

# TRACTATENBLAD

VAN HET

KONINKRIJK DER NEDERLANDEN

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JAARGANG 1994 Nr. 68

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A. TITEL

*Protocol bij het Verdrag van 1979 betreffende grensoverschrijdende  
luchtverontreiniging over lange afstand inzake de beheersing van  
emissies van stikstofoxiden of van de grensoverschrijdende stromen  
van deze stikstofverbindingen, met bijlagen;  
Sofia, 31 oktober 1988*

B. TEKST

De Engelse en de Franse tekst van het Protocol zijn geplaatst in *Trb.* 1989, 59. Zie voor de ondertekeningen ook *Trb.* 1991, 71.

Voor wijziging van de Technische Bijlage bij het Protocol zie rubriek J van *Trb.* 1992, 84 en rubriek J hieronder.

C. VERTALING

Zie *Trb.* 1991, 71 en rubriek J van *Trb.* 1992, 169.

D. PARLEMENT

Zie *Trb.* 1991, 71.

E. BEKRACHTIGING

Zie *Trb.* 1991, 71 en *Trb.* 1992, 84 en 169.

Behalve de aldaar genoemde Staten heeft nog de volgende Staat in overeenstemming met artikel 14, vierde lid, van het Protocol een akte van bekrachtiging, aanvaarding of goedkeuring nedergelegd bij de Secretaris-Generaal van de Verenigde Naties:

Denemarken<sup>1)</sup>. . . . . 1 maart 1993

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<sup>1)</sup> Onder de verklaring dat de aanvaarding niet geldt voor de Faeroër en Groenland.

F. TOETREDING*Verklaring van voortgezette gebondenheid*

De volgende Staat heeft een verklaring van voortgezette gebondenheid aan het Protocol afgelegd:

de Tsjechische Republiek. . . . . 30 september 1993

G. INWERKINGTREDING

Zie *Trb.* 1991, 71.

J. GEGEVENS

Zie *Trb.* 1989, 59, *Trb.* 1991, 71 en *Trb.* 1992, 84 en 169.

**Verwijzingen**

Voor het op 26 juni 1945 te San Francisco tot stand gekomen Handvest van de Verenigde Naties zie ook *Trb.* 1993, 168.

**Wijziging**

Op 21 januari 1994 heeft de Uitvoerend Secretaris van de Economische Commissie voor Europa in overeenstemming met artikel 11, vijfde lid, van het Protocol de wijzigingen van de Technische Bijlage bij het Protocol, welke tijdens de van 1 tot en met 3 december 1993 gehouden elfde vergadering van het Uitvoerend Orgaan werden aangenomen, medegedeeld aan de Partijen bij het Protocol.

De Engelse tekst van het gewijzigde deel (inleiding en deel I) van de Technische Bijlage bij het Protocol luidt als volgt:

**REVISED TECHNICAL ANNEX TO THE 1988 SOFIA  
PROTOCOL**

*Introduction and part I control technologies for NO<sub>x</sub> emissions from stationary sources*

1. The purpose of this annex is to provide guidance to the Parties to the Convention in identifying NO<sub>x</sub> control options and techniques in the implementation of their obligations under the Protocol.

2. It is based on information on options and techniques for NO<sub>x</sub> emission reduction and their performance and costs contained in official documentation of the Executive Body for the Convention and of the ECE Inland Transport Committee and of their subsidiary bodies.

3. The annex addresses the control of NO<sub>x</sub> emissions considered as the sum of nitrogen oxide (NO) and nitrogen dioxide (NO<sub>2</sub>) expressed as NO<sub>2</sub> and lists a number of NO<sub>x</sub> reduction measures and techniques

spanning a wide range of costs and efficiencies. Unless otherwise indicated these techniques are considered to be well established on the basis of substantial operating experience, which in most cases has been gained over five years or more. It cannot, however, be considered as an exhaustive statement of control options; its aim is to provide guidance to Parties in identifying best available technologies which are economically feasible as a basis for national emission standards and in the introduction of pollution control measures.

