Measurement report

no. 201015/01

Test of potential release of the copper material from respirators delivered by Respilon

Supplier: ICPF CAS, v.v.i., Laboratory of Aerosol Chemistry and Physics

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In Prague, 15.10. 2020

Aim of the measurement

Based on the request of Respilon company 2 respirators of the same type were tested. The respirators were fitted on the head of manikin and tested for the potential release of the copper material from the respirator surface. The measurements were performed with the respirator sealed around the edge with a tape. The respirators were tested under the volumetric flow rate of 95 l/min – following the EN 149 standard.

Measurement set-up

The number size distribution in front and behind the tested respirator was measured using filter testing system developed in cooperation of ICPF CAS (Institute of Chemical Process Fundamentals of Czech Academy of Sciences) and NINCBP (National Institute for Nuclear, Chemical and Biological Protection). The simplified schematics of measurement apparatus can be seen on Fig. 1.

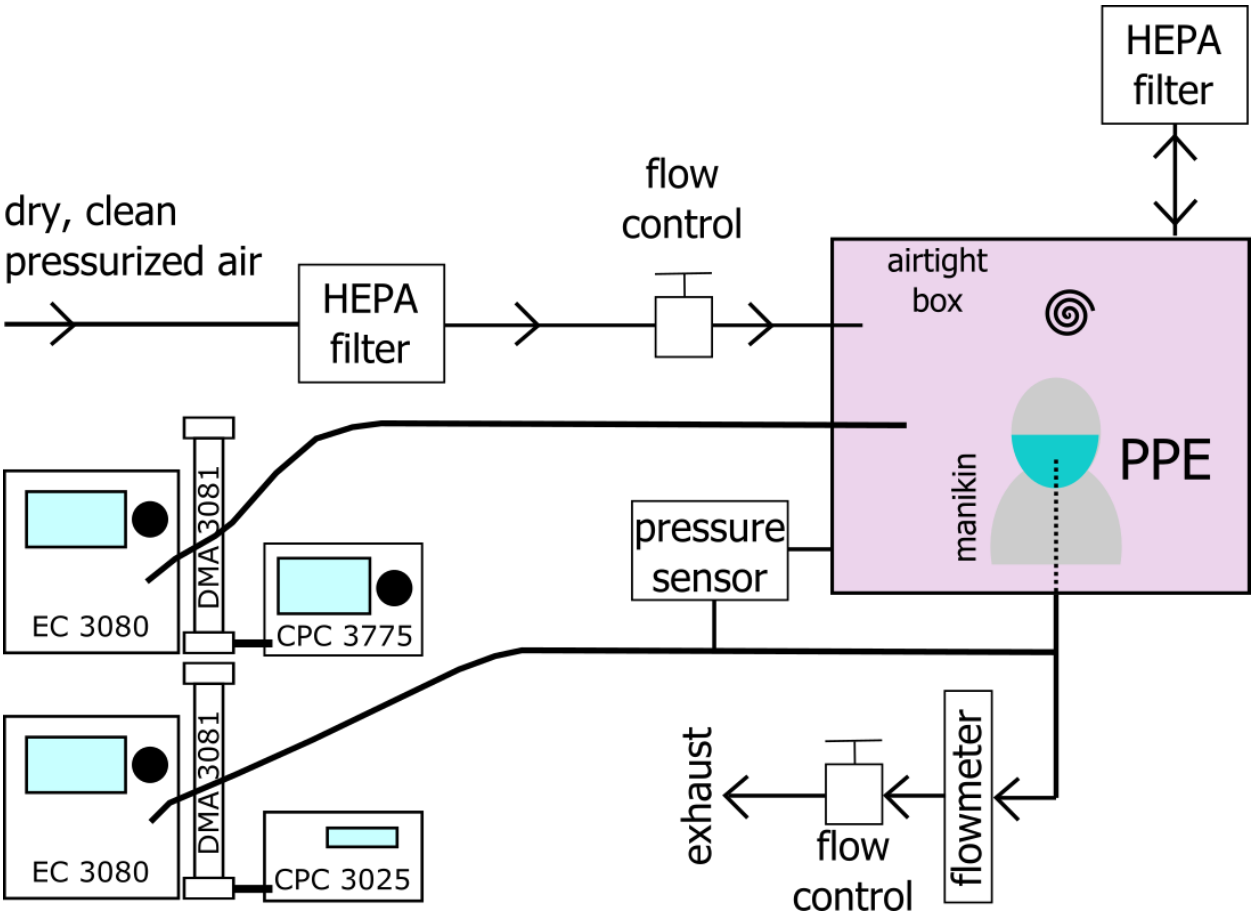

Fig. 1: *Schematics of measurement set-up. Clean, dry pressurized air enters the airtight testing box. The aerosol particle number size distribution is measured using set of two aerosol spectrometers SMPS, one sampling the aerosol in front and the second behind the respirator being*

tested. The measurement of pressure drop across the respirator allows for continuous monitoring of possible changes in the respirator properties and gives the information about the breathing resistance at the same time.

