Procedure and Methods for Determining Emissions of Pollutants from Combustion Plants into Ambient Air

Regulation No. 33 of 17 March 1999 of the Minister of the Environment

Pursuant to subparagraph 2 of paragraph 4 of the Law on the Protection of Ambient Air (RT (State Gazette) I 1998, 41/42, 624), I hereby establish:

1. to approve the procedure and methods for determining emissions of pollutants from combustion plants into ambient air.

Villu Reiljan, Minister

Rein Ratas, Secretary General

I General provisions

1. This Regulation regulates determination of emissions of sulphur dioxide (SO_2), nitrogen oxides ($NO_2 + NO$), carbon oxide (CO), volatile organic compounds (C_nH_m), solid particles, and heavy metals generated by combustion plants and emitted into ambient air.

   II Procedure for determining emissions of pollutants

2. Emissions of pollutants shall be determined on the basis of direct measurements and/or calculations.
3. With regard to combustion plants (technological furnaces included) with thermal capacity equal to or exceeding 50 MW_{th}, emission factors of pollutants shall be determined on the basis of direct measurements only. Emission factors of volatile organic compounds and heavy metals, and the emission factor of sulphur dioxide from liquid fuels can be determined, in addition to direct measurements, on the basis of calculations.

   III Determination of emissions of pollutants on the basis of direct measurements

4. On the basis of direct measurements, emissions of pollutants shall be determined as follows:

   4.1. a summary table including all fuel types consumed shall be drawn up in accordance with Annex 1 of this Regulation;

4.2. fuel consumption (B) shall be converted from mass units (t) into thermal units (GJ) by using the conversion ratios of energy units presented in Annex 9 of this Regulation and the lowest calorific value of the relevant fuel type Q^r_i:

$$B_1 = B \times Q^r_i, \text{ GJ}$$

where

B - fuel consumption in the studied time period, t;

Q^r_i - lowest calorific value of the relevant fuel, MJ/kg;

4.3. pollutant content in flue gases emitted from combustion plants shall be measured;

4.4. the person carrying out measurements shall draw up a measurement record and a report of measurement results in accordance with the model presented in Annex 2, and shall store these for at least 5 years;

4.5. the emission factor (q_i) of pollutant i shall be calculated on the basis of measurement results of each fuel type consumed, using the following formula:

$$q_i = c_i \, [\, V_g + (\alpha - 1)V] \, / \, Q^r_i \approx c_i \times \alpha \times 0.25 \times k, \text{ g/GJ (in the case of heavy metals, mg/GJ)}$$

where

c_i – concentration of pollutant i in dry flue gases, mg/Nm^3 (conversion ratios are presented in Annex 10 of this Regulation); in heavy metals, $\mu \, g/Nm^3$;

V_g – volume of dry flue gases generated by combustion of 1 kg of fuel, Nm^3/kg;

V – quantity of air theoretically needed for combustion of 1 kg of fuel, Nm^3/kg;

α - factor of excess air $\alpha \approx CO_2^{\,max}/CO_2 \approx 20.9/ (20.9 - O_2)$;

Q^r_i - lowest calorific value of the relevant fuel, MJ/kg;

0.25 – approximate volume of dry flue gases per energy unit generated by stoichiometrical combustion of dry substance of the fuel, Nm^3/MJ;

k – correctory factor related to water content of the fuel, presented in Annex 11 of this Regulation

Measurements carried out at working regimes that are close to the rated load of the combustion plant (at least 80% of the rated load) shall be regarded as acceptable basis for the calculation of emission factors;

4.6. emission of pollutant i (M_i) for each fuel type consumed shall be calculated by using the following formula:

$$M_i = 10^{-6} \times B_1 \times q_i, \text{ t (heavy metals, kg)}$$

where

B_1 - fuel consumption in the studied time period, t;

q_i – emission factor of pollutant i, g/GJ (heavy metals, mg/GJ).