4. The choice of pollution control measures for any particular case will depend on a number of factors, including the relevant legislative and regulatory provisions, primary energy pattern, industrial infrastructure and economic circumstances of the Party concerned and, in the case of stationary sources, the specific circumstances of the plant. It should be borne in mind also that sources of  $\text{NO}_x$  are often sources of other pollutants as well, such as sulphur oxides ( $\text{SO}_x$ ), volatile organic compounds (VOCs), and particulates. In the design of control options for such sources, all polluting emissions should be considered together in order to maximize the overall abatement effect and minimize the impact of the source on the environment.

5. The annex reflects the state of knowledge and experience of  $\text{NO}_x$  control measures, including retrofitting, which has been achieved by 1992, in the case of stationary sources, and by 1991 in the case of mobile sources. As this knowledge and this experience continuously expand, the annex needs to be updated and amended regularly.

## I. CONTROL TECHNOLOGIES FOR $\text{NO}_x$ EMISSIONS FROM STATIONARY SOURCES

6. Fossil fuel combustion is the main source of anthropogenic  $\text{NO}_x$  emissions from stationary sources. In addition, some non-combustion processes may contribute considerably to the emissions. The major stationary source categories of  $\text{NO}_x$  emissions, based on EMEP/CORINAIR '90, include:

- a) Public power, cogeneration and district heating plants:
  - (i) Boilers;
  - (ii) Stationary combustion turbines and internal combustion engines;
- b) Commercial, institutional and residential combustion plants:
  - (i) Commercial boilers;
  - (ii) Domestic heaters;
- c) Industrial combustion plants and processes with combustion:
  - (i) Boilers and process heaters (no direct contact between flue gas and products);
  - (ii) Processes (direct contact); (e.g. calcination processes in rotary kilns, production of cement, lime, etc., glass production, metallurgical operation, pulp production);
- d) Non-combustion processes, e.g. nitric acid production;

- e) Extraction, processing and distribution of fossil fuels;
- f) Waste treatment and disposal, e.g. incineration of municipal and industrial waste.

7. For the ECE region, combustion processes (categories (a), (b), (c), (d)) account for 85% of NO<sub>x</sub> emissions from stationary sources. Non-combustion processes, e.g. production processes, account for 12%, and extraction, processing and distribution of fossil fuels for 3% of total NO<sub>x</sub> emissions. Although in many ECE countries, power plants in category (a) are the largest stationary contributor to NO<sub>x</sub> emissions, road traffic is usually the largest single overall source of NO<sub>x</sub> emissions, but the distribution does vary between Parties to the Convention. Furthermore, industrial sources should be kept in mind.

#### GENERAL OPTIONS FOR REDUCING NO<sub>x</sub> EMISSIONS FROM COMBUSTION

8. General options for NO<sub>x</sub> reduction are:

- a) Energy management measures:<sup>1)</sup>
  - (i) Energy saving;
  - (ii) Energy mix;
- b) Technical options:
  - (i) Fuel switching/cleaning;
  - (ii) Other combustion technologies;
  - (iii) Process and combustion modifications;
  - (iv) Flue gas treatment.

9. To achieve the most efficient NO<sub>x</sub> reduction programme, beyond the measures listed in (a), a combination of technical options identified in (b) should be considered. Furthermore, the combination of combustion modification and flue gas treatment needs site specific evaluation.

10. In some cases, options for reducing NO<sub>x</sub> emissions may also result in the reduction of emissions of CO<sub>2</sub> and SO<sub>2</sub> and other pollutants.

#### *Energy saving*

11. The rational use of energy (improved energy efficiency/process operation, co-generation and/or demand-side management) usually results in a reduction in NO<sub>x</sub> emissions.

#### *Energy mix*

12. In general, NO<sub>x</sub> emissions can be reduced by increasing the proportion of non-combustion energy sources (i.e. hydro, nuclear, wind, etc.) to the energy mix. However, further environmental impacts have to be considered.