The measurement was conducted with the volumetric flow rate of 95 l/min (with corresponding face velocity of 10.6 cm/s), which corresponds to the increased breathing activity through the personal protective equipment (respirator/face mask with the surface area of 150 cm^2) of an adult during excercise. The testing box was cleaned from any aerosol particles in order to have zero concentration of aerosol particles in front of the tested respirator. The flow rate of clean dry air was controlled to compensate for the outgoing amount of the air being sampled through the head of the manikin. If any of the copper particles would be released from the material of the respirator, it would be detected in the sample taken behind the tested respirator. The respirator was exposed to the flow of clean air for several hours. The testing box was also connected to atmospheric pressure using the HEPA filter in order to prevent the over/under-pressurizing of the testing box. The tested respirator was fitted to the head of the manikin using a tape to seal the respirator on the head of manikin to prevent possible leakages. The aerosol particle number size distribution was monitored during the whole measurement using set of two aerosol spectrometers (SMPS). One spectrometer measured the particle size distribution outside of the respirator (in the volume of the airtight box) and the second one sampled from the line taking defined volumetric flow sucked by the mouth of the manikin through the tested respirator (allowing to take a sample behind/inside the tested respirator).

The changes in respirator material properties during the measurement were monitored by the measurement of pressure drop across the respirator, which gives an information about the breathing resistance at the same time. The description of the instruments used in the measurement set-up can be found in following paragraphs.

Tested materials

Two respirator of the same type RespiPro VK RPVK-L/M/S-000 were tested (see Fig. 2). The only difference between the two was a different production approach (resulting in slightly different color of the final product). The pressure drop during the measurement was monitored and the results are summarized in Tab. 1. The results are showed for respirator sealed to the face of the manikin.

***Tab. 1** Presure drop [Pa] over tested respirators with volumetric flow rate 95.0 l/min*

Material name	Volumetric flow rate [l/min]
	95.0
	Sealed
RespiPro VK RPVK-L/M/S-000 - light	140
RespiPro VK RPVK-L/M/S-000 - dark	150

