SOLID AEROSOL– SOURCE OF OCCUPATIONAL DISEASES

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Measurements of solid aerosol concentrations are important tools to monitor air conditions at the workplace. In particular, the requirement for the workplace air quality management is necessary to prevent health damage and occupational diseases in exposed jobs. In this case, exceeded limit values for the concentration of solid aerosols were measured for all exposed workers. If such concentrations persist, workers' health may be at risk and occupational diseases may occur after prolonged exposure.

KEYWORDS

Safety, solid aerosols, occupational diseases, concentration, exposure

1 SOLID AEROSOLS

Solid aerosols with a diameter more than 30 µm are referred to as so-called "Coarse dust" and quickly settle in the environment under normal conditions. In oxidative chemical processes, such as welding, smoke with particles of 0.01 to 0.1 µm is released. Thermal processes such as the combustion of organic matter produce smoke with particles from 0.01 to 0.5 µm [STN EN 143:2001].

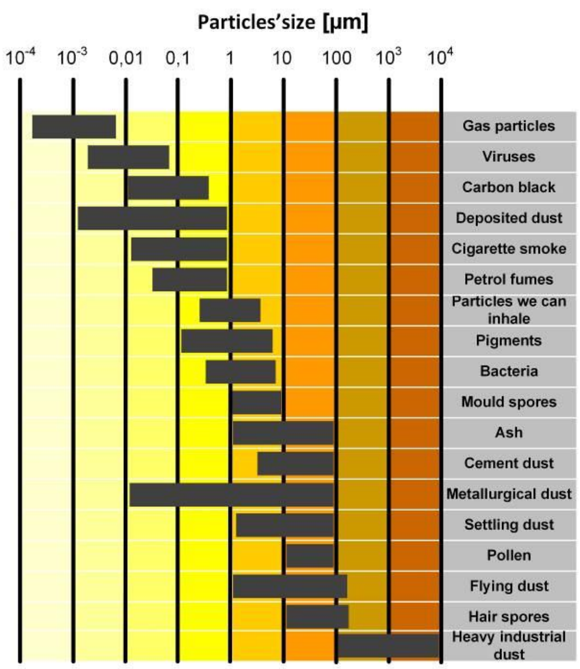

Figure 1. Sizes of particles present in the atmosphere

1.1 *Effects of solid aerosols on the human body*

Solid aerosols (SA) are divided according to various criteria. The basic division is toxic and non-toxic solid aerosol [Government Decree No. 471/2011].

Fibrogenic SA may induce an increase in lung tissue proliferation, the so-called pulmonary fibrosis. The fibrogenic component is crystalline silica in the form of quartz, tridymite or cristobalite and gamma form of alumina.

Infectious SA contains germs trapped on particles, which can cause serious diseases. Fungal and bacterial infections caused by bioaerosol also belong in this category.

Toxic SA can cause systemic intoxication in addition to local effects on the respiratory tract. Solid aerosols containing toxic substances are absorbed by the blood, which may lead to adverse effects on the tissue and organs even further from the point of entry of toxic substances.

Carcinogenic SA can cause cancer when inhaled, for people exposed to the effects of solid aerosols.

Figure 2 shows the method of intrusion, sedimentation and long-term effect of solid aerosol in the respiratory tract.

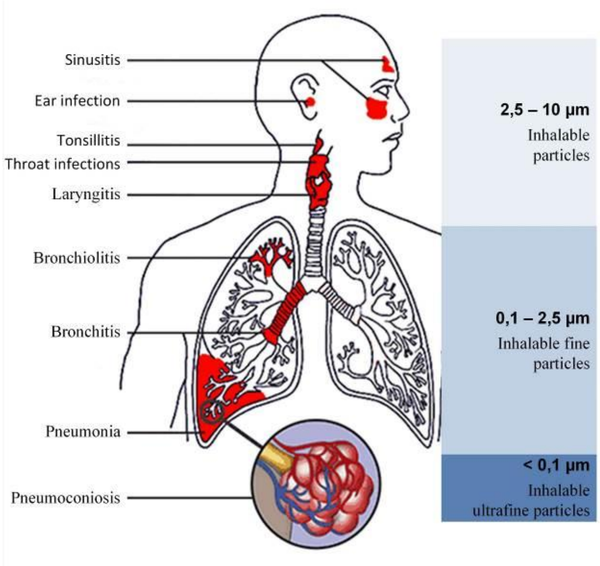

Figure 2. Respiratory tract exposed to the effects of solid aerosols

2 MEASUREMENT OF SA CONCENTRATION BY GRAVIMETRIC METHOD

Among the advantages of the gravimetric method of measuring concentration are its simplicity, instrumental simplicity, mutual reproducibility and the possibility of comparing the results of the measurement.