### *Fuel switching/cleaning*

13. Table 1 shows the uncontrolled  $\text{NO}_x$  emission levels to be expected during fossil fuel combustion for the different sectors.

14. Fuel switching (e.g. from high- to low-nitrogen fuels or from coal to gas) can lead to lower  $\text{NO}_x$  emissions but there may be certain restrictions, such as the availability of low  $\text{NO}_x$  emitting fuels (e.g. natural gas on plant level) and adaptability of existing furnaces to different fuels. In many UN/ECE countries, some coal or oil combustion plants are being replaced by gas-fired combustion plants.

15. Fuel cleaning for fuel nitrogen removal is not a commercial option. Increasing the application of cracking technology in refineries, however, also brings about a reduction in the nitrogen content of the end product.

### *Other combustion technologies*

16. These are combustion technologies with improved thermal efficiency and reduced  $\text{NO}_x$  emissions. They include:

- a) Cogeneration using gas turbines and engines;
- b) Fluidized bed combustion (FBC): bubbling (BFBC) and circulating (CFBC);
- c) Integrated gasification combined cycle (IGCC);
- d) Combined cycle gas turbines (CCGT).

17. The emission levels for these techniques are summarized in table 1.

18. Stationary combustion turbines can also be integrated into existing conventional power plants (known as topping). The overall efficiency can increase by 5% to 6%, but achievable  $\text{NO}_x$  reduction will depend on site and fuel specific conditions. Gas turbines and gas engines are widely applied in cogeneration applications. Typically some 30% energy saving can be attained.

Both have made significant progress in reducing  $\text{NO}_x$  emissions through new concepts in combustion and system technology. However, major alterations to the existing boiler system become necessary.

19. FBC is a combustion technology for burning hard coal and brown coal but it can also burn other solid fuels such as petroleum coke and low grade fuels such as waste, peat and wood. In addition, emissions can be reduced by integrated combustion control in the system. A newer concept of FBC is pressurized fluidized bed combustion (PFBC) presently being commercialized for the generation of electricity and heat. The total installed capacity of FBC has approached approximately 30,000  $\text{MW}_{\text{th}}$  (250 to 350 plants), including 8,000  $\text{MW}_{\text{th}}$  in the capacity range of > 50  $\text{MW}_{\text{th}}$ .

20. The IGCC process incorporates coal gasification and combined cycle power generation, in a gas and steam turbine. The gasified coal is

burned in the combustion chamber of the gas turbine. The technology also exists for heavy oil residue and bitumen emulsion. The installed capacity is presently about 1,000 MWel (5 plants).

21. Combined cycle gas power stations using advanced gas turbines with an energy efficiency of 48%–52% and with reduced  $\text{NO}_x$  emissions are currently being planned.

#### *Process and combustion modifications*

22. These are measures applied during combustion to reduce the formation of  $\text{NO}_x$ . They include the control of combustion air ratio, flame temperature, fuel to air ratio, etc. The following combustion techniques, either singly or in combination, are available for new and existing installations. They are widely implemented in the power plant sector and in some areas of the industrial sector:

- a) Low excess air combustion (LEA);<sup>2)</sup>
- b) Reduced air preheat (RAP)<sup>2)</sup>;
- c) Burner-out-of-service (BOOS);<sup>2)</sup>
- d) Biased-burner-firing (BBF);<sup>2)</sup>
- e) Low  $\text{NO}_x$  burners (LNB);<sup>2)</sup> and<sup>3)</sup>
- f) Flue gas recirculation (FGR)<sup>3)</sup>
- g) Over fire air combustion (OFA)<sup>2)</sup> and<sup>3)</sup>
- h) In-furnace- $\text{NO}_x$ -reduction reburning (IFNR);<sup>4)</sup>
- i) Water/steam injection and lean/premixed combination.<sup>5)</sup>

23. The emission levels due to the application of these techniques are summarized in table 1 (based mainly on experience in power plants).