IV Determination of emissions of pollutants on the basis of calculations

5. If emissions of pollutants are not determined by direct measurements, they shall be determined as follows:

5.1. a summary table including all fuel types consumed shall be drawn up in accordance with Annex 1 of this Regulation;

5.2. fuel consumption (B) shall be converted from mass units (t) into thermal units (GJ) by using the conversion ratios of energy units presented in Annex 9 of this Regulation and the lowest calorific value of the relevant fuel type Q^r_i:

$$B_1 = B \times Q^r_i, \text{ GJ}$$

where

B - fuel consumption in the studied time period, t;

Q^r_i - lowest calorific value of the relevant fuel, MJ/kg;

5.3. the value of the emission factor of pollutant i (q_i) can be found in the relevant annexes (Annexes 3 – 8);

5.4. emission of the relevant pollutant, M_i, except for sulphur dioxide, shall be calculated on the basis of fuel consumption B_1 and emission factor q_i by using the following formula:

$$M_i = 10^{-6} \times B_1 \times q_i, \text{ t (heavy metals, kg)}$$

where

B_1 - fuel consumption in the studied time period, t;

q_i – emission factor of pollutant i, g/GJ (heavy metals, mg/GJ).

5. emission of sulphur dioxide generated by solid or liquid fuels shall be calculated, on the basis of the sulphur content of the fuel, as follows:

$$M_{SO2} = 0.02 \times B \times S^r \times (1 - \eta), t$$

where

B - fuel consumption in the studied time period, t;

S^r – sulphur content in the consumable substance of fuel, mass %;

η - relative quantity of sulphur captured by sulphur capturing device or bound by fuel ash in a combustion plant; to be taken into account only in the case of oil shale.

5. Pollutant emission generated in one second (emission at a certain moment) can be calculated as follows:

$$M_{pi} = 10^{-3} \times P \times q, g/s \text{ (heavy metal, mg/s)}$$

where

P – thermal capacity of the combustion plant, MW_{th}; thermal capacity of the combustion plant shall mean energy input in a time unit;

q_i – emission factor of pollutant i, g/GJ (in the case of heavy metals, mg/GJ).

If emissions from two or more boilers are emitted through one and the same stack, the total emission of such pollution source at a certain moment can be calculated by summing up the relevant values of the boilers.

6. The emission of sulphur dioxide M_{pSO2} at a certain moment resulting from the consumption of liquid or solid fuel shall be calculated on the basis of the sulphur content of the fuel by using the following formula:

$$M_{pSO2} = 20 \times P \times S^r \times (1 - \eta)/Q^r_i, g/s$$

where

P – thermal capacity of the combustion plant, MW_{th};

S^r – sulphur content in the consumable substance of fuels, mass %;

η - relative quantity of sulphur captured by sulphur capturing device or bound by fuel ash in a combustion plant; to be taken into account only in the case of oil shale;

Q^r_i - lowest calorific value of the relevant fuel, MJ/kg.

Annex 1

to Regulation No. 33 of 17 March 1999 of the Minister of the Environment

Data on fuel types

	Fuel I	Fuel II	Fuel III etc.
Fuel type			
Annual fuel consumption B: - tonnes (solid fuel, liquid fuel) • thous. m^3 (gas) Fuel consumption of the combustion plant operating at rated load: • kg/s (solid fuel, liquid fuel) • m^3/s (gas)			
Origin of fuel (if possible to identify)			
Composition of the consumable substance of the fuel: • water content, W^r,% • ash, A^r, % • sulphur, S^r, % • carbon, C^r, % (if possible) • hydrogen, H^r, % (if possible) - nitrogen, N^r, % (if possible)			
Lowest calorific value Q^r_i of the consumable substance of the fuel: • MJ/kg (solid fuel, liquid fuel) • MJ/m^3 (gas)			
Conformity certificate of the fuel quality, date			

Annex 2

to Regulation No. 33 of 17 March 1999 of the Minister of the Environment

Measurement record

Date, time	
Name and address of the holder of the pollution source	
Location of the pollution source	
Name and address of the person carrying out measurements	
Name and contact details of the person responsible for carrying out measurements	

