

EXPERIMENTAL RESEARCH ON MASS CONCENTRATION OF GASEOUS CHLORIDES UPSTREAM AND DOWNSTREAM FLUE GAS DESULPHURISATION

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Abstract

To protect the environment, thermal power plants invest large sums of money in developing and improving the efficiency of flue gas treatment plants. Flue gas desulfurization plants are primarily designed to reduce sulfur oxide emissions, but they also contribute to the removal of other air pollutants, including gaseous chlorides and fluorides, particulate matter, mercury, and trace metals. This paper presents the results of an experimental investigation into gaseous chloride concentrations, expressed as HCl, measured before and after a flue gas desulphurisation plant in a coal-fired thermal power plant Kostolac B. The study evaluates the effectiveness of the flue gas desulphurisation system in reducing HCl emissions.

Keywords: mass concentration, emission, gaseous chlorides, environment

1. INTRODUCTION

Large thermal energy consumption has a long tradition in the production of heat and electricity. Electricity generated by thermal power plants is still the cheapest. The development of new, sustainable and environmentally friendly technologies has forced the thermal energy sector to make large investments in environmental protection. First, electrostatic filters were modernised, and then desulphurisation plants began to be built. This has significantly increased the cost of electricity production, but it has also significantly reduced environmental pollution, and the price of electricity remains competitive compared with electricity produced from renewable sources.

After the construction and commissioning of the desulphurisation plant, pollutant emission tests must be carried out to demonstrate the efficiency of the plant and obtain an integrated operating permit, which is now required for the operation of modern thermal power plants [1].

To evaluate the efficiency of the flue gas desulphurisation plant at the thermal power plant “Kostolac B” with two 350 MW generating units, various tests were carried out upstream and downstream of the plant. The aim of this paper was to determine the mass concentration of gaseous chlorides, expressed as HCl, before and after the flue gas desulphurisation plant and to evaluate its removal efficiency.

2. EXPERIMENTAL

The determination of the mass concentration of gaseous chlorides in the form of HCl was carried out in accordance with standard EN 1911: Stationary source emissions – Determination of mass concentration of gaseous chlorides expressed as HCl – Standard reference method. Before the desulphurisation plant, sampling was performed on the flue gas ducts at the outlet of the electrostatic precipitator, where working platforms and measuring ports had been installed, while after the desulphurisation plant, sampling was performed at the measuring ports and working platforms on the duct.

Samplings were carried in accordance with the result of the test of homogeneity carried out according to standard EN 15259. For sampling a straight heated probe with nozzle was used. Dust was removed by a high efficiency heated filter, and the gaseous chlorides were then collected in absorbers (Figure 1). The samples were analysed in the laboratory using a Libra S22 spectrophotometer.

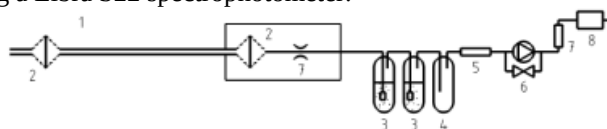


Figure 1. Schematic representation of the equipment for sampling and measuring the HCl content in flue gas at units 1 and 2 of the thermal power plant: 1) heated probe, 2) heated particle filter, 3) absorbers, 4) protective bottle, 5) cartridge with desiccant (optional), 6) pump, 7) flowmeter after the filter or before the gas meter, 8) gas meter

To determine the composition of the flue gas, the oxygen content was measured by the paramagnetic method in accordance with EN 14789, and the carbon dioxide content by non-dispersive infrared spectrometry in accordance with ISO 12039. A Horiba PG 350 gas analyser was used to measure oxygen and carbon dioxide. The moisture content of the flue gas was determined in accordance with EN 14790 using a measuring line manufactured by Paul Gothe GmbH. Flue gas flow and velocities were determined in accordance with ISO 16911-1 using the following measuring equipment: a DB3 digital absolute/relative pressure meter manufactured by PCE Group, a TSI 5825 differential micromanometer manufactured by TSI Instruments Ltd with Pitot-Prandtl probes, and PeakTech 5135 digital thermometers manufactured by PeakTech with K-type thermocouples.

The measuring planes behind the electrostatic precipitator on both units consist of two square flue gas channels with internal dimensions of 4×4 m. The measuring planes on unit 1 have five measuring openings, while those on unit 2 have four. On both units, the measuring planes are located on the vertical sections of the channels. The measuring planes on the ducts are at a height of 90 m, and the cross-section is circular with an internal diameter of 6.7 m. The measuring openings, the ratios of the highest and lowest velocities, and the angle of the flue gas flow comply with the requirements of EN 15259.

