METHOD OF CALCULATION OF THEORETICAL SO2 CONTENT IN THE EXHAUST GASES FROM COMBUSTION OF *FUEL OIL*

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DATA REQUIRED :

1 – Analysis of Fuel oil : **% C y % H_2**
If the analysis is unknown, the following typical ratio may be used:
% C = 84.5 %
% H_2 = 11.5 %

2 – Analysis of Sulphur content of Fuel oil : **% S**

3 – Excess of air in the exhaust gases: **% Excess**

4 – Average analysis of Oxygen in exhaust gases: **% O_2**

5 – Reference level of Oxygen for presentation of emissions data : **% O_2 Ref.**

CALCULATION 1 :

Calculation of stoichiometric air necessary for combustion of 1 Kg of Fuel oil , in accordance with analysis (% C , % H_2 , % S):

(a) Oxygen for C = (%C/100) x 22.4 / 12 m3
(b) Oxygen for H_2 = (%H_2/100) x 22.4 / 4 m3
(c) Oxygen for S = (%S/100) x 22.4 / 32 m3
(d) Total Oxygen = (a) + (b) + (c) = O_2

Dry stoichiometric air required = (d) O_2 / 0.21 = Air Nm3 / Kg Fuel oil

CALCULATION 2 : Exhaust Gases from combustion

Volume of gases formed in combustion:

(a’) CO_2 = (%C/100) x 22.4 / 12 N m3
(b’) H_2O = (%H2/100) x 22.4 / 2 N m3
(c’) SO_2 = (%S/100) x 22.4 / 32 N m3
(d’) N_2 = stoichiometric Air x 0.79 N m3

GHE = Wet Gases stoich.= (a') + (b') + (c') + (d') Nm3 / Kg Fuel oil

GSE = Dry Gases stoich. = (a') + (c') + (d') Nm3 / Kg Fuel oil

Excess Air:

Excess Air = stoichiometric Air x % Excess / 100

Total exhaust gases from combustion :

GHT = Total wet exhaust gases = Excess air + GHE

GST = Total dry exhaust gases = Excess air + GSE

<u>CALCULATION 3</u> : Theoretical emission of SO_2 with exhaust gases

ST = maximum emission of SO_2 =

% S x 10,000 x 64 / 32 = % S x 20,000 = mg S / Kg Fuel oil

Concentration of maximum theoretical SO_2 in gases, <u>relative to % O_2 measured</u> :

A) Based on wet gases: SO_2 (mg/Nm3) = ST / GHT

B) Based on dry gases: SO_2 (mg/Nm3) = ST / GST

Concentration of maximum theoretical SO_2 in gases, <u>relative to Reference % O_2</u>:

C) Based on wet gases:

SO_2 (mg/Nm3) = (A) x (21 - %O_2 Ref.) / (21 - %O_2 measured)

D) Based on dry gases:

SO_2 (mg/Nm3) = (B) x (21 - %O_2 Ref.) / (21 - %O_2 measured)

NOTES :

1. The emissions of SO_2 calculated must be normally refer to dry gases.
2. The emissions calculated are the maximum theoretically possible with the data of % S and % Excess air applied . In practice, the actual emissions are somewhat lower due to the fact that part of the SO_2 is converted into Sulphates (basically of calcium) and part into SO_3 . The calculation thus represents the maximum emission of Sulphur in the form of SO_2 .
3. The emissions data refer to the Reference % O_2, in accordance with the legislation in force in each Autonomous Community, for the type of combustion plant utilised.

EXAMPLE :

DATA :

Analysis of fuel oil :

% C	=	84.5 %
% H_2	=	11.5 %
% S	=	2.3 %

Analysis of the exhaust gases:

% O_2	=	13.4 %
Excess of air	=	185 %

Required Reference oxygen for the emission data: 5 %

CALCULATION 1 : Theoretical air required

Oxygen for C	=	(84.5/100) x 22.4 / 12	=	1.5773 Nm3
Oxygen for H_2	=	(11.5/100) x 22.4 / 4	=	0.6440 Nm3
Oxygen for S	=	(2.3/100) x 22.4 / 32	=	0.0161 Nm3
Total Oxygen	=	1.5773 + 0.644 + 0.0161	=	2.2374 Nm3

Stoichiometric air required = 2.2374 / 0.21 = 10.654 Nm3 / Kg of Fuel oil

CALCULATION 2 : Exhaust Gases from combustion

CO_2	=	(84.5/100) x 22.4 / 12	=	1.5773 Nm3
H_2O	=	(11.5/100) x 22.4 / 2	=	1.2880 Nm3
SO_2	=	(2.3/100) x 22.4 / 32	=	0.0161 Nm3
N_2	=	10.654 x 0.79	=	8.4167 Nm3

Stoichiometric Wet Gases =

1.5773 + 1.288 + 0.0161 + 8.4167 = 11.2981 Nm3 / Kg Fuel oil

Stoichiometric Dry Gases =

1.5773 + 0.0161 + 8.4167 = 10.0101 Nm3 / Kg Fuel oil

Excess Air = 10.654 x 185 / 100 = 19.7099 Nm3 / Kg Fuel oil

Total exhaust gases from combustion:

GHT = Total damp exhaust gases =

19.7099 + 11.2981 = 31.008 Nm3 / Kg Fuel oil

GST = Total dry exhaust gases =

19.7099 + 10.0101 = 29.720 Nm3 / Kg Fuel oil

CALCULATION 3 : Theoretical SO_2 Emissions

ST = total maximum SO_2 emitted = 2.3 x 20,000 = 46,000 mg / Kg Fuel oil

Concentration of SO_2 relative to actual measure % O_2 (13.4 %) :

A) Based on wet gases = 46,000 / 31.008 = 1,483 mg/ Nm3

B) Based on dry gases = 46,000 / 29.720 = 1,548 mg/ Nm3

Concentration of SO_2 relative to Reference % O_2 for data (5 %) :

C) Based on wet gases = 1,483 x (21-5) / (21-13.4) = 3,122 mg/ Nm3

D) Based on dry gases = 1,548 x (21-5) / (21-13.4) = 3,259 mg/ Nm3