THERMAL COMFORT CALCULATIONS MUSEUM AMSTELKRING **EN 09-10-2007**

Four variants are investigated.

	Variant 1	Variant 2	Variant 3	Variant 4	Remarks
Metabolism (W/m^2)	95	95	95	95	1.6 Met: Light activity
External work (W/m^2)	0	0	0	0	Ashrae
Average radiation temperature (^oC)	22	22..27	22..27	25	average
Air temperature (^oC)	25	25..30	25..30	28	Max temp in 2005 middle church
Relative Humidity (%)	35..80	55	55	55	
Clothing	0.3	0.3	0.3	0.3	light summer clothing
Air speed (m/s)	0.1	0.1	0.5	0.10..0.55	Low limit Estimated high limit ventilation

Table edited: 29-09-2007

PMV and PPD values calculated in Matlab using the script file as shown in Appendix A

Variant 1:

Metabolism [W/m^2]	External work [W/m^2]	Radiant temp. [˚C]	Air temp. [˚C]	Relative hum. [-]	Clothing [clo]	Air vel. [m/s]	**PMV [-]**	**PPD [%]**
95	0	22	25	0.35	0.3	0.1	-0.0103	5.0022
95	0	22	25	0.40	0.3	0.1	0.0178	5.0065
95	0	22	25	0.45	0.3	0.1	0.0458	5.0435
95	0	22	25	0.50	0.3	0.1	0.0739	5.1130
95	0	22	25	0.55	0.3	0.1	0.1019	5.2152
95	0	22	25	0.60	0.3	0.1	0.1300	5.3502
95	0	22	25	0.65	0.3	0.1	0.1581	5.5178
95	0	22	25	0.70	0.3	0.1	0.1861	5.7183
95	0	22	25	0.75	0.3	0.1	0.2142	5.9517
95	0	22	25	0.80	0.3	0.1	0.2423	6.2181

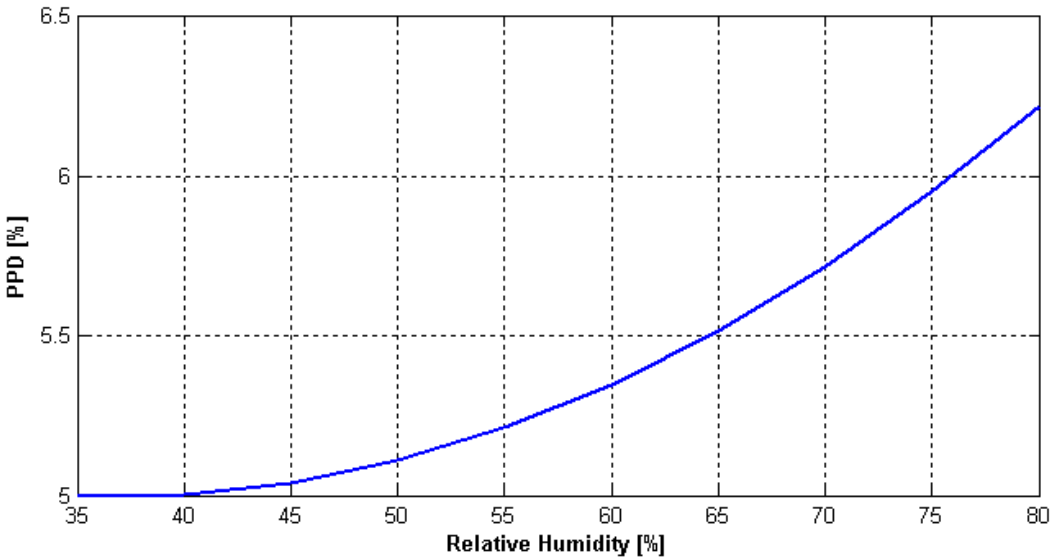

Figure 1 Results of the calculations for variant 1. PPD-value plotted against an increasing RH.