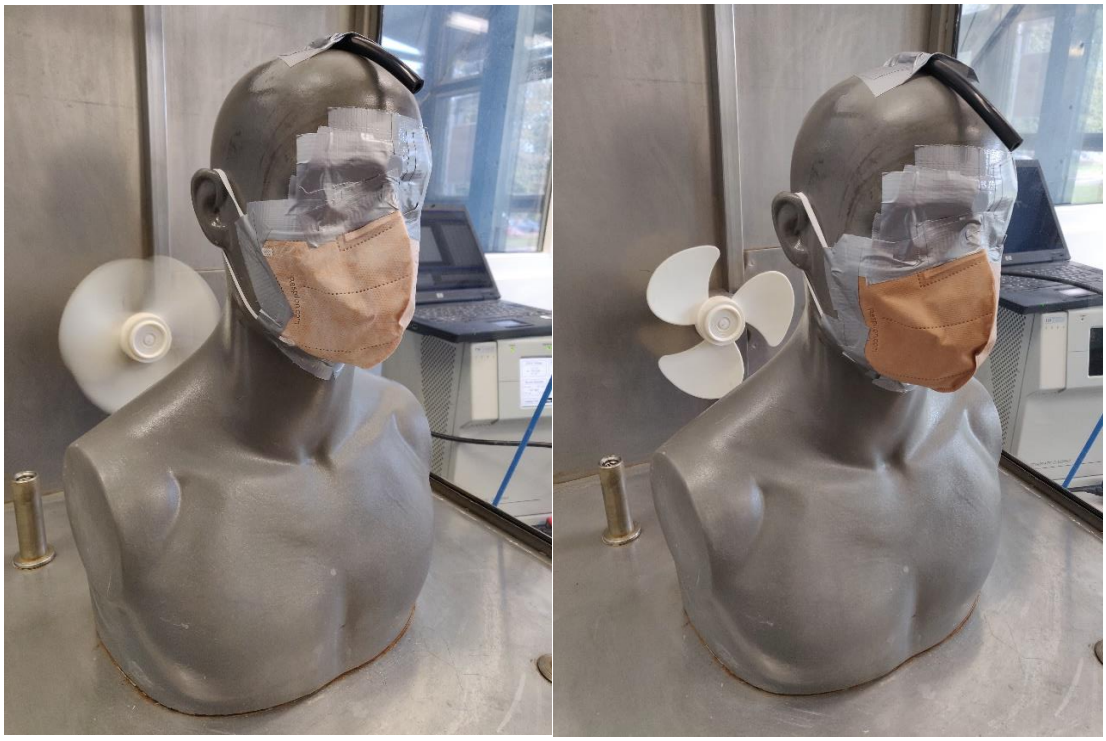

Fig.2 *Pictures of tested respirators RespiPro VK RPVK-L/M/S-000 – light and dark.*

The instrumentation

Scanning mobility particle sizer (SMPS)

Scanning mobility particle sizer (SMPS 3936NL, TSI, USA) enables to measure number concentration of aerosol particles and their size distribution in sub-micron size range (particles < 1 μm). The aerosol spectrometer consists of two parts:

1) the **electrostatic classifier** (EC model 3080, TSI, USA) gradually selects individual size fractions (with the resolution of 64 channels per decade) from the sampled, originally polydisperse, aerosol which is previously being brought to Boltzmann charge equilibria (by aerosol neutralizer) and being cut from the large particles (by inertial impaction). Dried polydisperse aerosol is in the electrostatic classifier charged in defined way (using ^{85}Kr) and afterwards individual size fractions of aerosol particles are selected (one by one depending on the set high voltage on the inner electrode of the DMA) in the electrostatic field based on their electrical mobility.
2) The monodisperse fraction of aerosol then continues to the **condensation particle counter** (CPC model 3775 and 3025, TSI, USA), where the number concentration of each fraction is measured. The individual particles undergo enlargement by condensation of n-butanol on their surface and the larger particles are then detected by otpical method (light scattering).

The size spectra are obtained after corrections for multiple charges, losses of particles inside the spectrometer due to Brownian diffusion, CPC counting efficiency and finally after the data inversion based on transfer functions for individual size bins.

The zero concentration test for both SMPS spectrometers was performed at the beginning of every measurement procedure. This test was based on sampling of clean air (without the aerosol generator running) from the testing box, which confirms that the whole apparatus is airtight and the measurement is not burdened with any leaks. When collocating both SMPS spectrometers, the results showed the difference between the two spectrometers lower than 10%. Nevertheless, in order to compensate for possible differences in detection efficiency of individual spectrometers, the parallel measurement of both aerosol spectrometers, without any PPE attached to the face of the manikin, was performed to estimate the size resolved correction factor between the two spectrometers prior to each measurement procedure.

Data treatment

The values of the number concentrations in individual size bins (the number size distribution) upstream and downstream of the respirator were measured using two aerosol spectrometers SMPS. Several hours of data were sampled by both SMPS spectrometers for each respirator in order to assure statistically correct results. The data were evaluated and the size distribution spectra plotted to observe potential releases of copper material from the tested respirator.

Measurement results

The results of testing of potential release of copper from respirators *RespiPro VK RPVK-L/M/S-000 – light* and *dark* are summarized in Fig. 3 and 4. Both graphs show the size distribution spectra measured by the SMPS spectrometer in front and behind of the tested respirator for several hours. As can be seen from both Figures, the concentration of aerosol particles in front of the respirator (inside the testing box) was zero during the whole observed periods (the small peaks are within the measurement uncertainty of both SMPS spectrometers). The same situation can be seen also for measurement behind both respirators, which means that no release of copper or other particles from the materials of both tested materials was observed.

