Steam Coil Air Preheater (SCAPH): Duty and Steam

Heat and steam to warm combustion air in a steam coil air preheater from the air flow and temperatures, with IF97 latent heat at the steam pressure.

Method: Energy balance with IAPWS-IF97 latent heat (saturated condensate)

Input parameters

Unit system: SI

Parameter	Value	Unit
Air flow	120.00	t/h
Air in	15.000	°C
Air out	50.000	°C
Air specific heat 1006 J/(kg·K) is dry air near ambient; humid combustion air is 1–2 % higher. Use it with the air flow on the same (dry or humid) basis.	1.0060	kJ/(kg·K)
Heating steam pressure (absolute) Absolute: add the atmospheric pressure to a gauge reading.	4.0000	bar
Heating steam	Dry saturated	
Heating steam temperature (superheated only)	200.00	°C

Calculated results

Parameter	Value	Unit
Air heating duty	1,173.7	kW
Latent heat at steam pressure	2,133.3	kJ/kg
Steam condensed	1,980.6	kg/h

Notes for this case

- A SCAPH raises the air heater's cold-end temperature at low load and in winter, at the cost of steam.

Formula and method

$$\dot{Q} = \dot{m}_a c_{p,a}(T_2 - T_1), \quad \dot{m}_s = \frac{\dot{Q}}{h_s - h_f(p_s)}, \quad h_{fg} = h_g - h_f$$

Variables

$\dot{m}_a$	Air flow	kg/s
T_1	Air in	K
T_2	Air out	K
$c_{p,a}$	Air specific heat	J/(kg·K)
p_s	Heating steam pressure (absolute)	Pa
$\dot{Q}$	Air heating duty	W
h_{fg}	Latent heat at steam pressure	J/kg
$\dot{m}_s$	Steam condensed	kg/s
state	Heating steam: dry saturated or superheated	-
T_s	Heating steam temperature (superheated only)	K
$h_s\$, \$h_f\$, \$h_g$	steam supplied, saturated liquid and saturated vapour enthalpies (IF97)	J/kg

Method and standards

Energy balance: the air heating duty is supplied by steam condensing to saturated liquid at the steam pressure, so each kilogram gives h_s − h_f (the latent heat h_fg = h_g − h_f for dry saturated steam, more when superheated). IAPWS-IF97 properties.

Assumptions and limits

- Saturated condensate out, no subcooling and no heat loss.
- Heating steam dry saturated or superheated as chosen; wet steam gives less heat per kg and needs more steam than shown.
- One air specific heat (default dry air near ambient); humid air is 1–2 % higher.
- A note appears when the air leaves within 5 K of the steam temperature.

References

- Energy balance with IAPWS-IF97 latent heat (saturated condensate)

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/furnace-heating-surfaces/steam-coil-air-preheater

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Reopens the calculator with the inputs of this report.