Boiler Efficiency by the Direct (Input–Output) Method

Boiler efficiency from measured steam flow, steam and feedwater conditions, blowdown, fuel flow and gross calorific value, with the evaporation ratio.

Method: ASME PTC 4-2013 Fired Steam Generators (input–output method); BIS IS 8753 (boiler efficiency, Indian practice); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Steam flow	10,000	kg/h
Steam pressure (absolute)	10.500	bar
Steam condition	Dry saturated	
Steam temperature (superheated only)	250.00	°C
Feedwater temperature	105.00	°C
Fuel flow	1,650.0	kg/h
Gross calorific value of the fuel, as fired	18,600	kJ/kg
Blowdown, as a share of steam	0	%
Drum pressure (absolute), for blowdown and feedwater; 0 = steam pressure For a superheated boiler the drum runs above the steam outlet pressure by the superheater pressure drop. Leave at 0 to take the steam pressure.	0	bar

Calculated results

Parameter	Value	Unit
Boiler efficiency (on GCV)	76.183	%
Heat to steam and blowdown	6,494.6	kW
Heat input from fuel	8,525.0	kW
Evaporation ratio	6.0606	kg/kg
Steam enthalpy	2,779.0	kJ/kg
Feedwater enthalpy	440.90	kJ/kg

Formula and method

$$\eta = \frac{\dot{Q}_{out}}{\dot{Q}_{in}} = \frac{\dot{m}_s\,(h_s - h_{fw}) + b\,\dot{m}_s\,(h_f - h_{fw})}{\dot{m}_f \cdot GCV}$$

$$\text{evaporation ratio} = \dot{m}_s / \dot{m}_f$$

Variables

$\dot{m}_s$	steam flow	kg/s
p	steam pressure, absolute	Pa
state	saturated or superheated steam	–
T_s	steam temperature (superheated steam)	K
T_{fw}	feedwater temperature	K
$\dot{m}_f$	fuel flow	kg/s
GCV	gross calorific value of the fuel, as fired	J/kg

b	blowdown as a share of steam flow	–
η	boiler efficiency on GCV	–
$\dot{Q}_{out}$	heat given to steam and blowdown	W
$\dot{Q}_{in}$	heat input from fuel	W
$\dot{m}_s/\dot{m}_f$	evaporation ratio, kg steam per kg fuel	kg/kg
h_s	steam enthalpy	J/kg
h_{fw}	feedwater enthalpy at the drum pressure p_d	J/kg
h_f	saturated water enthalpy (blowdown) at the drum pressure p_d	J/kg
p_d	drum pressure, absolute; 0 takes the steam pressure p	Pa

Method and standards

Input–output (direct) efficiency as defined in ASME PTC 4 and in the Indian practice of IS 8753: useful heat to the working fluid divided by the chemical energy of the fuel on the gross (higher) calorific value. Steam, feedwater and blowdown enthalpies from FireCAD's IAPWS-IF97.

Assumptions and limits

- Steady load; the fuel and steam quantities cover the same period.
- Gross calorific value of the fuel as fired; sensible heat in fuel and air, and auxiliary power, are not counted.
- No heat credits; steam leaving dry (saturated) or at the given temperature (superheated). Wet steam cannot be entered; carry-over moisture would make the efficiency read high.
- Feedwater and blowdown enthalpies are taken at the drum pressure; left at 0 it is the steam pressure. In a superheater boiler the drum runs above the outlet pressure by the superheater pressure drop: enter it for the blowdown heat to be exact.
- The 95 % warning is a FireCAD plausibility limit for non-condensing boilers.

References

• ASME PTC 4-2013 Fired Steam Generators (input–output method)
• BIS IS 8753 (boiler efficiency, Indian practice)
• IAPWS R7-97(2012) IF97

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/boilers/boiler-efficiency-direct

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Reopens the calculator with the inputs of this report.