24. Combustion modifications have been under continuous development and optimization. In-furnace- $\text{NO}_x$ -reduction is being tested in some large-scale demonstration plants, whereas basic combustion modifications are incorporated mainly into boiler and burner design. For example, modern furnace designs incorporate OFA ports, and gas/oil burners are equipped for flue gas recirculation. The latest generation of LNBs combines both air-staging and fuel-staging. A remarkable increase in full-scale retrofit of combustion modifications in UN/ECE member countries has been recorded in the last years. By 1992 a total of about 150,000 MW was installed.

#### *Flue gas treatment processes*

25. Flue gas treatment processes aim at removing already formed  $\text{NO}_x$  and are also referred to as secondary measures. Wherever possible it is usual to apply primary measures as a first stage of  $\text{NO}_x$  reduction before applying flue gas treatment processes. The state-of-the-art flue gas treatment processes are all based on the removal of  $\text{NO}_x$  by dry chemical processes.

26. They are the following:

- a) Selective Catalytic Reduction (SCR);
- b) Selective Non-catalytic Reduction (SNCR);
- c) Combined  $\text{NO}_x/\text{SO}_x$  removal processes:
  - (i) Activated Carbon Process (AC);
  - (ii) Combined catalytic  $\text{NO}_x/\text{SO}_x$  removal.

27. The emission levels for SCR and SNCR are summarized in table 1. Data are based on the practical experience gathered from a large number of implemented plants. By 1991 in the European part of the UN/ECE about 130 SCR plants corresponding to 50,000 MWel, 12 SNCR installations (2,000 MWel), 1 AC plant (250 MWel) and 2 combined catalytic processes (400 MWel) were erected. The  $\text{NO}_x$  removal efficiency of AC and combined catalytic processes are similar to SCR.

28. Table 1 also summarizes the costs of applying the  $\text{NO}_x$  abatement technologies.

### CONTROL TECHNIQUES FOR OTHER SECTORS

29. Unlike most combustion processes, the application of combustion and/or process modifications in the industrial sector has many process specific limitations. In cement kilns or glass melting furnaces, for example, certain high temperatures are necessary to ensure the product quality. Typical combustion modifications being used are staged combustion/low  $\text{NO}_x$  burners, flue gas recirculation and process optimization (e.g. precalcination in cement kilns).

30. Some examples are given in table 1.

### SIDE-EFFECTS/BY-PRODUCTS

31. The following side-effects will not prevent the implementation of any technology or method, but should be considered when several  $\text{NO}_x$  abatement options are possible. However, in general, these side-effects can be limited by proper design and operation:

- a) Combustion modifications:
  - Possible decrease in overall efficiency;
  - Increased CO formation and hydrocarbon emissions;
  - Corrosion due to reducing atmosphere;
  - Possible  $\text{N}_2\text{O}$  formation in FBC systems;
  - Possible increase of carbon fly ash;
- b) SCR:
  - $\text{NH}_3$  in the fly ash;
  - Formation of ammonium salts on downstream facilities;
  - Deactivation of catalyst;
  - Increased conversion of  $\text{SO}_2$  to  $\text{SO}_3$ ;
- c) SNCR:
  - $\text{NH}_3$  in the fly ash;
  - Formation of ammonium salts on downstream facilities;
  - Possible formation of  $\text{N}_2\text{O}$ .

32. In terms of by-products, deactivated catalysts from the SCR process are the only relevant products. Due to the classification as waste, a simple disposal is not possible, however recycling options exist.

33. The reagent production of ammonia and urea for flue gas treatment processes involves a number of separate steps which require energy and reactants. The storage systems for ammonia are subject to the relevant safety legislation and such systems are designed to operate as totally closed systems, with a resultant minimum of ammonia emissions. The use of  $\text{NH}_3$  is, however, not jeopardized even when taking into account the indirect emissions related to the production and transportation of  $\text{NH}_3$ .

### MONITORING AND REPORTING

34. The measures taken to carry out national strategies and policies for the abatement of air pollution include legislation and regulatory provisions, economic incentives and disincentives, as well as technological requirements (best available technology).

