Collector Heat Exchanger Penalty Factor F'R/FR

Reduction in collector heat removal factor caused by a heat exchanger between an antifreeze collector loop and the tank, from exchanger effectiveness and flows.

Input parameters

Unit system: SI

Parameter	Value	Unit
Collector area	40.000	m²
Collector F_R U_L	4.2000	W/(m²·K)
Collector F_R(τα)_n	72.000	%
Collector-loop flow	0.50000	kg/s
Collector-loop fluid specific heat	3.6000	kJ/(kg·K)
Tank-side flow	0.40000	kg/s
Tank-side fluid specific heat	4.1800	kJ/(kg·K)
Heat exchanger effectiveness	60.000	%

Calculated results

Parameter	Value	Unit
Collector-side capacitance rate	1,800.0	W/K
Minimum capacitance rate	1,672.0	W/K
Heat exchanger penalty factor	93.099	%
Intercept with the exchanger	67.031	%
Slope with the exchanger	3.9101	W/(m²·K)

Notes for this case

• The penalty acts as if the collector worked at a higher inlet temperature; a factor above about 0.95 is usual in good designs. Correct the collector for pipe losses first, then for the exchanger.

Formula and method

$$\frac{F'_R}{F_R} = \left[1 + \frac{A_c F_R U_L}{(\dot{m}c_p)_c}\left(\frac{(\dot{m}c_p)_c}{\varepsilon(\dot{m}c_p)_{min}} - 1\right)\right]^{-1}$$

Variables

A_c	Collector area	m²
$F_R U_L$	Collector F_R U_L	W/(m²·K)
$F_R(\tau\alpha)_n$	Collector F_R(τα)_n	-
$\dot{m}_c$	Collector-loop flow	kg/s
$c_{p,c}$	Collector-loop fluid specific heat	J/(kg·K)
$\dot{m}_s$	Tank-side flow	kg/s
$c_{p,s}$	Tank-side fluid specific heat	J/(kg·K)
ε	Heat exchanger effectiveness	-
$(\dot{m}c_p)_c$	Collector-side capacitance rate	W/K
$(\dot{m}c_p)_{min}$	Minimum capacitance rate	W/K
F'_R/F_R	Heat exchanger penalty factor	-

$F'_R(\tau\alpha)_n$	Intercept with the exchanger	-
$F'_R U_L$	Slope with the exchanger	W/(m²·K)

Method and standards

De Winter's collector–heat exchanger factor.

Assumptions and limits

- Steady state, constant effectiveness.

Report details

Report reference	FCC-89FJ-ZE78 (the same inputs always give the same reference)
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

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-heat-exchanger-penalty

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.