Flat-Plate Collector Top Loss and Overall Loss Coefficient (Klein)

Top loss coefficient of a flat-plate solar collector by Klein's empirical equation, with back and edge losses giving the overall loss coefficient UL.

Input parameters

Unit system: SI

Parameter	Value	Unit
Number of glass covers	1.0000	
Plate emittance (selective 0.1, black paint 0.95)	10.000	%
Glass emittance	88.000	%
Collector slope	30.000	°
Mean plate temperature	60.000	°C
Ambient temperature	20.000	°C
Wind heat transfer coefficient (about 5.7 + 3.8V)	15.000	W/(m²·K)
Back insulation conductivity	0.040000	W/(m·K)
Back insulation thickness	50.000	mm
Edge loss coefficient, referred to collector area	0.20000	W/(m²·K)

Calculated results

Parameter	Value	Unit
Klein factor f	2.3300	
Klein factor C	496.13	
Klein exponent e	0.30093	
Top loss, convective part	2.6010	W/(m²·K)
Top loss, radiative part	0.86340	W/(m²·K)
Top loss coefficient	3.4644	W/(m²·K)
Back loss coefficient	0.80000	W/(m²·K)
Overall loss coefficient	4.4644	W/(m²·K)
Heat loss per unit area at these temperatures	178.58	W/m²

Notes for this case

- Klein's equation reproduces the detailed cover-by-cover calculation within about 0.3 W/(m²·K) for plate temperatures from ambient to 200 °C, ambient −15 to 35 °C, wind 0–10 m/s, one to three covers and slopes 0–90°, for a plate-to-cover gap of about 25 mm.

Formula and method

$$U_t = \left[\frac{N}{\frac{C}{T_{pm}}\left(\frac{T_{pm}-T_a}{N+f}\right)^{e}+\frac{1}{h_w}}\right]^{-1} + \frac{\sigma(T_{pm}+T_a)(T_{pm}^2+T_a^2)}{(\varepsilon_p+0.00591Nh_w)^{-1}+\frac{2N+f-1+0.133\varepsilon_p}{\varepsilon_g}-N}$$

$$f=(1+0.089h_w-0.1166h_w\varepsilon_p)(1+0.07866N),\quad C=520(1-0.000051\beta^2),\quad e=0.430\left(1-\frac{100}{T_{pm}}\right),\quad U_L=U_t+\frac{k}{L}+U_e$$

Variables

N	Number of glass covers	-
ε_p	Plate emittance (selective 0.1, black paint 0.95)	-
ε_g	Glass emittance	-
β	Collector slope	rad
T_{pm}	Mean plate temperature	K
T_a	Ambient temperature	K
h_w	Wind heat transfer coefficient (about 5.7 + 3.8V)	W/(m²·K)
k_b	Back insulation conductivity	W/(m·K)
L_b	Back insulation thickness	m
U_e	Edge loss coefficient, referred to collector area	W/(m²·K)
f	Klein factor f	-
C	Klein factor C	-
e	Klein exponent e	-
$U_{t,conv}$	Top loss, convective part	W/(m²·K)
$U_{t,rad}$	Top loss, radiative part	W/(m²·K)
U_t	Top loss coefficient	W/(m²·K)
U_b	Back loss coefficient	W/(m²·K)
U_L	Overall loss coefficient	W/(m²·K)
q_L	Heat loss per unit area at these temperatures	W/m²

Method and standards

Klein's empirical fit to the cover-by-cover top loss calculation.

Assumptions and limits

- Plate-to-cover gap about 25 mm; slope above 70° treated as 70°.

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/environmental/solar-thermal/collector-top-loss-coefficient

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Reopens the calculator with the inputs of this report.