Heat loss through exhaust gases for steam and hot water boilers

$$qA = \frac{f}{CO_2 max} \cdot \frac{21}{21 - O_2} \cdot (t_A - t_L)$$

qA	=	waste gas loss in %, in relation to the firing capacity and lower calorific value
f	=	factor according to the table below
CO_2 max.	=	maximum carbon dioxide content (Vol. %) according to the table below
O_2	=	measured oxygen content in Vol. % in dry exhaust gas
t_A	=	measured exhaust temperature °C
t_L	=	reference and combustion air temperature 25 °C (constant)

If only the carbon dioxide content in the dry exhaust gas is measured, the following conversion applies:

$$O_2 = 21 \cdot \left(1 - \frac{\mathrm{CO_2}}{\mathrm{CO_2 max}}\right)$$

O_2	=	calculated oxygen content (Vol. %) in the dry exhaust gas which has to be used in the formula for determining the heat loss
CO_2	=	measured carbon dioxide content in Vol. % in the dry exhaust gas
CO_2 max.	=	maximum carbon dioxide content in Vol. % according to the table below

For the following factors and fuels, it is possible to determine the waste gas loss with a precision of 0.2%.

Fuel	CO_2 max Vol. %	Siegert Factors f as function of the O_2-content in Vol. %				
		1.91	2.74	3.50	4.20	4.85
Nat. gas L (Hu = 8.83 kWh/m³n)	11.67	0.4721	0.4677	0.4628	0.4608	0.4568
Nat. gas H (Hu = 10.35 kWh/m³n)	11.94	0.4764	0.4720	0.4681	0.4644	0.4609
Fuel oil EL (Hu = 11.89 kWh/kg)	15.31	0.5885	0.5841	0.5808	0.5755	0.5737
Heavy oil SA (Hu = 11.22 kWh/kg)	16.00	0.6202	0.6163	0.6133	0.6091	0.6062
Propane (Hu = 25.89 kWh/m³n)	13.69	0.5295	0.5253	0.5206	0.5183	0.5145
Propane-Butane (Hu = 27.95 kWh/m³n)	13.78	0.5326	0.5282	0.5242	0.5210	0.5175
Butane (Hu = 34.39 kWh/m³n)	14.00	0.5406	0.5361	0.532	0.5289	0.5253
Nat. gas GZ 35 (Hu = 7 kWh/m³n)	11.12	0.4610	0.4569	0.4524	0.4494	0.4465
Nat. gas GZ 41,5 (Hu = 8 kWh/m³n)	11.67	0.5213	0.5166	0.5113	0.5090	0.5045
Nat. gas GZ 50 (Hu = 9 kWh/m³n)	11.67	0.4631	0.4589	0.4541	0.4513	0.4481
Gas oil HL Schwechat (Hu = 11.64 kWh/m³n)	15.72	0.6041	0.6000	0.5952	0.5916	0.5898
Gas oil CLU 3 (Hu = 11.4 kWh/m³n)	16.11	0.6094	0.6056	0.6016	0.5993	0.5956
Biogas (70% Methane) (Hu = 6.97 kWh/m³n)	16.00	0.6759	0.6694	0.6635	0.6579	0.6529
Biogas (50% Methane) (Hu = 4.98 kWh/m³n)	20.95	0.9496	0.9404	0.9321	0.9241	0.9170

Interim values are to be interpolated.

Example:
Fuel nat. gas H, measured oxygen content 3,41 Vol %

$$f = 0{,}4720 + \frac{0{,}4681 - 0{,}4720}{3{,}50 - 2{,}74} \cdot (3{,}41 - 2{,}74)$$

- In Germany, Technical Information TI002 applies for monitoring of the compliance of waste gas losses in boilers covered by the Federal Emissions Protection Act.
- Area of validity of the formulae: without waste gas condensation, waste gas temperature from 50 to 350 °C.
- Under EN 12953 part 11 (shell boilers - Acceptance tests) section 8.3 the reference temperature is a constant 25 °C. In contract to the Fed.Em.Prot.Act formula, the combustion air temperature does not affect the waste gas loss.
- The precise factors in the formulae for waste gas losses were worked out on the basis of EN 12953 p art11 (large capacity boilers acceptance tests) and simplified to give the above easy-to-use formulae.
- The above equation for heat loss through waste gases corresponds to I (N)G according to equation 8.6-1in EN 12953 part 11. The index N relates to the lower calorific value (Net Calorific Value NCV).