Variant 2:

Metabolism [W/m^2]	External work [W/m^2]	Radiant temp. [˚C]	Air temp. [˚C]	Relative hum. [-]	Clothing [clo]	Air vel. [m/s]	**PMV [-]**	**PPD [%]**
95	0	22.0	25.0	0.55	0.3	0.1	0.1019	5.2152
95	0	22.5	25.5	0.55	0.3	0.1	0.2267	6.0659
95	0	23.0	26.0	0.55	0.3	0.1	0.3519	7.5770
95	0	23.5	26.5	0.55	0.3	0.1	0.4777	9.7658
95	0	24.0	27.0	0.55	0.3	0.1	0.6040	12.6498
95	0	24.5	27.5	0.55	0.3	0.1	0.7308	16.2413
95	0	25.0	28.0	0.55	0.3	0.1	0.8582	20.5429
95	0	25.5	28.5	0.55	0.3	0.1	0.9861	25.5377
95	0	26.0	29.0	0.55	0.3	0.1	1.1146	31.1832
95	0	26.5	29.5	0.55	0.3	0.1	1.2436	37.4045
95	0	27.0	30.0	0.55	0.3	0.1	1.3732	44.0885

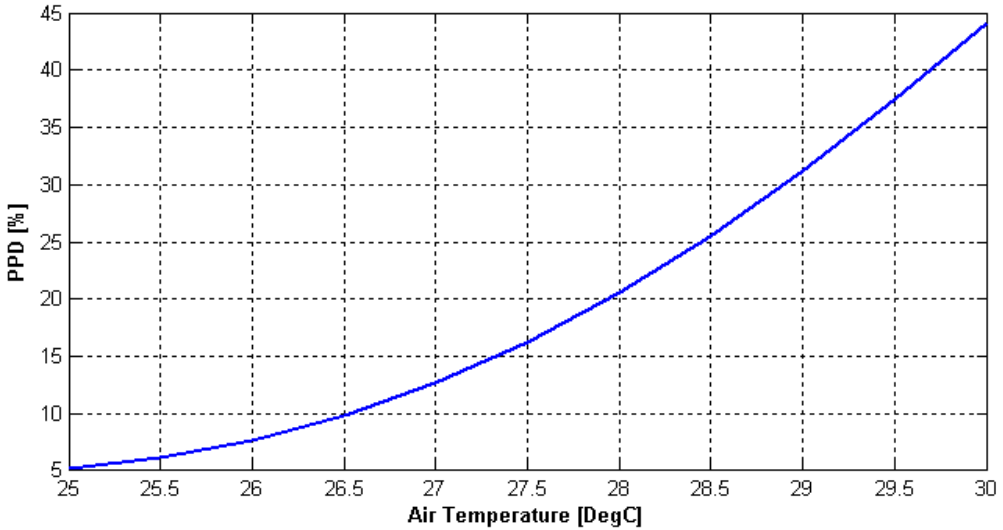

Figure 2 Results of the calculations for variant 2. Air temperature is plotted against the PPD-value.

Variant 3:

Metabolism [W/m^2]	External work [W/m^2]	Radiant temp. [˚C]	Air temp. [˚C]	Relative hum. [-]	Clothing [clo]	Air vel. [m/s]	**PMV [-]**	**PPD [%]**
95	0	22.0	25.0	0.55	0.3	0.5	-0.5132	10.5067
95	0	22.5	25.5	0.55	0.3	0.5	-0.3464	7.4966
95	0	23.0	26.0	0.55	0.3	0.5	-0.1792	5.6654
95	0	23.5	26.5	0.55	0.3	0.5	-0.0115	5.0027
95	0	24.0	27.0	0.55	0.3	0.5	0.1567	5.5089
95	0	24.5	27.5	0.55	0.3	0.5	0.3254	7.2013
95	0	25.0	28.0	0.55	0.3	0.5	0.4945	10.1096
95	0	25.5	28.5	0.55	0.3	0.5	0.6641	14.2663
95	0	26.0	29.0	0.55	0.3	0.5	0.8343	19.6837
95	0	26.5	29.5	0.55	0.3	0.5	1.0049	26.3261
95	0	27.0	30.0	0.55	0.3	0.5	1.1760	34.0838

