Prospects for the development of means for measuring the mass concentration of aerosol particles in the Russian Federation

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Abstract. The paper describes the state of affairs in the field of ensuring the uniformity of measurements of the mass concentration of aerosol particles in the Russian Federation. The definition of indicative measurements is given and the world experience in the use of indicators in environmental monitoring networks is described. The necessity of adopting relevant regulatory documents in the Russian Federation in order to introduce the concept of "indicative measurements" is shown.

1. Introduction

A special place in the field of ambient air quality monitoring is occupied by the aerosol particles mass concentration measurements, including the size fractions PM-2.5, PM-10 (PM-2.5, PM-10- particulate matter with size smaller than 2.5 and 10 μm, respectively). In accordance with the regulatory documentation in Russia, measurements of the mass concentration of particles should be carried out with a relative error of no more than 25 %.

To solve this problem, expensive equipment is used, which does not allow creating a chain for monitoring the quality of atmospheric air. In this regard, low-cost particle sensors are gaining popularity; however, their metrological characteristics do not meet the existing requirements.

It is proposed to introduce the concept of "indicative measurements" with a larger relative error to expand the monitoring chain and obtain a general assessment of the state of ambient air quality in cities. This practice already exists on the territory of the European Union and is reflected in the EC Directive 50 [1]. The extended uncertainty of such measurements reaches 50 %.

2. Aerosol particles concentration measurements

Aerosol particle concentration refers to the quantitative ratio of the dispersed phase and the dispersion medium. According to its value, sanitary standards for the content of specific dust are established, as well as methods of dust capture and devices are selected to reduce the dustiness of air in working areas and organized emissions.

Depending on the measurement method used, number and mass particle concentrations are distinguished.

The number concentration shows how many aerosol particles are contained in a unit of air volume (cm³). In general, this means the concentration of particles, regardless of their shape, size and chemical composition.

To characterize the purity of the air, the term "dustiness of the air" is usually used, which means the mass concentration of aerosol particles (g or mg per 1 m³ of air under normal conditions).
Currently, the main method of controlling the dustiness of the air of working areas and organized emissions is gravimetric. This method is based on filtering dusty air through a particular filter, followed by a weight determination of the amount of dust caught. The disadvantages of the method are low productivity, the need to take into account the speed of air movement, its pulsation; the accuracy of the results depends on the quality of the filter and the qualifications of the researcher.

Indirect methods are based on the use of various physical phenomena, the parameters of which vary depending on the concentration of dust in the studied air. The advantages of indirect methods are high productivity, ease of measurement. Disadvantages are the complexity of the design and the high cost of the devices.

To control the dustiness of working areas and organized emissions, the optical method is most widely used, which is characterized by greater measurement accuracy and high sensitivity. Other, less common methods of measuring the mass concentration of dust are charge-contact, radioisotope, piezoelectric and capacitive methods.

Acoustic, induction and other methods based on water dust capture have not been widely used due to low measurement accuracy, bulkiness and high cost.

3. State regulation of particles mass concentration measurements in Russia
State regulation in the field of measurements of aerosol particles mass concentration in the air of populated areas in Russia today is represented by two main documents [2-3]:

- Resolution of the Government of the Russian Federation No. 1847 "On approval of the list of measurements related to the sphere of state regulation of ensuring the uniformity of measurements".
- SanPiN 1.2.3685-21 "Hygienic standards and requirements for ensuring the safety and (or) harmlessness of environmental factors for humans".

In accordance with these documents, the measurement error of the equipment should not exceed 25% for the mass concentration of particle's fractions PM-10, PM-2.5 measurements. At the moment, amendments have been made to the regulatory documentation in order to ensure the control of the fraction PM-1, which is the most dangerous for people due to the small size of particles that penetrate the body and spread with blood flow, causing respiratory, and in some cases oncological diseases.

In large cities, monitoring of the atmospheric air is carried out by specialized organizations that use stationary and mobile air quality control posts, the metrological characteristics of which meet the requirements of existing regulatory documentation [2-3].

In order to improve the quality of air control, these organizations use measuring instruments with metrological characteristics that do not meet the specified requirements on an initiative basis as indicators. Due to the lower cost, the use of designated measuring instruments make it possible to create developed monitoring network.

One of the prospects for the development of measuring instruments for the mass concentration of aerosol particles in Russia is the introduction of the concept of indicative measurements based on the experience set out in EC Directive No. 50 of 2008.

4. Conclusions
The main prospect for the development of means for measuring the mass concentration of aerosol particles in the Russian Federation is the introduction of the concept of indicative measurements and the use of such equipment in atmospheric air monitoring networks on a par with high-precision measuring instruments.
5. References

[1] Council Directive 2009/50/EC of 25 May 2009 on the conditions of entry and residence of third-country nationals for the purposes of highly qualified employment

[2] Resolution of the Government of the Russian Federation of 16.11.2020 No. 1847 "On approval of the list of measurements related to the sphere of state regulation of ensuring the uniformity of measurements" (in Russian)

[3] SanPiN 1.2.3685-21 "Hygienic standards and requirements for ensuring the safety and (or) harmlessness of environmental factors for humans" (in Russian)