Case 1: Bagging of dry powder

Description of the case

Study

Study 1 focuses on occupational exposure to nanoparticles and their health effects. The overall goal of the project is to delineate exposure and health effects of selected nano-sized particles relevant to the occupational environment. During the project different partners performed measurement series in different companies. This case is available from company X in country Y that produces organically modified synthetic clay. Company was visited on 25 and 26 November.

During the manufacturing of organically modified synthetic clay, submicron particles can be released at two stages of the production process: during feeding the raw materials to the bunker and after milling /drying the final product and packaging.

Description of the task

Firstly, an empty plastic bag placed in a cardboard box is connected to the filling system using a leather belt around the bagging hose. When a bag contains 10 kilograms of dry end-product the bagging hose is closed and the air in the bag is manually pushed out. Subsequently the bag is closed and removed from the bagging-point.

The cardboard box is closed with tape. This last activity is not included in the data analysis.

Two workers are bagging both products on the same time in the same place. Person 1 fills bags with the nanoclay and person 2 fills other bags with Calciumacetylacetonat. The distance from the nanoclay bagging place to the equipment was about 1 meter. The distance from the equipment to the bagging place of Calciumacetylacetonat was about 5 meter.


Handled nanomaterial

Synthetic nanoclay, a composition of aluminium magnesium hydroxide and hydrogenated fatty acid. Dry powder.

Precautions and personal protective equipment used

Employees are not allowed to eat, drink, smoke or apply cosmetics in the work area. Hand care products are available for the employees. Warning signs are displayed for different dangers.

Occasionally, disposable RPE (3M) were used during emptying bags containing filter cake. During bagging of dry nanoclay disposable RPE is used more often. Disposable RPE are changed when necessary and after each shift. The stock of RPE is stored in a closed closet in the office. When operators use gloves they wear leather gloves. The use of gloves is not routinely. The stock of gloves is stored in a closed closet in the office. During the measurements no gloves were used.

Reusable cotton (woven) laboratory coats are worn by the operators which covered the whole body except head/neck, forearms and feet. One worker does not wear a coverall. For each worker 4 coveralls are available, the worker decides how often the coveralls are changed. Coveralls are cleaned weekly at the company. Washing facilities (showers) are available on the factory. In-use coveralls are stored in separate rooms at the production and research site. Safety boots are worn by all employees in the factory. The use of ear protection, goggles and a helmet is obligatory.

Location, ventilation and conditions

Air temperature and relative humidity were recorded during every measured task through the datalogger Kistock KT100 (KIMO) and Velocicalc 8386 a-m-gb RH-sonde (TSI, Shoreview USA). Air velocity and direction were recorded in the vicinity of the operator/ location of loading through an air velocity device (Testo). Temperature at the workplace was 27.3˚C and the relative humidity was 17 %, both measured with a VelociCalc. The exact locations of the measurements were indicated on the situation map (figure 1).

The filling of bags with dry end-product occurs on the ground floor. Local exhaust ventilation is present at the bagging system. Next to the bagging system for end-product a bagging station for raw material was situated. The distance between the bagging stations was approximately 5 meters.

The factory has mechanical air supply and mechanical extract ventilation. On the roof of the building is an exhaust fan and an air handling unit (AHU) for fresh air supply. The supplied air is filtered and if necessary heated. According to the given specifications of the AHU the supplied air is cleaned with a micro glass fibre pocket filter, filter class F5. The filter area is 9.4 m². The fresh air is distributed to the floors by air ducts and supplied through grilles. Air exhaust takes place trough grilles on each floor and is distributed to the roof by air ducts. Figure 1 shows both systems.

On the ground floor is a system for local dust removal with exhaust hoods at several processes. According to given specifications the extracted air is filtered by AAS polyester-needle filt pocket filters and transported to outside. The given output dust concentration of the filters is <10 mg/m³. Besides mechanical ventilation also natural ventilation is possible via windows in the outside wall.

The air flow measurements are performed with a Flowfinder, made by Acin. The operation principle of the Flowfinder is based on the zero pressure compensation method. The under pressure in the building is measured with a Halstrup digital manometer for the measurement of positive and negative differential pressure (type EMA 84, range 0-100 Pa).

