Condenser Air Removal: Vapour Load and Suction Volume

Air–vapour mixture mass and suction volume a condenser vacuum pump or ejector must remove for an air in-leakage, at suction pressure and offtake temperature.

Method: Dalton's law of partial pressures with IAPWS-IF97 saturation (definitions)

Input parameters

Unit system: SI

Parameter	Value	Unit
Dry air in-leakage	30.000	kg/h
Suction pressure (absolute)	8.0000	kPa
Air-offtake subcooling below saturation	4.2000	K

Calculated results

Parameter	Value	Unit
Saturation temperature	41.510	°C
Mixture temperature	37.310	°C
Vapour partial pressure	6.3888	kPa
Vapour carried with the air	73.982	kg/h
Total mixture	103.98	kg/h
Suction volume	1,659.3	m³/h

Notes for this case

• Dalton's law with the mixture saturated at the offtake temperature. Subcooling the air–vapour mixture in the air-cooling section cuts the vapour load sharply; the 4.2 K default is a FireCAD starting value; use the condenser maker's air-cooling section design.

Formula and method

$$\dot{m}_v = \dot{m}_a \frac{p_v}{p - p_v}\frac{M_w}{M_a}, \quad \dot{V} = \frac{\dot{m}_a R_a T}{p - p_v}, \quad p_v = p_{sat}(T_s - \Delta T)$$

Variables

$\dot{m}_a$	Dry air in-leakage	kg/s
p	Suction pressure (absolute)	Pa
ΔT	Air-offtake subcooling below saturation	K
T_s	Saturation temperature	K
T	Mixture temperature	K
p_v	Vapour partial pressure	Pa
M_w	molar mass of water, 18.015	kg/kmol
M_a	molar mass of dry air, 28.96	kg/kmol
R_a	gas constant of dry air, R/M_a = 287.06	J/(kg·K)
$\dot{m}_v$	Vapour carried with the air	kg/s
$\dot{m}$	Total mixture	kg/s
$\dot{V}$	Suction volume	m³/s

Method and standards

Dalton's law.

Assumptions and limits

- Mixture saturated at the offtake temperature.

- At zero subcooling the vapour load grows without bound, so at least 0.5 K is required. The 4.2 K default is a FireCAD starting value, not a code figure.

References

- Dalton's law of partial pressures with IAPWS-IF97 saturation (definitions)

Report details

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Release checks	2 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/boilers-power-plant/condensers-cooling/condenser-vacuum-pump-capacity

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.