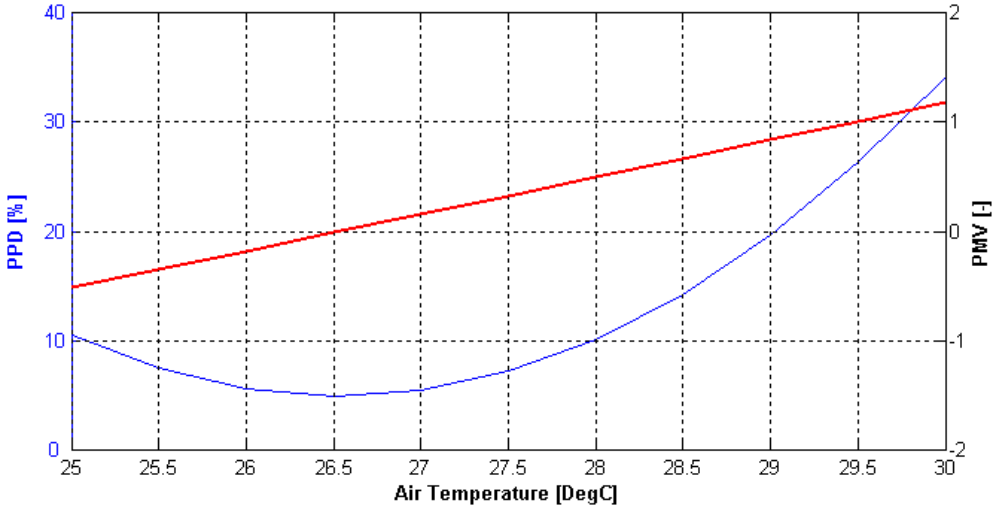

Figure 3 Results of the calculations for variant 3. Air temperature is plotted against PPD and PMV-value.

Variant 4:

Metabolism [W/m^2]	External work [W/m^2]	Radiant temp. [˚C]	Air temp. [˚C]	Relative hum. [-]	Clothing [clo]	Air vel. [m/s]	**PMV [-]**	**PPD [%]**
95	0	25	28	0.55	0.3	0.10	0.8582	20.5429
95	0	25	28	0.55	0.3	0.15	0.7834	17.9332
95	0	25	28	0.55	0.3	0.20	0.7236	16.0197
95	0	25	28	0.55	0.3	0.25	0.6733	14.5271
95	0	25	28	0.55	0.3	0.30	0.6296	13.3183
95	0	25	28	0.55	0.3	0.35	0.5908	12.3153
95	0	25	28	0.55	0.3	0.40	0.5558	11.4672
95	0	25	28	0.55	0.3	0.45	0.5239	10.7402
95	0	25	28	0.55	0.3	0.50	0.4945	10.1096
95	0	25	28	0.55	0.3	0.55	0.4673	9.5589

