Thermal Comfort: Predicted Mean Vote (PMV) and PPD

Fanger's predicted mean vote and predicted percentage dissatisfied from air and radiant temperature, air speed, humidity, metabolic rate and clothing insulation.

Method: Fanger's predicted mean vote and predicted percentage dissatisfied (the ISO 7730 and ASHRAE 55 method)

Input parameters

Unit system: SI

Parameter	Value	Unit
Air temperature	24.000	°C
Mean radiant temperature	25.000	°C
Relative air speed	0.15000	m/s
Relative humidity	50.000	%
Metabolic rate (1 met = 58.15 W/m²; office 1.1–1.2)	1.1000	
Clothing insulation (summer 0.5, winter 1.0 clo)	0.60000	

Calculated results

Parameter	Value	Unit
Predicted mean vote (−3 cold to +3 hot)	-0.26020	
Predicted percentage dissatisfied	6.4057	%
Clothing surface temperature	29.374	°C
Convective heat transfer coefficient	4.6863	W/(m²·K)
Operative temperature (mean of air and radiant)	24.500	°C

Notes for this case

• Fanger's heat-balance model (no external work). Valid for PMV between −2 and +2, 10–30 °C air, 0.8–4 met and 0–2 clo. Comfort categories commonly use |PMV| < 0.5 (PPD < 10 %).

Formula and method

$$PMV = (0.303e^{-0.036M} + 0.028)\left[(M-W) - H_{evap} - H_{resp} - 3.96\times10^{-8} f_{cl}\left[(t_{cl}+273)^4 - (\bar{t}_r+273)^4\right] - f_{cl}h_c(t_{cl}-t_a)\right]$$

$$PPD = 100 - 95\exp\left(-0.03353PMV^4 - 0.2179PMV^2\right)$$

Variables

t_a	Air temperature	K
$\bar{t}_r$	Mean radiant temperature	K
v_{ar}	Relative air speed	m/s
RH	Relative humidity	-
M	Metabolic rate (1 met = 58.15 W/m²; office 1.1–1.2)	-
I_{cl}	Clothing insulation (summer 0.5, winter 1.0 clo)	-
PMV	Predicted mean vote (−3 cold to +3 hot)	-
PPD	Predicted percentage dissatisfied	-
t_{cl}	Clothing surface temperature	K
h_c	Convective heat transfer coefficient	W/(m²·K)
t_o	Operative temperature (mean of air and radiant)	K

Method and standards

Fanger's heat-balance comfort model.

Assumptions and limits

- Steady state, moderate environments, no external work.

References

Fanger's predicted mean vote and predicted percentage dissatisfied (the ISO 7730 and ASHRAE 55 method)

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/hvac/loads/pmv-ppd-thermal-comfort

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.