35. In general emission limiting standards may be set per emission source according to plant size, operating mode, combustion technology, fuel type and whether it is a new or existing plant. An alternative approach also used is to set a target for the reduction of total  $\text{NO}_x$  emissions from a group of existing sources and to allow the parties to choose where to take action to reach this target (bubble concept).

36. The limiting of the  $\text{NO}_x$  emissions to the levels set out in the national framework legislation has to be controlled by a permanent monitoring and reporting system and reported to the supervising authorities.

37. Several monitoring systems, using both continuous and discontinuous measurement methods, are available. However quality requirements vary among Parties. Measurements are to be carried out by qualified institutes and approved measuring/monitoring systems. To this end a certification system would provide the best assurance.

38. In the framework of modern automated monitoring systems and process control equipment, reporting creates no problems. The collection of data for further use is a state-of-the-art technique. However, data to be reported to competent authorities differ from Party to Party. To obtain better comparability, data sets and prescribing regulations should be harmonized. Harmonization is also desirable for quality assurance of measuring/monitoring systems. This should be taken into account when comparing data from different Parties.

39. To avoid discrepancies and inconsistencies, key issues and parameters including the following, must be well-defined:



- Definition of the standards expressed as ppmv, mg/m<sup>3</sup>, g/GJ, kg/h or kg/t of products. Most of these units need to be calculated and need specification in terms of gas temperature, humidity, pressure, oxygen content or heat input value;

- Definition of time over which standards may be averaged, expressed as hours, months or a year;

- Definition of failure times and corresponding emergency regulations regarding bypass of monitoring systems or shut-down of the installation;

- Definition of methods for backfilling of data missed or lost as a result of equipment failure;

- Definition of the parameter set to be measured. Depending on the type of industrial process, the necessary information may differ. This also involves the location of the measurement point within the system.

40. Quality control of measurements must be ensured.

#### Notes

1) Options 1 (a) and (b) are integrated in the energy structure/policy of a party. Implementation status, efficiency and costs per sector are not considered here.

2) Typical retrofit measures, with limited efficiency and applicability.

3) State-of-the-art in new plants.

4) Implemented in single large commercial plants; operational experience still limited.

5) For combustion turbines.

Table 1

Source category (i): Public power, cogeneration and district heating

Energy source	Uncontrolled Emissions		Process and Combustion Modifications			Flue Gas Treatment:		(a) Non-catalytic ECU/kW <sub>el</sub> <sup>2)</sup>			(b) Catalytic (after primary measures)		
	mg/m <sup>3 1)</sup>	g/GJ <sup>1)</sup>	mg/m <sup>3 1)</sup>	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>	mg/m <sup>3 1)</sup>	g/GJ <sup>1)</sup>	mg/m <sup>3 1)</sup>	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>	mg/m <sup>3 1)</sup>	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>
Boilers:													
- Coal, WBB <sup>3)</sup>	1 500-2 200	530-770	1 000-1 800	350-630	3-25	no data		no data	< 200	< 70	50-100(125-200) <sup>12)</sup>		
- Coal, DBB <sup>5)</sup>	800-1 500	280-530	300-850	100-300	3-25	200-400	70-140	9-11	< 200	< 70	50-100(125-200) <sup>12)</sup>		
- Brown coal <sup>5)</sup>	450-750	189-315	190-300	80-126	30-40	< 200	< 84		< 200	< 85	80-100		
- Heavy oil <sup>6)</sup>	700-1 400	140-400	150-500	40-140	uo to 20	175-250	50-70	6-8	< 150	< 40	50-70		
- Light oil <sup>6)</sup>	350-1 200	100-332	100-350	30-100	up to 20	no data		6-8	< 150	< 40	50-70		
- BE <sup>14)</sup>	800		no data		no data	no data							no data
- Natural gas <sup>6)</sup>	150-600	40-170	50-200	15-60	3-20	no data		5-7	< 100	< 30			
FBC	200-700		180-400		1 400-1 600 <sup>7)</sup>	< 130			no data				
PFBC	150-200	50-70			1 100 <sup>7)</sup>	60			< 140	< 50			
IGCC <sup>13)</sup>	< 600		< 100						no data				
Gas turbines + CCGT <sup>13),18)</sup>					Investment Cost:								
- natural gas	165-310	140-270	30-150	26-130	Dry : 50-100 ECU/kW <sub>el</sub>	NA			2 0	17			
- diesel oil	235-430	200-370	50-200	45-175	Wet: 10-50 ECU/kW <sub>el</sub>	NA			120-180	70			
IC Engines <sup>4)</sup> (natural gas < 1 MW <sub>el</sub> )	4 800-6 300	1 500-2 000	320-640	100-200									

