Actual issues of introduction of continuous emission monitoring systems for control of negative impact of TPP to atmospheric air

O E Kondrateva¹, P V Roslyakov¹, A M Borovkova¹, O A Loktionov¹
¹National Research University "MPEI", Moscow, Russia

KondratyevaOYe@mpei.ru

Abstract. Over the past 3 years there have been significant changes in Russian environmental legislation related to the transition to technological regulation based on the principles of the best available technologies (BAT). These changes also imply control and accounting of the harmful impact of industrial enterprises on the environment. Therefore, a mandatory requirement for equipping automatic continuous emission monitoring systems (ACEMS) is established for all large TPPs. For a successful practical solution of the problem of introducing such systems in the whole country there is an urgent need to develop the governing regulatory document for the design and operation of systems for continuous monitoring of TPP emissions into the air, allowing within reasonable limits to unify these systems for their work with the state data fund of state environmental monitoring and make easier the process of their implementation at operating facilities for industrial enterprises. Based on the large amount of research in the field of creation of ACEMS, which conducted in National Research University "MPEI", a draft guidance document was developed, which includes the following regulatory provisions: goals and objectives of ACEMS, the stages of their introduction rules of carrying out preliminary inspection of energy facilities, requirements to develop technical specifications, general requirements for the operation of ACEMS, requirements to the structure and elements of ACEMS, recommendations on selection of places of measuring equipment installation, rules for execution, commissioning and acceptance testing, continuous measurement method, method for determination of the current gross and specific emissions. The draft guidance document, developed by the National Research University "MPEI", formed the basis of the Preliminary national standards PNST 187-2017 "Automatic systems for continuous control and metering of contaminants emissions from thermal electric power stations into the atmospheric air. General requirements". [1]

1. Introduction
High level of the anthropogenic impact on the environment in the Russian Federation and considerable negative environmental consequences of past economic activities identified the acute need for urgent changes in the approach to ensuring the quality of the environment and safeguarding the health of the population. For the past three years, Russia has developed and introduced new environmental legislation and the numerous environmentally oriented normative-legal acts, introducing new management arrangements for environmental protection.

From January 1, 2015 the Federal Law №219-FL of 21.07.2014 [2] entered into force, determining the mechanisms of transition to technological norming on the principles of best available technologies (BAT), one of which is mandatory equipment of all major large thermal power plants by automatic
continuous emission monitoring system (ACEMS). And, if in Europe and the US ACEMS has long been widely used at industrial enterprises, in Russia, according to experts, currently only some elements of such systems are used by no more than 25% of TPP.

The development and implementation of ACEMS is a complex technical task, which includes the choice and installation of measuring systems, methods and means of fixing, processing and transmitting information, as well as ensuring the reliability of measurements, etc. It is necessary to have a document regulating the process of creating ACEMS to solve this problem. Besides, the expediency of unifying such systems is obvious, for working with the state fund of state ecological monitoring data and developing standard solutions that greatly simplifies the process of their implementation at operating facilities.

Based on the large amount of research in the ACEMS creation field, conducted in the National Research University "MPEI", the draft guidance document was developed, including a set of organizational, methodological and technical provisions aimed at the development and implementation of such systems.

2. Main provisions

The implementation of ACEMS at TPP is conditioned by the need to comply with the requirements of environmental legislation, therefore, the main purpose of ACEMS implementing at power facilities is reduction the negative impact of thermal power plants on the environment by ensuring continuous monitoring of harmful emissions into the atmosphere and organizing targeted activities to reduce these emissions.

Therefore, the main tasks of continuous emission monitoring system are:
- direct continuous instrumental measurement with a required accuracy of the concentrations of pollutants in the flue gas of TPP;
- receiving information about the actual mass emissions of these pollutants into the atmospheric air from stationary air pollution sources and transfer information about the mass of emissions to the state data fund of state environmental monitoring.

In the developed draft of regulatory document for Russia was proposed to extend the list of the main objectives of the designed system in comparison with the international experience and include, in addition to the tasks of control and accounting of pollutant emissions into the atmosphere and prepare environmental reports, also the task of monitoring the technological parameters for optimization of burning processes and increase environmental safety and economic efficiency of equipment resulting from the ACEMS introduction.

One of the most difficult task, solution of which needed when ACEMS creating, is the choice of measurement systems. The classification of modern methods of gas analysis is proposed by authors (Figure 1) for identification the most promising methods for ACEMS. The analysis of the main technical characteristics of modern gas analysis methods showed, that for the purposes of control and accounting pollutant emissions can be used chromatography, magnetic, electrochemical and optical methods. Besides, the most promising is the use of optical gas analyzers. For the purposes of controlling and optimizing the combustion process can be applied the thermal, ionization and semiconductor methods. The use of electrochemical methods is possible, if necessary, for the reducing the cost of gas analysis equipment. For measuring particulate matter emissions it is recommended the use of optical gas analyzers, in basis of which lies molecular spectroscopy and fluorescent methods.

