Stack Loss: Dry Gas and Moisture Losses

The four stack losses of a boiler (dry gas, water from hydrogen, fuel moisture, air moisture) per kg fuel and as a fraction of GCV, from measured gas quantities and temperatures.

Method: ASME PTC 4-2013 §5.14.2–5.14.4 (loss definitions); NIST-JANAF Shomate heat capacities; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Gross calorific value of the fuel	20,000	kJ/kg
Flue gas temperature at the stack	150.00	°C
Combustion air temperature	30.000	°C
Dry flue gas per kg fuel From the combustion calculator or a measured flue gas flow.	12.500	kg/kg
Dry air per kg fuel	11.500	kg/kg
Hydrogen in fuel, as fired	3.5000	%
Moisture in fuel, as fired	10.000	%
Air humidity (kg water per kg dry air)	0.013000	kg/kg
CO_2 in dry flue gas	14.000	%
O_2 in dry flue gas	5.0000	%

Calculated results

Parameter	Value	Unit
Dry gas loss	1,513.3	kJ/kg
Water from hydrogen loss	831.16	kJ/kg
Fuel moisture loss	265.75	kJ/kg
Air moisture loss	33.851	kJ/kg
Total stack loss	2,644.1	kJ/kg
Dry gas loss	7.5665	%
Water from hydrogen loss	4.1558	%
Fuel moisture loss	1.3287	%
Air moisture loss	0.16926	%
Total stack loss	13.220	%
Mean specific heat of dry gas, air to stack temperature	1.0089	kJ/(kg·K)

Formula and method

$$Q_{dg} = m_{g,dry}\left[h_g(T_g) - h_g(T_a)\right] \qquad Q_H = \frac{M_{H_2O}}{M_{H_2}} H\left[h_v(T_g) - h_f(T_a)\right] \qquad Q_M = M\left[h_v(T_g) - h_f(T_a)\right] \qquad Q_\omega = \omega m_a\left[h_v(T_g) - h_v(T_a)\right]$$

$$Q_{st} = Q_{dg} + Q_H + Q_M + Q_\omega \qquad L_i = \frac{Q_i}{GCV} \qquad \bar{c}_{p,g} = \frac{h_g(T_g) - h_g(T_a)}{T_g - T_a}$$

Variables

GCV	gross calorific value of the fuel as fired	J/kg
T_g	flue gas temperature at the stack	K

T_a	combustion air temperature (reference for the losses)	K
$m_{g,dry}$	dry flue gas per kg fuel	kg/kg
m_a	dry combustion air per kg fuel	kg/kg
H	hydrogen in the fuel as fired, mass fraction	–
M	moisture in the fuel as fired, mass fraction	–
ω	air humidity, kg water per kg dry air	kg/kg
y_{CO_2}, y_{O_2}	CO_2 and O_2 in the dry flue gas, volume fractions (N_2 + Ar by difference)	–
h_g	enthalpy of the dry flue gas (Shomate integration over the entered composition)	J/kg
h_v	enthalpy of water vapour: IF97 at 1 psia for the water from hydrogen and fuel moisture; ideal-gas (Shomate) H_2O for the moisture in the air	J/kg
h_f	enthalpy of saturated liquid water at T_a (IF97)	J/kg
M_{H_2O}/M_{H_2}	water formed per kg hydrogen, 8.936	kg/kg
Q_{dg}, Q_H, Q_M, Q_ω, Q_{st}	losses per kg fuel: dry gas, water from hydrogen, fuel moisture, air moisture, total	J/kg
L_{dg}, L_H, L_M, L_ω, L_{st}	the same as fractions of GCV	–
$\bar{c}_{p,g}$	mean specific heat of the dry flue gas between T_a and T_g	J/(kg·K)

Method and standards

The loss definitions of ASME PTC 4 §5.14 applied with the combustion air temperature as the reference, which is the form used by the BS 845 / IS 8753 audit methods. Dry gas enthalpy is integrated from NIST Shomate heat capacities of the entered $CO_2/O_2/N_2$ composition instead of a constant 1.005 kJ/(kg·K); the water terms use IF97 enthalpies of vapour at 1 psia and of liquid at the air temperature, which is what the latent-heat-plus-superheat approximation (2 442 + 1.88 ΔT) stands in for.

Assumptions and limits

- Argon and SO_2 in the dry gas are lumped into N_2 (error below 0.2 % of the dry gas loss).
- Complete combustion; CO, unburned carbon, radiation and residue losses are not included here; use the boiler efficiency calculator for the full balance.
- Stack temperature above about 39 °C (water vapour at 1 psia).
- The dry gas mass, dry air mass and dry gas CO_2 and O_2 are independent inputs and are not checked against each other; take all of them from the same combustion calculation at the measured excess air, or the dry gas loss matches neither condition.

References

• ASME PTC 4-2013 §5.14.2–5.14.4 (loss definitions)
• NIST-JANAF Shomate heat capacities
• IAPWS-IF97

Report details

Report reference	FCC-T90M-HKVR (the same inputs always give the same reference)
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Calculator	Stack Loss: Dry Gas and Moisture Losses
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/boilers/combustion-heat-loss

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.