Steam Humidifier Load and Power

Steam needed to humidify an air stream from its entering condition to a target relative humidity, and the power of an electric steam humidifier for it.

Method: ASHRAE psychrometrics; IAPWS-IF97 (saturation and steam enthalpy)

Input parameters

Unit system: SI

Parameter	Value	Unit
Air flow at the entering condition	10,000	m³/h
Atmospheric pressure	101.33	kPa
Entering air temperature	20.000	°C
Entering relative humidity	20.000	%
Supply air temperature after the humidifier	21.000	°C
Target relative humidity	45.000	%
Feed water temperature	15.000	°C

Calculated results

Parameter	Value	Unit
Entering humidity ratio	2.8850	g/kg
Target humidity ratio	6.9492	g/kg
Dry air flow	11,986	kg/h
Steam needed	48.714	kg/h
Power of an electric steam humidifier	35.352	kW

Notes for this case

- Steam injection adds almost no sensible heat; the humidifier power is for raising feed water to steam at atmospheric pressure, with no losses.

Formula and method

$$W = 0.622 - \text{type ratio}: \quad \frac{M_w}{M_a}\frac{\phi\, p_{sat}(T)}{p - \phi\, p_{sat}(T)}$$

$$\dot{m}_a = Q/v(T_1, W_1), \quad \dot{m}_s = \dot{m}_a(W_2 - W_1)$$

$$P = \dot{m}_s[h_g(1\ \text{atm}) - h_f(T_w)]$$

Variables

Q	air flow at the entering condition	m³/s
p	atmospheric pressure	Pa
T_1	entering temperature	K
ϕ_1	entering relative humidity	-
T_2	supply temperature	K
ϕ_2	target relative humidity	-
T_w	feed water temperature	K
ϕ	relative humidity	-
p_{sat}	saturation pressure (IF97)	Pa
M_w, M_a	molar masses of water and dry air	kg/kmol

v	humid volume per kg dry air	m³/kg
W	humidity ratio	kg/kg
W_1	entering humidity ratio	kg/kg
W_2	target humidity ratio	kg/kg
$\dot{m}_a$	dry air flow	kg/s
$\dot{m}_s$	steam needed	kg/s
h_g	saturated steam enthalpy	J/kg
h_f	feed water enthalpy	J/kg
P	humidifier power	W

Method and standards

Humidity ratios at the two conditions follow from relative humidity and IF97 saturation pressure; the steam needed is the dry air flow times the rise in humidity ratio. Humidifier power heats feed water to saturated steam at atmospheric pressure.

Assumptions and limits

- Steam humidification; no condensation in the duct; no losses.
- Air temperatures from 0 °C (the saturation equation used is over water).

References

• ASHRAE psychrometrics
• IAPWS-IF97 (saturation and steam enthalpy)

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/psychrometry/humidifier-steam-load

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.