Source category (ii): Commercial, institutional and residential combustion plants

Energy source	Uncontrolled Emissions		Process and Combustion Modifications			Flue Gas Treatment:		(a) Non-catalytic			(b) Catalytic (after primary measures)			
	mg/m <sup>3</sup> 1)	g/GJ <sup>1)</sup>	mg/m <sup>3</sup> 1)	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>	mg/m <sup>3</sup> 1)	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>	mg/m <sup>3</sup> 1)	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>	mg/m <sup>3</sup> 1)	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>
Coal	110-500	40-175												
Brown coal	70-400	30-160												
Light oil	180-440	50-120	130-250	35-70										
Gas	140-290	40-80	60-150	16-40	2-10									
Wood <sup>15)</sup>	85-200	50-120	70-140	40-80										

Source category (iii): Industrial combustion plants and processes with combustion

Energy source	Uncontrolled Emissions		Process and Combustion Modifications			Flue Gas Treatment:		(a) Non-catalytic			(b) Catalytic (after primary measures)			
	mg/m <sup>3</sup> 1)	g/GJ <sup>1)</sup>	mg/m <sup>3</sup> 1)	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>	mg/m <sup>3</sup> 1)	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>	mg/m <sup>3</sup> 1)	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>	mg/m <sup>3</sup> 1)	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>
Industrial combustion plants:														
- Coal PF <sup>6)</sup>	600-2 200	200-770	up to 700	up to 245										
- Coal, grates <sup>3)</sup>	150-600	50-200	up to 500	up to 175										
- Brown coal	200-800	80-340												
- Heavy oil <sup>6)</sup>	400-1 000	110-280	up to 650	up to 180										
- Light oil <sup>6)</sup>	150-400	40-110	up to 250	up to 70										
- Natural gas <sup>5)</sup>	100-300	30-80	up to 150	up to 42	2-10									
Gas turbines + CCGT <sup>1,3)18)</sup>					Investment Cost:									
- natural gas	165-310	140-270	30-150	26-130	Dry: 50-100 ECU/kW <sub>el</sub> Wet: 10-50 ECU/kW <sub>el</sub>	NA			20	17				
- diesel oil	235-430	200-370	50-200	45-175		NA			120-180	70				
FBC <sup>8)</sup>	100-700		100-600											



Source category (iv): Non-combustion processes

Energy source	Uncontrolled Emissions		Process Modifications			Flue Gas Treatment: (a) Non-catalytic			(b) Catalytic (after primary measures)		
	mg/m <sup>3 1)</sup>	kg/t <sup>9)</sup>	mg/m <sup>3 1)</sup>	kg/t <sup>9)</sup>	ECU/t <sup>2)</sup>	mg/m <sup>3 1)</sup>	kg/t	ECU/kW <sub>el</sub> <sup>2)</sup>	mg/m <sup>3 1)</sup>	kg/t <sup>9)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>
Nitric acid:											
- Low pressure (1-2.2 bar)	5 000	16.5									
- Medium pressure (2.3-8 bar)	approx. 1 000	3.3									
- High pressure (8-15 bar)	< 380	< 1.25							0.01-0.8		
- HOKO (-50 bar)	< 380	< 1.25									
Pickling:											
- Brass		25 <sup>10)</sup>									
- Stainless steel		0.3									
- Carbon steel		0.1									

