Vapour Compression Refrigeration Cycle from Enthalpies

Refrigerant flow, compressor power, condenser heat, refrigerating effect, COP and kW per ton of a vapour compression cycle from the enthalpies read off the p–h chart.

Method: Vapour compression cycle energy balance (ASHRAE Handbook—Fundamentals, ch. 2)

Input parameters

Unit system: SI

Parameter	Value	Unit
Refrigerating capacity	100.00	kW
Enthalpy at compressor suction	400.00	kJ/kg
Enthalpy at compressor discharge	430.00	kJ/kg
Enthalpy leaving the condenser (= h_4 after the expansion valve)	250.00	kJ/kg

Calculated results

Parameter	Value	Unit
Refrigerating effect $h_1 - h_4$	150.00	kJ/kg
Compressor work $h_2 - h_1$	30.000	kJ/kg
Refrigerant flow	2,400.0	kg/h
Compressor power (to the refrigerant)	20.000	kW
Heat rejected in the condenser	120.00	kW
Coefficient of performance	5.0000	
Power per ton of refrigeration	0.70337	

Notes for this case

- Read all three enthalpies from the same chart or table: refrigerant tables use different reference states, so mixing sources gives nonsense.

Formula and method

$$q_e = h_1 - h_4, \quad w = h_2 - h_1, \quad \dot{m} = \frac{\dot{Q}_e}{q_e}$$

$$COP = \frac{h_1 - h_4}{h_2 - h_1}, \quad \dot{Q}_c = \dot{m}(h_2 - h_3)$$

Variables

$\dot{Q}_e$	Refrigerating capacity	W
h_1	Enthalpy at compressor suction	J/kg
h_2	Enthalpy at compressor discharge	J/kg
h_3	Enthalpy leaving the condenser (= h_4 after the expansion valve)	J/kg
q_e	Refrigerating effect $h_1 - h_4$	J/kg
w	Compressor work $h_2 - h_1$	J/kg
$\dot{m}$	Refrigerant flow	kg/s
P	Compressor power (to the refrigerant)	W
$\dot{Q}_c$	Heat rejected in the condenser	W
COP	Coefficient of performance	-
kW/TR	Power per ton of refrigeration	-

Method and standards

Steady energy balance on each component; the expansion valve is isenthalpic ($h_4 = h_3$).

Assumptions and limits

- Ideal compressor power to the refrigerant; no line losses.

References

- Vapour compression cycle energy balance (ASHRAE Handbook—Fundamentals, ch. 2)

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/vapour-compression-cycle

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Reopens the calculator with the inputs of this report.