The only disadvantage of this method is the overrated importance of larger particles (more than 10 µm in size). These particles are not of great importance with regard to the health risks of solid aerosols because they are retained in the upper respiratory tract. Large particles can significantly affect the result of the measurement. This deficiency can be eliminated by analysing the SA size composition or by two-stage dust measurement. The aim of the two-stage measurement is to sort the SA already at the sampling, into a respirable and non-respirable fraction, and finally to determine the total weight concentration. It is a mechanical separation of a respirable components of retained SA. Cyclones or polyurethane foams are most commonly used to separate the respirable SA component.

The selection of workers is mainly a random selection of a worker or a group of workers from all exposed workers. The second method of selection is to divide the exposed workers into groups by exposure, within such a group a representative worker can then be selected. It is necessary to verify the correct selection of groups by a critical study of the work activities and by examining the data from the preliminary sampling of air [STN EN 689+AC:2019].

A personal sampling pump (Fig. 3) is a basic measuring instrument used in the gravimetric measurement of SA concentration in the working atmosphere. A personal sampling pump must be capable of continuous operation for eight hours per battery charge. Before measuring, the head with the prepared filter type is clamped on the pump [Kelemen 2004].

Figure 3. Sizes of particles present in the atmosphere

2.1 *Identification of SA exposure at a real workplace*

Measurement of SA exposure in the work atmosphere was carried out in real conditions during normal operation at a selected workplace. The measurement was performed on selected exposed workers.

Before the measurement itself, a workplace inspection was carried out, followed by information from the safety technician and the Occupational Health Service representative on the technology used in the workplace and on the substances with which workers come into contact during work. Based on this information, a list of all chemical substances at the model workplace was compiled, followed by the assignment of the relevant exposure limit values according to Annex No. 1 NV. 471/2011. Maximum exposure limits for each factor are set out in Tab. 1 below.

Factor	NPELc [mg/m3]
Brown coal	10
Ash	10
Slag	10
Carbon black (Class 1 carcinogen)	2 (TSH)

Table 1. Factors and allowed exposure limits

2.2 *Determination of factors of measured workplace*

A source of SA at workplaces is technological equipment or work technology of individual sections and cleaning work. During the measurements, workers were exposed to SA from brown coal, carbon black, ash and slag. Coal in the wagons was thawed on the day of measurement before unloading. Only one boiler was in operation during the measurements.

The subject of the measurement was the determination of SA exposure of selected exposed jobs on three sections of the workplace, namely waste management section, the fuel preparation section and the boiler control section, a separate group was the shift master for all sections.

2.3 *Results of SA concentration in work atmosphere measurement*

At the beginning of the measurement, it is necessary to determine the input values i.e. microclimatic conditions on individual sections of the workplace, which affect the accuracy of measured results and then take them into account in the measurement results [Kotianova 2012]. The following table shows the measured exposure values for the individual exposed workers. It is a comparison of the all shift exposure concentration in exposed workers with a limit exposure value of the so-called overall dustiness.

Job	All shift exposure concentration TWA [mg/m3]	NPELc [mg/m3]	Evaluation
Foreman of slag and ash removal, ash disposal	61.83	10	exceeded
Operation of slag and ash removal, ash disposal	54.56	10	exceeded
Dozer operation	100.93	10	exceeded
Foreman operator of unloading	27.87	10	exceeded
Operation of slot feeder	44.16	10	exceeded
Operation of deep feeder collector	53.14	10	exceeded
Operation of unloading equipment	29.84	10	exceeded
Boiler room helper	7.39	2	exceeded
Shift leader at workplaces	7.29	*5,7	exceeded

* NPEL determined by calculation for a mixture of solid aerosols

Table 2. Evaluation of exposed workers measurement

The measurement results apply only to the jobs listed and are valid under the conditions of the workplace at the time of measurement.

3 EVALUATION OF MEASUREMENT RESULTS

The main reason why the measurement results in all exposed jobs significantly exceeded the limit values of SA concentration in the work atmosphere is mainly the obsolete technology of thermal energy production, as well as leaks at individual technological equipment such as boilers and the like. Another important reason is that individual sections of the workplace are not equipped with forced exhaustion. Therefore, there is no regular air exchange, which has a detrimental effect on the health of employees.