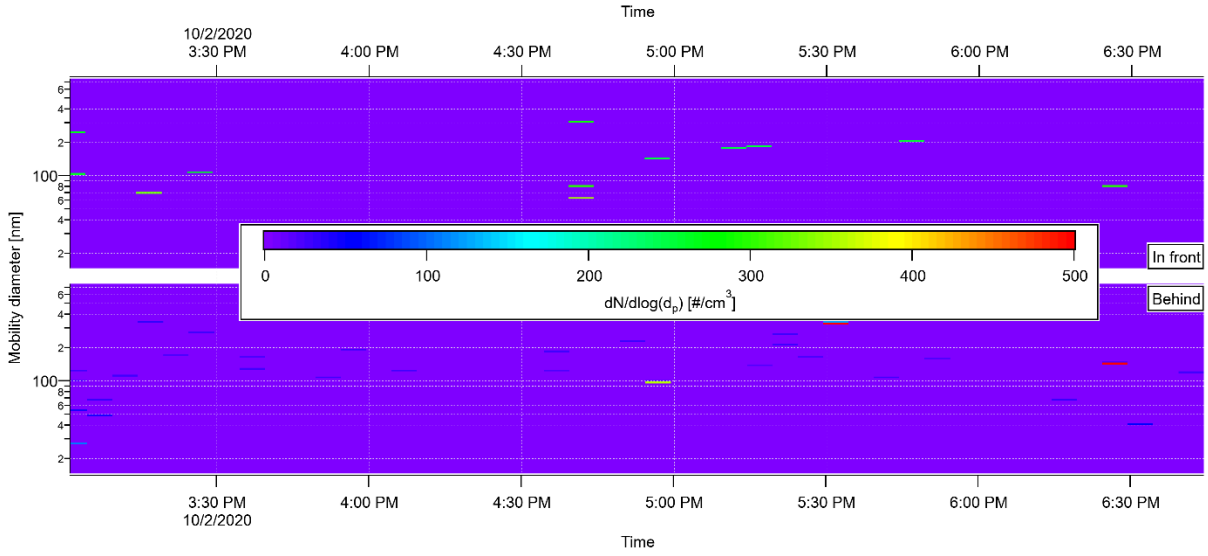

Fig.3 *Size distribution spectra measured in front and behind RespiPro VK RPVK-L/M/S-000 - light.*

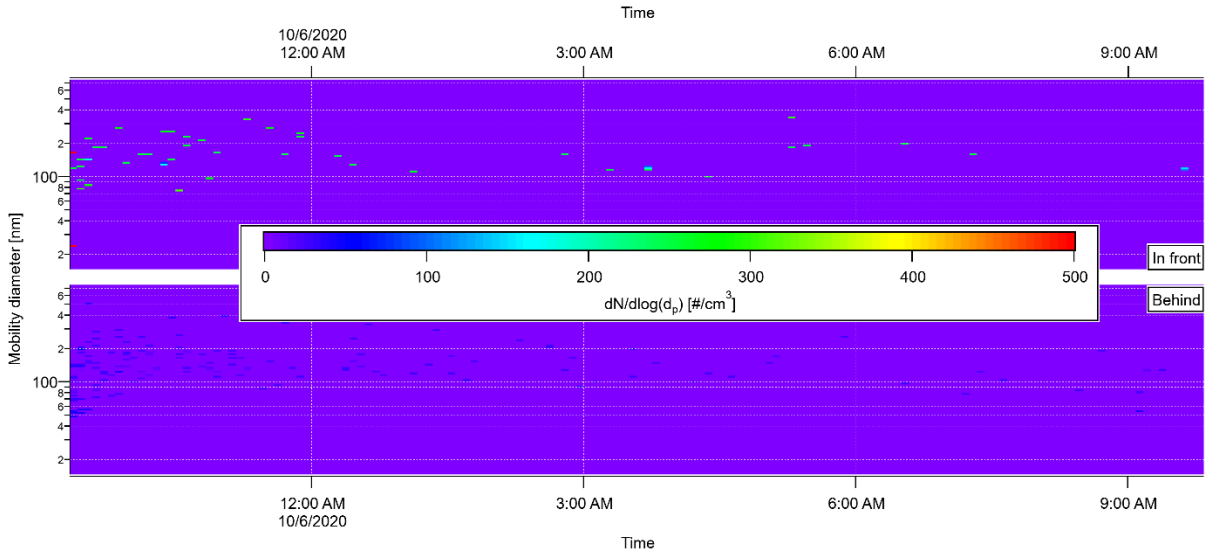

Fig.4 *Size distribution spectra measured in front and behind RespiPro VK RPVK-L/M/S-000 - dark.*

According to previously mentioned facts, both tested respirators **do not show any release of any particles** (including the copper material) during several hours of being exposed to volumetric flow of 95 l/min.

In Prague, 15.10. 2020 Jakub Ondráček