Condenser Vacuum, TTD and Vacuum Efficiency

Absolute pressure and saturation temperature from the condenser vacuum and barometer, with terminal temperature difference, subcooling, vacuum and condenser efficiency.

Method: IAPWS R7-97(2012) IF97; HEI Standards for Steam Surface Condensers (TTD and ITD terms)

Input parameters

Unit system: SI

Parameter	Value	Unit
Vacuum gauge reading (below the barometer)	680.00	mmHg
Barometric pressure	760.00	mmHg
Cooling water inlet temperature	32.000	°C
Cooling water outlet temperature	41.000	°C
Condensate (hotwell) temperature	44.000	°C

Calculated results

Parameter	Value	Unit
Absolute condenser pressure	10.666	kPa
Saturation temperature	47.074	°C
Terminal temperature difference	6.0740	K
Initial temperature difference	15.074	K
Cooling water temperature rise	9.0000	K
Condensate subcooling	3.0740	K
Vacuum efficiency	93.883	%
Condenser (cooling water) efficiency	59.706	%

Formula and method

$$p_c = p_{atm} - p_{vac} \qquad T_{sat} = T_{sat}(p_c) \qquad TTD = T_{sat} - T_{cw,2} \qquad ITD = T_{sat} - T_{cw,1}$$

$$\eta_{vac} = \frac{p_{vac}}{p_{atm} - p_{sat}(T_{cw,1})} \qquad \eta_c = \frac{T_{cw,2} - T_{cw,1}}{T_{sat} - T_{cw,1}} \qquad \Delta T_{sub} = T_{sat} - T_{hw}$$

Variables

p_{vac}	vacuum gauge reading	Pa
p_{atm}	barometric pressure	Pa
$T_{cw,1}$	cooling water inlet temperature	K
$T_{cw,2}$	cooling water outlet temperature	K
T_{hw}	hotwell (condensate) temperature	K
p_c	absolute condenser pressure	Pa
T_{sat}	saturation temperature	K
TTD	terminal temperature difference	K
ITD	initial temperature difference	K
ΔT_{cw}	cooling water rise, $T_{cw,2} - T_{cw,1}$	K
ΔT_{sub}	condensate subcooling	K
η_{vac}	vacuum efficiency	–
η_c	condenser efficiency	–

p_{sat}	saturation pressure of water	Pa

Method and standards

Saturation properties by FireCAD's IAPWS-IF97; TTD and ITD as used in the HEI condenser standards; vacuum and condenser efficiencies as defined in steam-plant practice (the usual examination definitions; no single standard governs them). The vacuum is a pressure difference below the barometer, so it is entered in mmHg, kPa or similar, never as a gauge pressure.

Assumptions and limits

- Pure steam saturated at condenser pressure (air partial pressure neglected).
- The 10 K TTD warning is a FireCAD rule of thumb; a hotwell above saturation is flagged as a reading error.

References

• IAPWS R7-97(2012) IF97
• HEI Standards for Steam Surface Condensers (TTD and ITD terms)

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-vacuum

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Reopens the calculator with the inputs of this report.