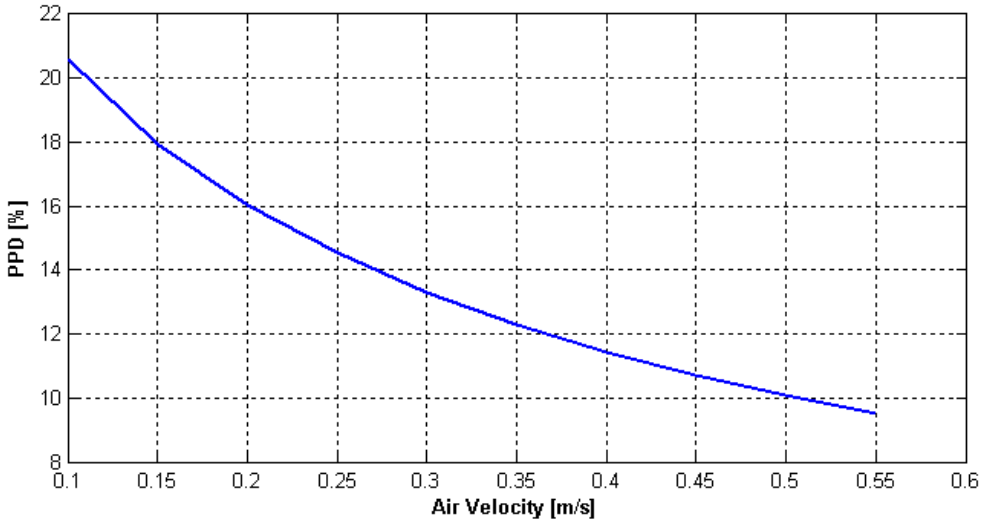

Figure 4 Results of the calculations for variant 4. Air velocity is plotted against the PPD-value.

Appendix A

Matlab script file as used for calculating PMV and PPD values

```
%PMVF   Calculation of the Predicted Mean Vote (pmv) and the
%   Predicted Percentage of Dissatisfied (ppd) according
%   Fanger
%
% SYNOPSIS: [PMVOUT]=pmvf(PMVPAR)
%
% DESCRIPTION:
%  PMVVAR is a n-by-7 matrix which contains the input parameters
%  for calculating the pmv and ppd:
%  PMVVAR(:,1): metabolism [W/m^2]
%  PMVVAR(:,2): external work [W/m^2]
%  PMVVAR(:,3): radiant temperature [degree celsius]
%  PMVVAR(:,4): air temperatuur [degree celsius]
%  PMVVAR(:,5): relative humidity    [0 < Rh < 1]
%  PMVVAR(:,6): clothing [clo]
%  PMVVAR(:,7): air velocuty [m/s]
%
%  PMVOUT is a n-by-2 matrix containing in the first colum
%  the pmv values and in the second colum the ppd values.
%
% EXAMPLE:
%  PMVVAR=[58.2 0 20 20 0.5 1 0.2;58.2 0 20 20 0.5 1 0.3];
%  [PMVOUT]=pmvf(PMVVAR)
%  PMVOUT =
%
%   -1.1337   32.0718
%   -1.2965   40.0881

% MFILES REQUIRED: pmveqf, ppdf
% AUTEUR/DATE: JvS/1998/03

function q=pmvf(in)
insize=size(in);
q=zeros(insize(1),2);
if insize(2)==7
 q=zeros(insize(1),1);
  for i=1:insize(1)
  pm=in(i,:);
  uu11=pm;
  pm(6)=pm(6)*0.155;
   if pm(6) <= 0.078,
     fclpmv=1+1.29*pm(6);
   else
     fclpmv=1.05+0.645*pm(6);
   end
  pm(8)=fclpmv;
  x=fminsearch('pmveqf',[30 30]',[],pm);
  tclpmv=x(1);
  hcpmv=x(2);
  pm=uu11;
  q1=(0.303*exp(-0.036*pm(1))+0.028);
  q(i,1)=q1*(pm(1)-pm(2)-3.05e-3*(5733-6.99*(pm(1)-pm(2))-pm(5)*psatf(pm(4)))-
0.42*(pm(1)-pm(2)-58.15)-1.7e-5*pm(1)*(5867-pm(5)*psatf(pm(4))) -
0.0014*pm(1)*(34-pm(4))-3.96e-8*fclpmv*( (tclpmv+273)^4 -(pm(3)+273)^4 ) -
fclpmv*hcpmv*(tclpmv-pm(4)));
  q(i,2)=ppdf(q(i,1));
end
else
  disp('Wrong inputmatrix. Inputmatrix must be: n-by-7 ')
  disp('CALCULATION INTERRUPTED !')
  q=[]
end
```

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