Source category (v): Extraction, processing and distribution of fossil fuels

Energy source	Uncontrolled Emissions		Process and Combustion Modifications			Flue Gas Treatment:			(b) Catalytic (after primary measures)		
	mg/m <sup>3</sup> <sup>1)</sup>	g/GJ <sup>1)</sup>	mg/m <sup>3</sup> <sup>1)</sup>	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>	mg/m <sup>3</sup> <sup>1)</sup>	g/GJ <sup>1)</sup>	(a) Non-catalytic ECU/kW <sub>el</sub> <sup>2)</sup>	mg/m <sup>3</sup> <sup>1)</sup>	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>
Refineries <sup>5)</sup>	- 1 000		100-700								

Source category (vi): Waste treatment and disposal

Energy source	Uncontrolled Emissions		Process and Combustion Modifications			Flue Gas Treatment:			(b) Catalytic (after primary measures)		
	mg/m <sup>3</sup> <sup>1)</sup>	g/GJ <sup>1)</sup>	mg/m <sup>3</sup> <sup>1)</sup>	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>	mg/m <sup>3</sup> <sup>1)</sup>	g/GJ <sup>1)</sup>	(a) Non-catalytic ECU/kW <sub>el</sub> <sup>2)</sup>	mg/m <sup>3</sup> <sup>1)</sup>	g/GJ <sup>1)</sup>	ECU/kW <sub>el</sub> <sup>2)</sup>
Incineration <sup>11)</sup>	250-500		200-400						< 100		

<sup>1)</sup> Emissions in mg/m<sup>3</sup> NO<sub>2</sub> (STP dry) resp. g/GJ thermal input. Conversion factors (mg/m<sup>3</sup> to g/GJ) for NO<sub>x</sub> emission from coal (hard coal): 0.35, coal (lignite): 0.42, oil/gas: 0.277, peat: 0.5, wood + bark: 0.588 [1 g/GJ = 3.6 mg/kWh].

<sup>2)</sup> Total investments 1 ECU = 2 DM.

<sup>3)</sup> Reduction generally achieved in combination with primary measures. Reduction efficiency between 80 and 95%.

<sup>4)</sup> At 5% O<sub>2</sub>.

<sup>5)</sup> At 6% O<sub>2</sub>.

<sup>6)</sup> At 3% O<sub>2</sub>.

<sup>7)</sup> Incl. costs for boiler.

<sup>8)</sup> At 7% O<sub>2</sub>.

<sup>9)</sup> Emissions from industrial processes are generally expressed as kg/t of product.

<sup>10)</sup> g/m<sup>2</sup> surface area.

<sup>11)</sup> At 11% O<sub>2</sub>.

<sup>12)</sup> Tail gas SCR configuration as opposed to high dust.

<sup>13)</sup> At 15% O<sub>2</sub>.

<sup>14)</sup> Bitumen emulsion.

<sup>15)</sup> Untreated wood only.

<sup>16)</sup> Heat recovery and gas recirculation.

<sup>17)</sup> For dry substance < 75%.

<sup>18)</sup> With supplementary firing; approximate additional thermal NO<sub>x</sub>: 0-20 g/GJ.

NA - not applicable.

x - not necessary, standards attainable without no data - technology applied, but no data available.

Ingevolge artikel 11, vierde lid, van het Protocol zijn de wijzigingen op 20 februari 1994 in werking getreden.

In overeenstemming met artikel 5, tweede zin, van de Rijkswet van 22 juni 1961 (*Stb.* 207), houdende regeling inzake de bekendmaking van internationale overeenkomsten en van besluiten van volkenrechtelijke organisaties, heeft de Minister van Buitenlandse Zaken bepaald dat bovenstaande gewijzigde tekst in Nederland zal zijn bekendgemaakt op de dag na die der uitgifte van dit *Tractatenblad*.

Uitgegeven de *elfde* april 1994.

*De Minister van Buitenlandse Zaken,*

P. H. KOOLMANS