Data on combustion plant	
Name	
Boiler type	
Burner type	
Manufacturer	
Year of manufacturing or date of delivery	
Rated capacity	
Efficiency factor	
Other	

Data on working regimes of combustion plants				
	Estimated		**Actual**	
Fuel consumption, kg/s, m^3/s				
Pressure of fuel before reaching the				

burner (liquid fuel, gas), bar				
Fuel temperature (liquid fuel), C°				
Pressure of vapor/air in fuel injection, bar				
Thermal capacity, MW				
Pressure in furnace, kPa				
Temperature of flue gases, C°				
Pressure of primary air, kPa				
Pressure of secondary air, kPa				
Disturbances in device operation				
Other				
Description of measuring points	Technological chart together with locations of measuring points			

Report of the measurement results

Measurement methods	

Temperatures, pressure				
	In furnace	In front of economizer	After economizer	In front of smoke suction hood
Temperature of flue gases, C°				
Pressure, kPa				
Composition of dry flue gases				
	In front of economizer		At measuring points	
O_2, %				

CO$_2$, %				

Pollutant content in dry flue gases					
	ppm	mg/Nm^3	mg/Nm^3 O$_2$ = 3% Liquid fuel or gas	mg/Nm^3 O$_2$ = 6% Solid fuel	Pollutant emission factor, mg/MJ
SO$_2$					
CO					
NO					
NO$_2$					
NO$_x$					
Other					

Data on the measuring instruments and measuring devices used					
Name	Type	Manu-facturer	Year of manu-facturing	Parameters to be measured, scale of measure-ments	Data on calibration (by whom, time, method, and devices used)

Responsible person: …………………….... ……………..

(Name, position, signature) (date)

Annex 3

to Regulation No. 33 of 17 March 1999 of the Minister of the Environment

Emission factor of solid particles

Fuel type, control device	Emission factor of solid particles q, g/ GJ					
	Thermal capacity of combustion plants (P), method of fuel combustion					
	P < 10 MW$_{th}$				50 MW$_{th}$> P > 10 MW$_{th}$	
	Burner	Pre-furnace	Grate furnace	Fluidized bed	Burner	Fluidized bed
Coal			3000			
Oil shale: • cyclone • electrostatic filter			12000	3000 1000		
Peat: -no control device • cyclone • electrostatic filter		1000	2000 700	700 200		700 200
Timber: -no control device - cyclone -electrostatic filter			1000 500	1000 500	1000	1000 100
Heavy fuel oil	100				100	
Shale oil	100				100	
Light fuel oil	100				100	

Annex 4

to Regulation No. 33 of 17 March 1999 of the Minister of the Environment

Emission factor of sulphur dioxide

Fuel type	Emission factor of sulphur dioxide q, g/GJ					
	Thermal capacity of combustion plants (P), method of fuel combustion					
	P < 10 MW$_{th}$				50 MW$_{th}$> P > 10 MW$_{th}$	
	Burner	Pre-furnace	Grate furnace	Fluidized bed	Burner	Fluidized bed
Coal	Calculated on the basis of sulphur content in coal, binding by ash shall not be taken into account					
Oil shale	Calculated on the basis of sulphur content in oil shale, binding by ash shall be taken into account within the scope of 50%					
Peat		200	200			
Timber		10	10	0		0
Heavy fuel oil Shale oil Light fuel oil	Calculated on the basis of sulphur content in fuel, binding by ash shall not be taken into account					
Natural gas	0				0	

Annex 5

to Regulation No. 33 of 17 March 1999 of the Minister of the Environment

Emission factor of nitrogen oxides

Fuel type	Emission factor of nitrogen oxides q, g/ GJ					
	Thermal capacity of combustion plants (P), method of fuel combustion					
	P < 10 MW$_{th}$				50 MW$_{th}$> P > 10 MW$_{th}$	
	Burner	Pre-furnace	Grate furnace	Fluidized bed	Burner	Fluidized bed

