative humidity (%) Used only this way to input humidity level
    // met, metabolic rate (met)
    // clo, clothing (clo)
    // wme, external work, normally around 0 (met)

    var pa, icl, m, w, mw, fcl, hcf, taa, tra, tcla, p1, p2, p3, p4,
    p5, xn, xf, eps, hcn, hc, tcl, hl1, hl2, hl3, hl4, hl5, hl6,
    ts, pmv, ppd, n;

    pa = rh * 10 * exp(16.6536 – 4030.183 / (ta + 235));

    icl = 0.155 * clo; //thermal insulation of the clothing in M2K/W
    m = met * 58.15; //metabolic rate in W/M2
    w = wme * 58.15; //external work in W/M2
    mw = m – w; //internal heat production in the human body
    if (icl <= 0.078) fcl = 1 + (1.29 * icl);
    else fcl = 1.05 + (0.645 * icl);

    //heat transf. coeff. by forced convection
    hcf = 12.1 * sqrt(vel);
    taa = ta + 273;
    tra = tr + 273;
    tcla = taa + (35.5 – ta) / (3.5 * icl + 0.1);

    p1 = icl * fcl;
    p2 = p1 * 3.96;
    p3 = p1 * 100;
    p4 = p1 * taa;
    p5 = 308.7 – 0.028 * mw + p2 * pow(tra / 100, 4);
    xn = tcla / 100;
```

```
    xf = tcla / 50;
    eps = 0.00015;

    n = 0;
    while (abs(xn – xf) > eps) {
        xf = (xf + xn) / 2;
        hcn = 2.38 * pow(abs(100.0 * xf – taa), 0.25);
        if (hcf > hcn) hc = hcf;
        else hc = hcn;
        xn = (p5 + p4 * hc – p2 * pow(xf, 4)) / (100 + p3 * hc);
        ++n;
        if (n > 150) {
            alert('Max iterations exceeded');
            return 1;
        }
    }

    tcl = 100 * xn – 273;

    // heat loss diff. through skin
    hl1 = 3.05 * 0.001 * (5733 – (6.99 * mw) – pa);
    // heat loss by sweating
    if (mw > 58.15) hl2 = 0.42 * (mw – 58.15);
    else hl2 = 0;
    // latent respiration heat loss
    hl3 = 1.7 * 0.00001 * m * (5867 – pa);
    // dry respiration heat loss
    hl4 = 0.0014 * m * (34 – ta);
    // heat loss by radiation
    hl5 = 3.96 * fcl * (pow(xn, 4) – pow(tra / 100, 4));
    // heat loss by convection
    hl6 = fcl * hc * (tcl – ta);

    ts = 0.303 * exp(–0.036 * m) + 0.028;
    pmv = ts * (mw – hl1 – hl2 – hl3 – hl4 – hl5 – hl6);
    ppd = 100.0 – 95.0 * exp(–0.03353 * pow(pmv, 4.0) – 0.2179 * pow(pmv, 2.0));

    var r = {}
    r.pmv = pmv;
    r.ppd = ppd;

    return r
}
```

~~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 m2K/W
170   M  =  MET * 58.15                                      : ‘ metabolic rate in W/m2
180   W  =  WME * 58.15                                      : ‘ external work in W/m2
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) + .028
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
```

Validation Table~~EXAMPLE~~: Values used to generate the comfort envelope in Figure 5.3.1.

Run	Air Temp.		RH	Radiant Temp.		Air Speed					
#	°F	C	%	°F	C	FPM	m/s	Met.	CLO	PMV	~~PPD %~~
1	67.3	19.6	86	67.3	19.6	20	0.10	1.1	1	–0.47~~0.5~~	~~10~~
2	75.0	23.9	66	75.0	23.9	20	0.10	1.1	1	0.48~~0.5~~	~~10~~
3	78.2	25.7	15	78.2	25.7	20	0.10	1.1	1	0.53	~~10~~
4	70.2	21.2	20	70.2	21.2	20	0.10	1.1	1	–0.48~~0.5~~	~~10~~
5	74.5	23.6	67	74.5	23.6	20	0.10	1.1	0.5	–0.47~~0.5~~	~~10~~
6	80.2	26.8	56	80.2	26.8	20	0.10	1.1	0.5	0.52	~~10~~
7	82.2	27.9	13	82.2	27.9	20	0.10	1.1	0.5	0.50	~~10~~
8	76.5	24.7	16	76.5	24.7	20	0.10	1.1	0.5	–0.49~~0.5~~	~~10~~

Note: In every case listed above, the PMV result corresponds to a calculated PPD of 10%.

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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.

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