Waste Heat Boiler Fouling from Operating Data

Clean exit gas temperature of a waste heat boiler at a new gas flow from reference data, against the measured value, and the heat and money lost to fouling.

Method: Ganapathy; Industrial Boilers and Heat Recovery Steam Generators (Marcel Dekker, 2003); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Boiler type	Water tube (U ∝ W_g^0.6)	
Reference (clean) gas flow	34,019	kg/h
Reference gas inlet temperature	537.78	°C
Reference gas exit temperature	260.00	°C
Reference steam pressure (absolute)	20.684	bar
Present gas flow	22,680	kg/h
Present gas inlet temperature	510.00	°C
Present steam pressure (absolute)	20.684	bar
Measured present exit gas temperature	271.11	°C
Gas specific heat	1.0886	kJ/(kg·K)
Operating hours per year	8,000.0	h
Cost of heat (currency per GJ)	2.8430	

Calculated results

Parameter	Value	Unit
Present saturation temperature	214.09	°C
Predicted clean exit gas temperature	243.85	°C
Exit temperature rise due to fouling	27.263	K
Heat lost to fouling	186.97	kW
Annual cost of the lost heat (currency)	15,309	

Notes for this case

- The measured exit temperature is more than 5 K above the clean prediction: fouling is likely; check gas pressure drop as well.

Formula and method

$$\ln\frac{T_{g1}-T_s}{T_{g2}-T_s}=\frac{UA}{W_g c_p}\propto W_g^{-0.2}\ \text{(fire tube)},\ W_g^{-0.4}\ \text{(water tube)},\quad Q_{loss}=W_g c_p(T_{g2,meas}-T_{g2,pred})$$

Variables

type	Boiler type	-
$W_{g,1}$	Reference (clean) gas flow	kg/s
$T_{g1,1}$	Reference gas inlet temperature	K
$T_{g2,1}$	Reference gas exit temperature	K
p_1	Reference steam pressure (absolute)	Pa
$W_{g,2}$	Present gas flow	kg/s
$T_{g1,2}$	Present gas inlet temperature	K
p_2	Present steam pressure (absolute)	Pa

$T_{g2,meas}$	Measured present exit gas temperature	K
c_p	Gas specific heat	J/(kg·K)
t_a	Operating hours per year	s
c_E	Cost of heat (currency per GJ)	-
T_s	Present saturation temperature	K
$T_{g2,pred}$	Predicted clean exit gas temperature	K
ΔT	Exit temperature rise due to fouling	K
Q_{loss}	Heat lost to fouling	W
C	Annual cost of the lost heat (currency)	-

Method and standards

Ganapathy's evaporator scaling: the clean exit temperature at the present flow, inlet temperature and pressure follows from the reference test with UA/(W_g c_p) scaled as W_g^−0.2 (fire tube) or W_g^−0.4 (water tube). The heat lost is the gas heat between the measured and predicted exit temperatures, costed per GJ for the operating hours.

Assumptions and limits

- Evaporator only; gas-side-controlled U.
- The 5 K margin for flagging fouling is a FireCAD rule of thumb for measurement scatter, not a sourced figure.
- A measured exit below the clean prediction gives a negative heat loss and dT (no fouling); the cost is then zero.

References

• Ganapathy
• Industrial Boilers and Heat Recovery Steam Generators (Marcel Dekker, 2003)
• Q8.15a and Q8.17 (evaporator performance and fouling inferred from operating data); IAPWS-IF97 saturation

Report details

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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/whb-fouling-from-operating-data

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.