

TARTU ÜLIKOOLI TOIMETISED  
ACTA ET COMMENTATIONES UNIVERSITATIS TARTUENSIS

Alustatud 1893.a. VIHIK 947

AIR IONS  
AND  
ELECTRICAL  
AEROSOL ANALYSIS

TARTU 1992

## ELECTRICAL PARAMETERS OF AIR POLLUTION

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### Electrical parameters of the air

In the theory of electrical conductivity of the air, the electrical condition of the air is described by means of the distribution function or the spectrum of charge density by air ion mobility. The distribution function can be perfectly described only through an infinite table of values. Full determination of a function by measurement is impossible.

In practical measurements we are to be satisfied with a finite-dimensional description of the electrical condition of the air. Sophisticated equipment used for laboratory investigations makes it possible to measure partial charge densities for about ten mobility fractions. In ordinary geophysical observations it is possible to measure only few integral parameters.

A question arises as to which integral air electricity parameters should be measured. Below it will be assumed that the parameters to be measured are to:

- 1) give a maximum information useful in applications,
- 2) measurable with simple and reliable equipment.

### Factors of the electrical condition of the air

The average time of existence of a small air ion is only about one minute. Therefore the electrical condition of the air is in a dynamic balance and depends on some primary factors. The main factors are:

- 1) ionizing radiation,
- 2) aerosol composition of the air.

The electrical condition of the air is somewhat dependent on the chemical composition of its gaseous phase. This, however, is reflected only in fine effects and will not be considered below.

The primary factors of the electrical condition of the air are directly connected with air pollution, and therefore the electrical condition of the air can be considered as a pollution indicator. This points to an important application of air electricity measurements and is to be taken into account already in the stage of the determination of the main integral electrical parameters of the air.

### Small air ions

Small air ions make up an isolated group in the air ion mobility spectrum. Due to their high mobility they determine the main part of the conductivity of the air. The measurement of small air ions is easier than the measurement of other fractions in the air ion mobility spectrum.

Above the zone of the ground-layer electrode effect the concentrations of negative and positive air ions are nearly equal. Small air ions have relatively stable average mobilities and the concentrations of small air ions are in a nearly functional manner connected with the polar conductivities of the air.

Let us assume that the concentration of both negative and positive small air ions is  $n$ . Then the rate of small air ion loss on the account of recombination is  $an^2$  where  $a$  is the relatively stable coefficient of recombination. The rate of small air ion loss on the account of collisions with neutral and charged aerosol particles is  $gn$ , where the coefficient of adsorption  $g$  depends only on the aerosol composition of the air. As a rule  $gn$  is considerably larger than  $an^2$ . If ionizing radiations generate small air ions with the rate  $q$ , then

$$\frac{dn}{dt} = q(t) - an^2 - gn. \quad (1)$$

This differential equation determines the function  $n(t)$ . The solution of the equation depends on the function  $q(t)$  and on the coefficient  $g$ . If the ion generation is constant, the balance  $q = an^2 + gn$  is obtained.

### The ionization rate

The ionization rate is determined by the intensity of ionizing radiations. A part of air ions, usually 10-20%, are generated by cosmic radiation, the rest are generated by radioactivity. As cosmic radiation is a stable factor, the ionization rate can be considered as an integral characteristic of radioactive pollution of the environment.

The traditional measurement unit of the ionization rate 1J means that one pair of elementary charges is formed in 1 s in 1 cm<sup>3</sup>. The unit in SI is 1 A/m<sup>3</sup> = 8.24 · 10<sup>12</sup> J. As a practical unit 1 pA/m<sup>3</sup> is acceptable.

The ionization rate is the first integral air electricity

parameter that can be considered as an indicator of atmospheric pollution.

#### Aerosol electrical density

Integral aerosol density is defined by the equation

$$v_p = \int p(r)f(r)dr, \quad (2)$$

where  $f(r)dr$  is the numeric density or the concentration of aerosol particles with radii from  $r$  to  $r+dr$ , and  $p(r)$  is the weight function. When  $p(r)=1$  we get the numeric density, when  $p(r) = r^2$  - the surface density, when  $p(r) = r^3$  - the volume density. A special weight function in equation (2) describes the optical density of aerosol. It is possible to determine a special weight function so that  $v_p = g$ . Therefore the adsorption coefficient of small air ions  $g$  can be considered as aerosol electrical density.

In comparison with other integral parameters, aerosol electrical density more completely characterizes the effect of aerosol in electrical processes. Supposedly, aerosol electrical density is correlated with the effect of aerosol in some other processes. The range of application of the concept of aerosol electrical density expands over the limits of specific electrical phenomena.

The measurement unit of aerosol electrical density is  $s^{-1}$ . Aerosol electrical density is the second integral air electricity parameter that can be considered as a characteristic of atmospheric pollution.

#### Measurement methods

The classical method of ionization rate measurement by means of an ionization chamber does not make it possible to create a simple and reliable measurement equipment. It is evident that for this reason in the practice of atmospheric electricity research the ionization rate is dealt with relatively seldom.

Equation (1) points to a possibility of simultaneous measurement of ionization rate and aerosol electrical density using a simple device - a counter of small air ions. For this purpose the counter is to be supplemented by a generator of small air ions having a reasonable constant ionization rate.

The concentration of small air ions  $n_1$  is measured at a switched-off and  $n_2$  at a switched-on air ion generator. Both

measured variables are dependent on the arguments  $q$  and  $g$ :

$$\begin{aligned} n_1 &= f_1(q, g) \\ n_2 &= f_2(q, g) \end{aligned} \quad (3)$$

The parameters of the air ion generator are taken into account in the expression of the function  $f_2$ . The system of equations (3) is solved in relation to the unknown members  $q$  and  $g$ . The function  $f_2$  is weakly dependent on the argument  $q$ . This ensures a well-conditioned system of equations and quick convergence of the iterations by numerical solution.

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Translated from:

Таммет Х.Ф. Электрические параметры загрязненности воздуха  
// Уч. зап. Тарт. ун-та. - 1977. - Вып. 443. - С. 48-51.