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NONSTANDARD MEASUREMENT OF A DUSTY AEROSOL

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This paper deals with an effect of the modified discrete sampling air at a non-standard measurement of aerosol particles, when it is used for measurement of suspended particulate matter by Czech Hydrometeorological Institute. In the paper is an explaination of very non-standard measurements and practical measurement.
Key words: nonstandard measurement, dusty aerosol, air.

Nestandardno mjerenje čestične tvari. Ovaj rad se bavi djelovanjem modificiranog diskretnog uzorkovanja zraka na nestandardno mjerenje čestične tvari koje se koristi za mjerenje lebdećih čestica u Češkom hidrometeorološkom zavodu. U radu je objašnjeno vrlo nestandardno i praktično mjerenje.
Ključne riječi: nestandardno mjerenje, čestične tvari, zrak.

INTRODUCTION

Suspended particulate matter is one of the pollutants in the air. In the Czech Republic, there is due to the local air quality the most serious problem of exceeding the emission limits and threat to public health every year. Therefore, great emphasis is put on imission monitoring of suspended particulate matter. This paper deals with effect of the modified disrete sampling air at a non-standard measurement of aerosol particles, which is used to measurement of suspended particulate matter (when standard measurement is the stationary one).

NON-STANDARD MEASUREMENT OF SUSPENDED PARTICULATE MATTER

Measurements are carried out not only through standard network of measuring stations, but also using aircraft or automobile. This makes it possible to perform measurements virtually anywhere and within a short time. Measurements on mobile means of transport may also bring negatives. For technical reasons it is not possible to take an air sample to be analyzed directly into the analyzer, as in the case of stationary measurements. Measured sample of air must be acquired at some distance from the analyzer - sampling is under the wing of the aircraft or on the car roof, while the analyzer is placed inside the aircraft or automobile. The impact of sampling route is also brought to the measurement. In practice (when Czech Hydrometeorological Institute measurements by analyzer GRIMM 1.109) as the sampling line uses a steel tube with a diameter of 3 mm of different length and curvatures as needed, provided with the sampling probe. The particles are then accumulating and the efficiency of particle transport to the analyzer is reduced. [1]

The effect of sampling route on the measurement results of suspended particulate matter

Sampling route efficiency is affected by gravitational force acting on particles, inertia force in bends and narrowings of trails, electrostatic force, diffusion of particles, thermoforesis and turbulent environment. Total efficiency of sampling route is the sum of the efficiencies of above mentioned effects. As regards the particle size, the efficiency decreases with increasing particle size due to the influence of gravitational force, diffusion and inertioal forces in bends route. If the air flow velocity increases, the effiency is increased due to gravity and diffusion and decreases due the influence of inertia force in bends route. [2]

Comparative measurement of standard and of modified sampling

Two devices GRIMM1109 were used for the measurement. The device No.1 was used as an etalon, and during the entire measurementwas connected to a sampling route in the shape of a rectangular knee in lengthof 35 cm and diameter of the bend 15 cm. The device No.2 was connected to different sampling points in accordance the measurement. Sampling routes were made by steel tubes (inner diametr 3 mm), which are used by Czech Hydrometeorological Institute in practice.

Both devices GRIMM 1109 were set at a normal mode of data storage, with a 1-minute increments. Measurement of the influence of the sampling routes conducted for 20 hours at each connection, there is for each route 1,200 values in each particle size fraction. The first two hours of measurement were in the air entering the ventilator added aerosol particles in the form of dust from vacuum cleaners, sprays and smoke from blown out tea candles, and the remaining 18 hours was measured circulating air in a room with no outside interference. In determining the influence of the sampling probe were measured 9 combinations of setting the probe and air speed, each of these measurements was carried for 1 hour. Within one hour every 10 minutes were added to the air entering the ventilator aerosol particles in the form of dust from the vacuum cleaner. There were obtained 60 values in each combination of setting the probe and air speed.

Sets of measured data from both devices were time-aligned for each measured involvement. Exclusion of incompletely described objects was used for matching temporal moments when at least one of the data files was missing or incorrect (i.e. equal to-1). In the case values of zero were measured by one of the devices, were excluded only incomplete pairs.

Due to the intermittent addition of relatively large amounts of aerosol particles there was a significant fluctuation of pairs of data measured by both devices at these moments. This was apparent from the correlations for the files with all data and correlations for files which have been excluded because of very extreme values. Extreme values were defined as ten times the median. Exclusion due to the extreme values then was applied to the pair of data.

From these adjusted data each size fraction calculated averages $\overline{\mathbf{X_1}}$ (for unit No.1), $\overline{\mathbf{X_2}}$ (for unitNo.2) and the sampling route efficiency$\boldsymbol{\eta}$ was determined by the equation (1).

$$\eta = \frac{\overline{X_2}}{\overline{X_1}} \qquad (1)$$

Evaluation of the comparative measurement

Measurement of the influence of the sampling routes confirmed theoretical relationships, under which should be measured smaller efficiency of sampling routes for the larger particles. For etalon knee equal to 30 cm shoulder was a decrease for particles larger than 2 mm, the loop equal to 30 cm armand 3 m long flat shoulder was a decrease for particles larger than 6.5 microns. Efficiency of sampling route in the implementation of long straight tube was relatively high. If there are any bends in the sampling route (knee, loop), then by the carried measurement the measurement efficiency decreases to the values, when will any data correction be very inaccurate. (Figure 1)

