Carnot COP of a Refrigerator or Heat Pump

Ideal (Carnot) COP for cooling and for heating from evaporating and condensing temperatures, the least kW per TR, and the second-law efficiency of a real machine.

Method: Carnot cycle (classical thermodynamics)

Input parameters

Unit system: SI

Parameter	Value	Unit
Evaporating temperature	5.0000	°C
Condensing temperature	40.000	°C
Actual cooling COP of the machine	5.5000	

Calculated results

Parameter	Value	Unit
Carnot COP, cooling	7.9471	
Carnot COP, heating (heat pump)	8.9471	
Least power per ton of refrigeration (kW/TR)	0.44253	
Second-law efficiency of the machine	69.207	%

Formula and method

$$COP_{R,C} = \frac{T_e}{T_c - T_e} \qquad COP_{HP,C} = \frac{T_c}{T_c - T_e} \qquad \mathrm{kW/TR}_{min} = \frac{3.517}{COP_{R,C}} \qquad \eta_{II} = \frac{COP}{COP_{R,C}}$$

Variables

T_e	evaporating temperature	K
T_c	condensing temperature	K
COP	actual cooling COP	–
$COP_{R,C}$	Carnot cooling COP	–
$COP_{HP,C}$	Carnot heating COP	–
$\mathrm{kW/TR}_{min}$	least power per TR	kW/TR
η_{II}	second-law efficiency	–

Method and standards

Reversed Carnot cycle between two reservoirs at the evaporating and condensing temperatures.

Assumptions and limits

- Ideal reversible cycle; real cycles lose to compression, throttling and heat-exchanger approach.

References

- Carnot cycle (classical thermodynamics)

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/refrigeration/refrigeration-carnot-cop

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.