The measurement results are represented in Table 1. The dimensions of the factory building are derived from drawings of the building construction and its systems. The total air flow through the local dust exhaust system on the ground floor is not measured but is also retrieved from the drawings. The calculated volumes of the floors are not compensated for the volume of systems or machinery.

The results from Table 1 show that the air exhaust flow is much larger than the mechanical air supply flow. As result of this an under pressure occurs in the building.

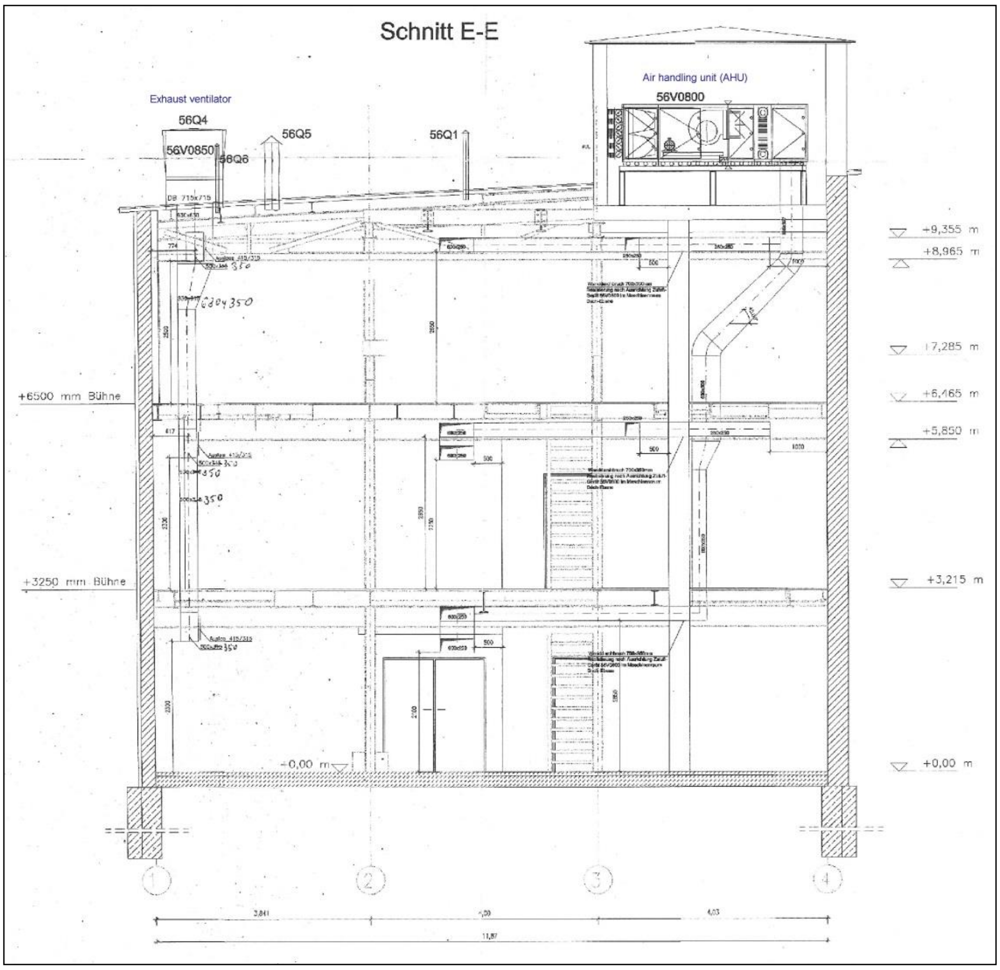


Figure 1. Cross section of the factory with air exhaust and air supply systems.

Table 1.Results of ventilation measurements.