A distinctive feature draft guidance document for the ACEMS introduction, developed in the National Research University "MPEI", from similar documents in other countries, for example from the TKP 17.13-01-2008 [3], which introduced in 2008 in Belarus, is the presence of a considerable amount of technical recommendations. The recommendations are developed taking into account the results of the analysis of measuring equipment presented on the Russian market, and review of recently adopted regulatory legal acts providing implementation of the main Russian Federal laws for control air pollution.
Figure 1. Classification of gas analysis methods.

For control and regulation modes of fuel burning in the combustion chamber is recommended the installation of sampling measuring systems. For continuous automatic emission control, appropriate to use non-sampling gas analyzers that are installed directly to the chimney or flue, the main advantages of which are: the best metrological characteristics and the absence of additional errors associated with extracting, transporting, and changes in the sample of gas.

Systematization and generalization of research results on conversion of combustion products in the flue gas of boilers and the irregularity of their concentration fields [4-6] allowed to formulate practical recommendations for the installation of measuring systems to monitor and record emissions of TPP such as:

- the combined installation of individual measuring systems in the boilers to control and setup the environmentally friendly operating modes, and in the chimney to account for total mass emissions from all connected boilers;
- the installation of measuring systems in the chimney at a minimum distance of 14 equivalent diameters from the last disturbance of the flue-gas flow for accurate metering of gross emissions of thermal power plants into the atmosphere, provided that the concentration of controlled substances in the inlet flue gas do not differ more than ±20% from their calculated average value;
- the installation of two multi-point probes the entire depth of the duct in the centers of each side to account of uneven concentration fields in depth and width of the duct in the restricted regime section;
- the use of single sampling averaging probes in control sections behind the boiler, which are recommended to be installed in the middle of the smaller side of the flue to the full depth of the larger side.

One of the most acute issues that triggered numerous disputes and discussions with representatives of the biggest energy companies and Russia's leading metrologists, was the question of the permissible error of ACEMS measurement.
In accordance with the standard STO 70238424.27.100.078-2009 "Instrumentation and thermal automation systems TPP. Terms of creation. Norms and requirements" [7] the permissible relative error of instrumental measurements should not exceed:
- for concentrations of O₂, CO, NOₓ, SO₂ - ± 10%;
- for the concentration of solids - ± 25%;
- for flue gas velocity - ± 10%.

It should be noted that there is no normative value for measuring the mass yield of gaseous components in this document.

Thus, in accordance with the Information-technical directory on best available techniques in ITS 22.1-2016 "The General principles of industrial environmental control and metrological assurance" [8] specifies the possible range of values of maximum permissible relative error of measurement of the concentration of organic and inorganic substances in industrial emissions into the atmosphere, constituting from 8 to 25%.

Further, this range of values is specified (table 1):

| Designated component | Measurement range (mg/m³) | Limits of permissible basic error |
|----------------------|----------------------------|----------------------------------|
| CO                   | 0 – 75                     | ± 5 mг/м³ (abs.)                  |
|                      | 75 – 1000                  | ± 5 % (rel.)                     |
| NO                   | 0 – 50                     | ± 5 % (rel.)                     |
|                      | 50 – 1000                  | ± 10 % (rel.)                    |
| NO₂                  | 80 – 200                   | ± 5 % (rel.)                     |
|                      | 100 – 1000                 | ± 10 % (rel.)                    |
| SO₂                  | 0 – 100                    | ± 10 % (rel.)                    |
|                      | 100 – 1000                 | ± 10 % (rel.)                    |
| Particulate matter (dust) | 20 – 100 000             | ± 20 % (rel.)                    |

But, because ITS 22.1-2016 has the status of an advisory document, the main legal act regulated the allowable value of measurement error for ACEMS at the moment is The Order of the Ministry of 07.12.2012 N.425 [9], which indicates the range of maximum permissible error of measurement of mass concentration in industrial emissions: from 8 to 25 %

Accordingly, the draft guidance document normative values of permissible relative error of instrumental measurements are:
- for concentrations of O₂, CO, NOₓ, SO₂ ±10%
- for particulate – ± 25 %
- for the speed of the flue gases ± 10 %
- for mass emissions of gaseous components ±25%.

Figure 2 [10] shows the creation and implementation stages of ACEMS TPP, which are described in detail in the proposed draft regulatory document. One of the most difficult and labor-intensive stages for the enterprise is the stage of drafting the technical specifications. To facilitate this step for the
personnel of TPP in the proposed draft guidance document included requirements to develop technical specifications. Also, for the preliminary survey at the stage of the pre-design works, a sample questionnaire is included in the annex to the guidance document, which should include at least three groups of information: characteristics of pollution sources, information about existing boiler and gas turbine/combined cycle plants, information on contaminants (marker substances) ejected into the atmosphere.

**Figure 2.** Creation stages of ACEMS. [10]

The main provisions, included in the draft unified guidance document for the development and operation of ACEMS presented in figure 3.
Conclusion
The draft guidance document, developed by the National Research University "MPEI", formed the basis of the Preliminary national standards PNST 187-2017 "Automatic systems for continuous control and metering of contaminants emissions from thermal electric power stations into air. General requirements", approved by the Order of Rosstandart №2-PNST from 25.04.2017. This regulatory document is the first Russian preliminary national standard in the field of automatic control systems of industrial emissions and shall come into force from January 1, 2018.

References
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