Fuel type	Burner	Pre-furnace	Grate furnace	Fluidized bed	Burner	Fluidized bed
Coal		200	200			
Oil shale					150	
Peat		300	300	300		300
Timber		100	100	100	100	100
Heavy fuel oil	200				250	
Shale oil	150				200	
Light fuel oil	100					
Natural gas	60				100	

Annex 6

to Regulation No. 33 of 17 March 1999 of the Minister of the Environment

Emission factor of carbon oxide

Fuel type	Emission factor of carbon oxide q, g/ GJ					
	Thermal capacity of combustion plants (P), method of fuel combustion					
	P < 10 MW$_{th}$				50 MW$_{th}$> P > 10 MW$_{th}$	
	Burner	Pre-furnace	Grate furnace	Fluidized bed	Burner	Fluidized bed
Coal		100	100			
Oil shale					100	
Peat		1200	500	100		200
Timber		1200	1000	400		200
Heavy fuel oil	100				100	
Shale oil	100				100	
Light fuel oil	100				100	

Natural gas	60				40	

Annex 7

to Regulation No. 33 of 17 March 1999 of the Minister of the Environment

Emission factor of volatile organic compounds (VOC)[1)]

Fuel type	Emission factor of volatile organic compounds q, g/GJ	
	Thermal capacity of combustion plants (P)	
	P < 50 MW$_{th}$	P ≥ 50 MW$_{th}$
Coal	15	1.5
Peat	100	
Timber	48	
Heavy fuel oil	3	3
Light fuel oil	1.5	
Natural gas	4	2.5

1. methane excluded

Annex 8

to Regulation No. 33 of 17 March 1999 of the Minister of the Environment

Emission factor of heavy metals

Fuel type, boiler, control device	Emission factor of heavy metals q, g/GJ								
	Hg	Cd	Pb	Cu	Zn	As	Cr	Ni	V
Boilers fired with coal:	5	30	700	100	230	90	400	400	1500
• no control device	5	10	200			20	80	80	300
• cyclone	5	5	40			5	10	10	50

• electrostatic filter									
Soda boiler:	0.8	3	50				0.5	0.3	
• electrostatic filter	0.8	2	30			2	0.1	0.1	
• electrostatic filter + washing device						1			
Boilers fired with pulverized Estonian oil shale: - electrostatic filter	5	5	300	20	410	90	80	50	130
Boilers fired with wood or tree bark: • no control device	0.5	5	200	5	500	1	35	30	100
• cyclone	0.5	2	60			0.3	10	10	30
• electrostatic filter	0.5	0.5	15			0.1	2	2	9
Boilers fired with peat: • no control device	5	10	200	50	150	100	80	350	250
• cyclone	5	4	50			30	20	80	60
• electrostatic filter	5	0.7	15			7	6	25	20
Boilers fired with heavy fuel oil: • no control device	0.03	0.3	20	10	40	2	1	300	1000
- cyclone	0.03	0.2	10			1	0.5	150	450
Boilers fired with gas	0	0	0	0	0	0	0	0	0

Annex 9

to Regulation No. 33 of 17 March 1999 of the Minister of the Environment

Conversion ratios of energy units

	Toe	MWh	GJ	Gcal
Toe	1	11.63	41.87	10.00
MWh	0.0860	1	3.600	0.860
GJ	0.0239	0.278	1	0.239
Gcal	0.1000	1.163	4.187	1

Annex 10

to Regulation No. 33 of 17 March 1999 of the Minister of the Environment

Conversion ratios of concentrations of gaseous pollutants

	Concentrations of gaseous pollutants					
	NO_x calculated into NO_2 equivalent		SO_2		CO	
	ppm	mg/Nm³	ppm	mg/Nm³	ppm	mg/Nm³
Ppm	1	2.054	1	2.915	1	1.25
mg/m³	0.487	1	343	1	0.8	1

Annex 11

to Regulation No. 33 of 17 March 1999 of the Minister of the Environment

Correction factor k related to water content of the fuel

Water content of fuel W, %	Correction factor per one kg of dry substance of fuel, k
10	1.01
20	1.03
30	1.05
40	1.08

| 50 | 1.12 |
| 60 | 1.19 |