HRSG Off-Design Performance: Evaporator and Economiser

Steam, gas temperatures and economiser outlet of an unfired HRSG at a new gas flow, temperature and drum pressure, from its design-point data.

Method: Ganapathy; Steam Plant Calculations Manual; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Design gas flow	17.640	kg/s
Design gas inlet temperature	526.67	°C
Design gas temperature leaving the evaporator	208.89	°C
Design drum pressure (absolute)	14.803	bar
Design economiser duty	1,125.4	kW
Design economiser LMTD	27.778	K
New gas flow	20.790	kg/s
New gas inlet temperature	471.11	°C
New drum pressure (absolute)	11.356	bar
Feedwater temperature	110.00	°C
Blowdown fraction of steam	5.0000	%
Gas specific heat, evaporator	1.1304	kJ/(kg·K)
Gas specific heat, economiser	1.0593	kJ/(kg·K)
Heat retention factor (1 − casing loss)	99.000	%
Exponent of gas flow in the economiser UA	0.65000	

Calculated results

Parameter	Value	Unit
Saturation temperature	185.49	°C
Gas leaving the evaporator	197.56	°C
Evaporator duty	6,364.3	kW
Steam generated	11,456	kg/h
Water leaving the economiser	184.26	°C
Economiser duty	1,069.1	kW
Exit (stack) gas temperature	148.52	°C

Notes for this case

• Unfired HRSG with evaporator and economiser; the evaporator NTU scales as W_g^−0.4 and the economiser UA as W_g^m (gas-side controlled), as Ganapathy's Q4.35.

Formula and method

$$\ln\frac{T_{g1}-T_s}{T_{g2}-T_s}=\ln\frac{T_{g1,d}-T_{s,d}}{T_{g2,d}-T_{s,d}}\left(\frac{W_g}{W_{g,d}}\right)^{-0.4},\quad Q_{ev}=W_g c_p h_l (T_{g1}-T_{g2})$$

$$\dot{m}_s = \frac{Q_{ev}}{(h_g - h_{w2}) + b(h_f - h_{w2})}, \quad Q_{ec} = \dot{m}_s(1+b)(h_{w2} - h_{fw}) = UA\,\Delta T_{lm}, \quad UA = \frac{Q_{e,d}}{\Delta T_{lm,d}} \left(\frac{W_g}{W_{g,d}} \right)^m$$

Variables

$W_{g,d}$	Design gas flow	kg/s
$T_{g1,d}$	Design gas inlet temperature	K
$T_{g2,d}$	Design gas temperature leaving the evaporator	K
p_d	Design drum pressure (absolute)	Pa
$Q_{e,d}$	Design economiser duty	W
$\Delta T_{lm,d}$	Design economiser LMTD	K
W_g	New gas flow	kg/s
T_{g1}	New gas inlet temperature	K
p	New drum pressure (absolute)	Pa
T_{fw}	Feedwater temperature	K
b	Blowdown fraction of steam	-
$c_{p,ev}$	Gas specific heat, evaporator	J/(kg·K)
$c_{p,ec}$	Gas specific heat, economiser	J/(kg·K)
h_l	Heat retention factor (1 − casing loss)	-
m	Exponent of gas flow in the economiser UA	-
T_s	Saturation temperature	K
T_{g2}	Gas leaving the evaporator	K
Q_{ev}	Evaporator duty	W
$\dot{m}_s$	Steam generated	kg/s
T_{w2}	Water leaving the economiser	K
Q_{ec}	Economiser duty	W
T_{g3}	Exit (stack) gas temperature	K

Method and standards

Ganapathy's NTU-type simulation, solved for the economiser outlet temperature by bisection between the feedwater temperature + 0.01 K and the saturation temperature, after checking that the heat balance changes sign in that range. The new gas inlet must be at least 1 K above saturation. If the economiser could heat the water past saturation, the water is taken to leave at saturation, as in Ganapathy's Q4.41, and a warning is shown.

Assumptions and limits

- Unfired; no superheater; gas-side-controlled U.
- The design economiser duty and LMTD are taken as given; they are not checked against the design gas and water temperatures, so enter a consistent design case.
- A steaming economiser is not modelled: the water is capped at saturation and the economiser duty kept sensible, so the stack temperature is overstated and the steam understated when the warning appears.

References

- Ganapathy
- Steam Plant Calculations Manual
- 2nd ed. (Marcel Dekker, 1993)
- Q4.35 (off-design simulation of an HRSG) and Q4.34 (design case)
- Q4.41 (steaming in the economiser); IAPWS-IF97 steam properties

Report details

Report reference	FCC-D1EX-T93C (the same inputs always give the same reference)
Generated	17 November 2026, 19:50 UTC
Calculator	HRSG Off-Design Performance: Evaporator and Economiser
Method last reviewed	13 November 2026
Software release	FireCAD Calc, release of 17 November 2026
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/hrsg-waste-heat/hrsg-off-design-performance

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.