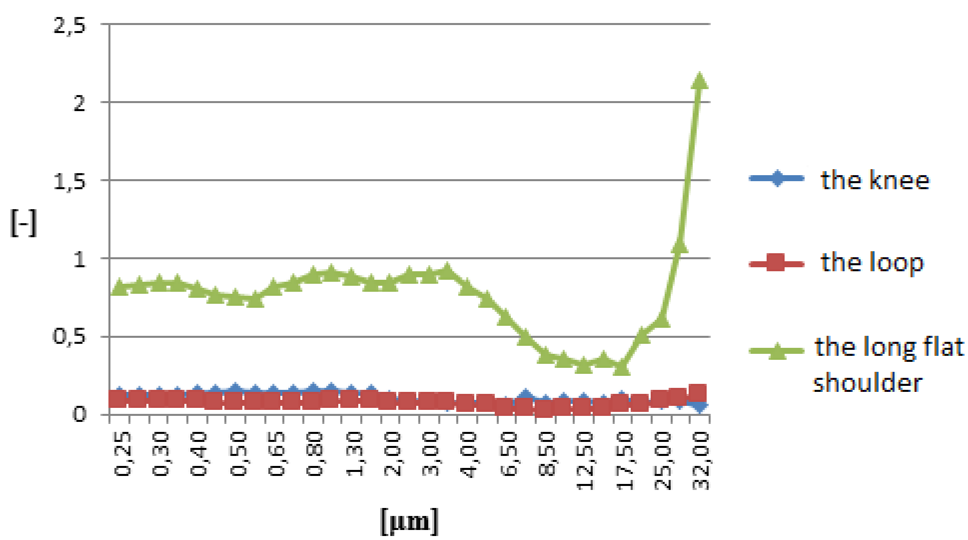

Figure 1. The influence of the sampling route
Slika 1. Utjecaj načina uzorkovanja

According to the carried out measurements is the efficiency of the samplilng route even lower when using a sampling probe. This may be caused by conical tip of the probe, which reduces the aerodynamic drag and thus the particles are entrained by air flowing around the probe. Significant appears to be again size fraction of 2 and 6.5 micron, for which there is an increase of efficiency.

Figure 2 shows the measured efficiency influenced by the sampling probe for various combinations of air velocity and probe setting. Measurements did not prove the influence of any probe setting or air velocity on measurement results. The efficiency influenced by sampling probe is very low – for particles of 6.5 micron reaches the values from 0.001 to 0.05, for larger particles, the efficiency increases up to the value above 0.2.

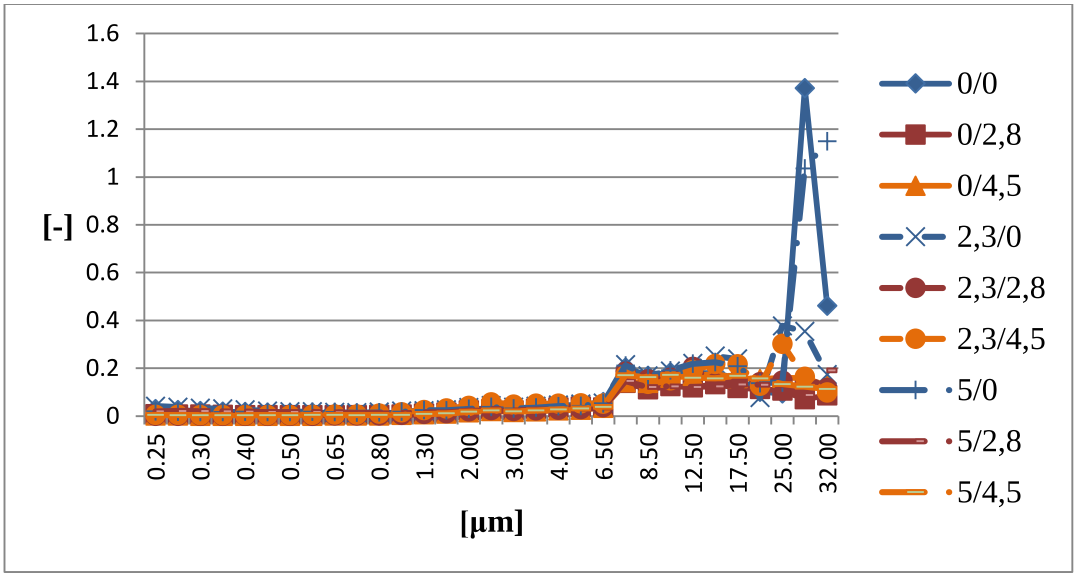

Figure 2. Effect of sampling parameters
Slika 2. Utjecaj parametara uzorkovanja

The significant increase in efficiency (above the value of 1 - the value of the physical principle incorrect) for larger particle size is probably due to insufficient amount of data for these fractions - for this reason, the measurements of this particle size have not sufficiently explanatory value. Considering the number of data obtained in the individual fractions can be regarded as relevant to the results of measurement of particles of 6.5 micron size.

CONCLUSION

The curve of as certained efficiencies of the sampling route and the sampling probe thus correspond to theoretical expectations, but are striking in terms of achieved values. It thus is advisable to further investigate the problem either further measurements or theoretical modeling of the behavior of particles. It should be noted that the measurements were carried out for air velocity 2.8 m/s, but the speed when measuring by car or plane reaches much higher values, which should increase the efficiency of the sampling route influenced by gravity and diffusion (conversely the efficiency of bends on the sampling route will decrease even more). In practice, it would be advisable to avoid as many bends at the sampling route.

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