Problems with work organization, insufficiently cleaned technological equipment, which not only significantly increased the concentration of SA in the atmosphere but also exposed the whole workplace, were also found during the measurements. If such conditions lasted for a certain period, it could lead to an explosive atmosphere in the plant.

Figure 4. Contaminated area of belt conveyor and electrical wiring

4 PROPOSED PROTECTIVE MEASURES

Increased SA concentrations in the atmosphere were measured at all sections of the workplace where exposed employees were performing their normal work activities. This is the main reason for the need to design protective measures to reduce SA concentration in the workplace. By combining various methods of protection, a significant reduction in SA concentration can be achieved, thereby reducing the risk of harm to employees and consequent occupational diseases. It is also necessary to pay increased attention to the identified deficiencies in the maintenance of technological equipment and thus to prevent the formation of an explosive atmosphere.

Individual measures – PPE - These are measures designed to protect individual workers from the adverse effects of SA.

Protection of respiratory tract - The following Tab. 3 contains the recommended protection of the respiratory tract of individual jobs according to measured concentrations. Filter classes are divided into three protection levels P1, P2 and P3 according to efficiency, with a P3 protection class filter being the most efficient [STN EN 143:2001].

Whole-body protection - Due to the occurring SA and measured exposure concentrations at a workplace, an anti-static non-flammable coverall has been proposed as suitable body protection for all exposed workers. This body protection should be supplemented with suitable working antistatic gloves and antistatic work shoes.

Range of measured values of SA [mg/m^3]	Recommended filter classes for protection against SA according to EN143 [7]	Load capacity of filter	Measured value of SA [mg/m^3]
1 – 40	P1 – protection against solid particles without special toxicity, efficiency 78%	4xNPK	7.29
			7.39
			27.87
			29.84
41 – 60	P2 – protection against solid particles or harmful or irritating water aerosols efficiency 92%	10xNPK	44.16
			53.14
			54.56
61 - 100	P3 – protection against poisonous solid particles or water aerosols, efficiency 98%	50xNPK	61.83
over 100		200xNPK	100.93

Table 3. Recommended protection of workers according to measured values

5 TECHNOLOGICAL AND ORGANIZATIONAL MEASURES

To significantly reduce the concentration of SA in the workplace, it is necessary to design protection directly on the largest SA sources, i.e. on conveyors and spilling stations. The installation of covers and the SA dust collection system for each conveyor belt is a suitable solution for the workplace. Dust collection system and filtration equipment are designed to extract dust as closely as possible to prevent it from spreading and settling in the surrounding area. A covered belt conveyor with a dust collection system is shown in Fig. 5.

Fig. 5 Conveyor with SA dust collection system

In all visible areas of the workplace where there is a risk of exposure to SA, hang a sign of respiratory system protection, maybe together with the notice "Use a dust respirator" as shown in Fig. 6.

Fig. 6 Proposed signs

Reorganize times for individual work activities, devote more time to cleaning technological equipment to prevent explosive atmospheres, secure a sufficient number of workers for cleaning work [Pacaiova 2016].

When cleaning technological equipment and extracting coal dust, it is necessary to use a vacuum cleaner for explosive atmospheres.

6 CONCLUSIONS

The excessive presence of dust in the workplace can be very dangerous at many levels. The most common dust-related problems in the workplace are dust-related diseases, which are one of the main killers in terms of occupational health.

A cloud of concentrated dust is potentially flammable and therefore can cause explosions, so it is important for companies to maintain their working environment as relatively dust-free to avoid such potential disasters.

Proposed preventive measures such as individual filters, antistatic PPE are not financially demanding but serve to prevent occupational diseases and prevent accidents. Another inexpensive measure, but with a high benefit, is regular housekeeping procedures in dusty areas. Housekeeping procedures can prevent serious consequences such as explosion and fire. The most complicated solution from the technological and financial point of view is the installation of a dust collection system.

By creating a positive, safe and healthy environment for employees, the company can increase morale, improve the work-life balance of employees, and then positively influence the company's business. The obvious benefit of a healthy workforce is that healthier employees are less often absent. Healthy workers are more motivated to stay at work, recover more quickly from disease, and are at less risk of long-term illness.

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