3. RESULTS AND DISCUSSION

In recent years, several tests have been carried out upstream and downstream of the desulphurisation plant. Figure 2 show the results of tests from the previous three years. For each investigation of gaseous chlorine compounds, three sampling operations and laboratory analyses were carried out.

The mass concentration of HCl in the flue gas upstream of the desulphurisation plant ranged from 6 to 25 mg/Nm³ at standard conditions of $p = 101325$ Pa, $T = 273.15$ K and oxygen content of $O_2 = 6\%$, corresponding to an HCl emission to air of 9 to 35 kg/h [2-7].

The measured mass concentration of HCl in the flue gas in the duct, downstream of the desulphurisation plant, was below the lower limit of the method according to EN 1911, i.e. less than 1 mg/Nm³ at standard conditions of $p = 101325 \text{ Pa}$, $T = 273.15 \text{ K}$ and oxygen content of $O_2 = 6\%$ [2-7]. This corresponds to an HCl emission to air of less than 1.3 kg/h, which is many times lower than the HCl concentration upstream of the desulphurisation plant.

Table 1. HCl mass concentration in the flue gas and emission into air upstream and downstream of the desulphurization plant

	Year	Unit 1 - upstream			Unit 2 - upstream		
HCl [mg/Nm ³]	2023	6.3	7.4	6.1	6.4	7.0	6.8
HCl [kg/h]	2023	9.4	11.3	9.2	9.2	9.9	9.5
HCl [mg/Nm ³]	2024	25.1	18.5	19.8	18.6	23.0	21.1
HCl [kg/h]	2024	35.3	26.0	27.7	24.3	30.2	27.4
HCl [mg/Nm ³]	2025	12.2	11.4	13.6	10.7	13.5	11.2
HCl [kg/h]	2025	16.5	14.9	18.3	14.1	17.5	14.6
		Unit 1 - downstream			Unit 2 - downstream		
HCl [mg/Nm ³]	2023	< 1	< 1	< 1	< 1	< 1	< 1
HCl [kg/h]	2023	< 1.27	< 1.24	< 1.21	< 1.18	< 1.19	< 1.17
HCl [mg/Nm ³]	2024	< 1	< 1	< 1	< 1	< 1	< 1
HCl [kg/h]	2024	< 1.24	< 1.21	< 1.23	< 1.27	< 1.33	< 1.33
HCl [mg/Nm ³]	2025	< 1	< 1	< 1	< 1	< 1	< 1
HCl [kg/h]	2025	< 1.16	< 1.10	< 1.10	< 1.16	< 1.13	< 1.11

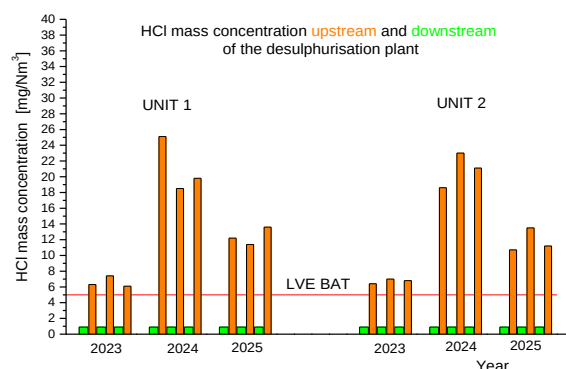


Figure 2. Mass concentrations of HCl in flue gas at units 1 and 2 of the thermal power plant

Limit values for chloride emissions expressed as HCl into the air from stationary pollution sources, the ducts of units 1 and 2, are defined in the Best Available Techniques (BAT) Reference Document for Large Combustion Plants, Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control), February 2017, and in COMMISSION IMPLEMENTING DECISION (EU) 2021/2326 of 30 November 2021 establishing best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council for large combustion plants, Chapter 10, Part 10.1.2, BAT 4. The emission levels to air according to the best available techniques (BAT) for the combustion of coal and/or lignite for existing plants with a total thermal input of more than 100 MW_{th} for HCl is < 5 mg/Nm³. The measured gaseous HCl emission levels are below the prescribed limits.

4. CONCLUSION

The modernisation of the old production units in the thermal power plant and the construction of the desulphurisation plant have significantly reduced pollutant emissions into the air. In the example presented in the paper, in addition to the reduction in sulphur oxide emissions, there was a substantial reduction in chlorine compounds expressed as HCl, which can be more than 20 times lower than if the production unit of the thermal power plant operated without a desulphurisation plant. The levels of HCl emitted into the air are below the prescribed limit values according to the best available techniques (BAT) for the combustion of coal and/or lignite in existing large thermal power plants.

As a result, electricity generation from thermal power plants remains competitive with other energy sources because the price of electricity is lower, while environmental protection has improved significantly compared with the period when thermal power plants operated without modernisation of existing generating units and flue gas desulphurisation plants.

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