Surface Condenser Heat Load and Cooling Water Flow

Heat load of a steam surface condenser and the cooling water flow it needs, from exhaust steam flow and dryness, condenser pressure and cooling water temperatures.

Method: IAPWS R7-97(2012) IF97; HEI Standards for Steam Surface Condensers (terminology)

Input parameters

Unit system: SI

Parameter	Value	Unit
Exhaust steam flow to the condenser	40,000	kg/h
Exhaust steam dryness fraction	90.000	%
Condenser pressure (absolute)	10.000	kPa
Condensate subcooling below saturation	0	K
Cooling water inlet temperature	32.000	°C
Cooling water outlet temperature	41.000	°C
Cooling water pressure (absolute)	3.0000	bar

Calculated results

Parameter	Value	Unit
Condenser heat load	23.921	MW
Cooling water flow	2,289,974	kg/h
Cooling water volume flow	2,301.2	m³/h
Saturation temperature in the condenser	45.808	°C
Exhaust steam enthalpy	2,344.7	kJ/kg
Condensate enthalpy	191.81	kJ/kg

Formula and method

$$\dot{Q} = \dot{m}_s\,(h_{in} - h_c) \qquad h_{in} = h_f + x\,h_{fg} \text{ at } p_c \qquad h_c = h(p_c,\ T_{sat} - \Delta T_{sub})$$

$$\dot{m}_{cw} = \frac{\dot{Q}}{h(T_{cw,2}) - h(T_{cw,1})} \qquad \dot{V}_{cw} = \frac{\dot{m}_{cw}}{\rho(T_{cw,1})} \quad (\text{water properties at } p_{cw})$$

Variables

$\dot{m}_s$	exhaust steam flow	kg/s
x	exhaust steam dryness	–
p_c	condenser pressure, absolute	Pa
ΔT_{sub}	condensate subcooling	K
$T_{cw,1}$	cooling water inlet temperature	K
$T_{cw,2}$	cooling water outlet temperature	K
p_{cw}	cooling water pressure, absolute	Pa
$\dot{Q}$	condenser heat load	W
$\dot{m}_{cw}$	cooling water mass flow	kg/s
$\dot{V}_{cw}$	cooling water volume flow	m³/s
T_{sat}	saturation temperature	K
h_{in}	exhaust steam enthalpy	J/kg

h_c	condensate enthalpy	J/kg
$h_f\$, \$h_{fg}$	saturated liquid enthalpy and latent heat at p_c	J/kg
ρ	water density	kg/m³

Method and standards

Energy balance of the condenser; steam, condensate and cooling water properties by FireCAD's IAPWS-IF97. Terms (TTD, ITD, heat load) as used in the HEI condenser standards.

Assumptions and limits

- Exhaust wet or saturated at condenser pressure; condensate at saturation unless subcooling is entered; no air in the steam.
- Only the turbine exhaust is counted. Heater drains, gland steam, turbine bypass and other flows dumped into the condenser add to the load; include them in the steam flow at their own enthalpy.

References

• IAPWS R7-97(2012) IF97
• HEI Standards for Steam Surface Condensers (terminology)

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/boilers-power-plant/condensers-cooling/condenser-heat-load

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Reopens the calculator with the inputs of this report.