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

Public Review Draft

Proposed Addendum b to Standard 55-2017, Thermal Environmental Conditions for Human Occupancy

First Public Review (August 2018)
(Draft shows Proposed Changes to Current Standard)

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FOREWORD

This proposed addendum updates the computer code for calculation of PMV-PPD using the JavaScript language to ease the 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 to Reviewers: This addendum makes proposed changes to the current standard. These changes are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) except where the reviewer instructions specifically describe some other means of showing the changes. Only these changes to the current standard are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it relates to the proposed changes.]

Addendum b to 55-2017

Revise Normative Appendix B as shown below.

(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		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	-0.47 ~~-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%.