CO Loss (Incomplete Combustion Loss)

Boiler efficiency loss from carbon monoxide in the flue gas, from the CO reading, the fuel analysis and excess air, with the CO in mg/Nm³ (ASME PTC 4).

Method: ASME PTC 4-2013 Fired Steam Generators §5.14 (CO loss); BIS IS 8753 (boiler efficiency)

Input parameters

Unit system: SI

Parameter	Value	Unit
CO in dry flue gas	300.00	ppm
Carbon	45.000	%
Hydrogen	3.5000	%
Oxygen	5.0000	%
Nitrogen	1.0000	%
Sulphur	0.50000	%
Ash	35.000	%
Moisture	10.000	%
Excess air	20.000	%
Air humidity (kg water per kg dry air)	0.013000	kg/kg
Gross calorific value of the fuel, as fired	18,600	kJ/kg
Fuel firing rate	12,000	kg/h

Calculated results

Parameter	Value	Unit
CO loss, % of heat input	0.26638	%
Heat lost as CO	165.16	kW
CO per kg of fuel	2.0966	g/kg
CO concentration, dry, normal	374.90	mg/Nm³

Formula and method

$$m_{CO} = CO_{dry} \cdot n_{dg} \cdot M_{CO} \qquad L_{CO} = \frac{m_{CO} \cdot HHV_{CO}}{GCV} \qquad \dot{Q}_{CO} = \dot{m}_f m_{CO} HHV_{CO}$$

$$c_{CO} = \frac{CO_{dry} M_{CO}}{V_m}$$

Variables

CO_{dry}	CO in dry flue gas, volume fraction	–
$C\$, \$H\$, \$O\$, \$N\$, \$S\$, \$A\$, \$M$	ultimate analysis as fired, mass fractions	–
EA	excess air	–
ω	air humidity, kg water per kg dry air	kg/kg
GCV	gross calorific value	J/kg
$\dot{m}_f$	fuel firing rate	kg/s
L_{CO}	CO loss, fraction of input	–
$\dot{Q}_{CO}$	heat lost as CO	W

m_{CO}	CO per kg of fuel	kg/kg
c_{CO}	CO concentration, dry, at 0 °C and 101.325 kPa	kg/m³
n_{dg}	dry flue gas per kg of fuel, from the combustion balance	kmol/kg
M_{CO}	molar mass of CO, 28.010 kg/kmol	kg/kmol
HHV_{CO}	heat of burning CO to CO_2, 10 160 Btu/lb = 23.63 MJ/kg (PTC 4)	J/kg
V_m	molar volume at normal conditions, 22.414 m³/kmol	m³/kmol

Method and standards

CO loss as in ASME PTC 4 §5.14: the mass of CO per kg of fuel times the heat of burning CO to CO_2, 10 160 Btu/lb, over the gross calorific value. The dry flue gas quantity comes from FireCAD's exact-ratio combustion balance of the fuel analysis at the given excess air.

Assumptions and limits

- CO is the only unburned gas; hydrogen and hydrocarbons are not counted.
- The gas quantity is computed with all carbon burned to CO_2 (the CO share is small). Above about 1 % CO the dry gas is noticeably understated and a warning appears.
- Excess air must be the value at the CO sampling point, consistent with the O_2 the analyser reads there; use the excess air from O_2 calculator.
- Air humidity changes only the wet flue gas; the dry gas quantity, and so every output here, does not depend on it.
- A warning appears when the GCV differs from the Channiwala–Parikh estimate of the analysis by more than 15 %.

References

• ASME PTC 4-2013 Fired Steam Generators §5.14 (CO loss)
• BIS IS 8753 (boiler efficiency)

Report details

Report reference	FCC-X3N6-GKDH (the same inputs always give the same reference)
Generated	17 November 2026, 19:36 UTC
Calculator	CO Loss (Incomplete Combustion Loss)
Method last reviewed	10 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	3 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/combustion/co-loss

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.