Floor	**Supply air**	**Exhaust air**	**Local dust exhaust***	**Outside air infiltration**	**Floor area***	**Height***	**Volume**	**Ventilation rate**
	$[m^3/s]$	*$[m^3/s]$*	*$[m^3/s]$*	*$[m^3/s]$*	*$[m^2]$*	*[m]*	*$[m^3]$*	*[ACH]*
Ground	0.66	1.19	0.56	1.09 0.54**	204	2.9	592	11 7.2**

1st	0.67	1.17	-	0.49	204	3.0	602	7.0
2nd	0.83	1.05	-	0.22	227	3.5	790	4.8
Total	2.16	3.41	0.56	1.80 1.25**	-	-	1,983	7.2 6.2**

* Derived from technical system drawing

** Without local dust exhaust

Local ventilation:

At the measurement location on the ground floor (filling bags) a circular exhaust hood is installed around the filling tube/valve. This hood is connected to the local dust exhaust system. The average air velocity in the exhaust opening is 1.3 m/s and varies from 0.15 to 5.3 m/s due to the eccentric exhaust hose connection. The extract opening area of the exhaust hood is 0.033 m². The exhaust air flow is about 0.043 m³/s (155 m³/h).

Because spatial variations and partly low air velocity in the exhaust hood, the efficiency of the hood seems to be low. This is also confirmed by practise as during the filling of the bags, dust emission was visible. The 'bag filling' position is located near to an outside door at a distance of 3 to 4 metres. Because of the under pressure in the building an air flow comes in through the 1 cm high opening under the door with an air velocity of 6.5 m/s. This results in an increased air velocity at measurement position. At floor level the air velocity amounts to 0.5 m/s. At a height of 0.6 m the air velocity is 0.2 m/s. Because of this air flow an effect of the outside (particle) concentrations on the measurement results is expected. If the local exhaust system is on, the estimated ventilation rate at the ground floor is 11 ACH.

Used measurement devices

The parameters mass-, and number concentration, and surface area were measured directly (online measurement). For off-line characterization of the particles by using Transmission electron microscopy (TEM), air samples were collected by use of a portable pumps. All measurement devices were used by qualified personnel.

SMPS (Scanning Mobility Particle Sizer) was used to measure number-based particle mobility size distributions in the range of approx 14 to 661 nm. The SMPS exists of three parts: an electrostatic classifier (TSI, model 3080, serial number 3238) with a differential mobility analyzer (DMA) to separate particles on base of (mobility) size range and a CPC (TSI model 3025, low flow) to count the particles in each size range. The SMPS had a scan time of 2.5 minutes therefore its use in very short processes is limited. The default settings are given in report D2.1 (Mark et al, 2007) and the corresponding instrument SOP. The flow rate was 3 l/min, the sampling volume was 300 ml/min.

UCPC (TSI model 3786, serial number 70519009) was used to count nanoparticles with a particle size range from 2.5 to 3000 nm using an optical particle detector. Because the kind and size of nanoparticles that were measured is not yet known, we used the digital signal that was scaled automatically by the software program. The flow rate was 300 ml/min and the scan time was 20 seconds.

Personal air samples (PAS) are taken using a sampling device consisting of an open-faced filter holder including a 25 mm gold coated polycarbonate on which a TEM grid was placed. A backing filter, i.e. a 5 µm pore size mixed esters of cellulose, was used. The pump was a 2 litre/minute diaphragm pump (GSA SG4000EX). The flow rate of the sampling assembly (pump plus filter) was measured using a calibrated flow meter at the start and end of the sampling period. Due to the small pore size of the filter, a relatively high pressure drop of the pumps was experienced. However, the recommended flow rate of 0.4 l/min was achieved. The samples that are collected on TEM grids through the precipitator were analyzed by Transmission Electron Microscopy (Health and Safety Laboratory, UK). Analysis include X-ray analysis on individual particle and X-ray mapping; analysis of transmitted or scanned images for size and agglomeration of collected particles.

Static air samples were collected using the TSI 3089 nanometer aerosol sampler **(NAS)** (serial number SN 7071526) to collect nanoparticles on holey TEM grids (3 mm Holey Carbon film 400 mesh Ni, serial number S147N4H). Static samples were positioned 1-2 m above floor level and away from large obstructions/walls. The flow rate was 1 l/min and the voltage was -10 Kvolt during the measurement.

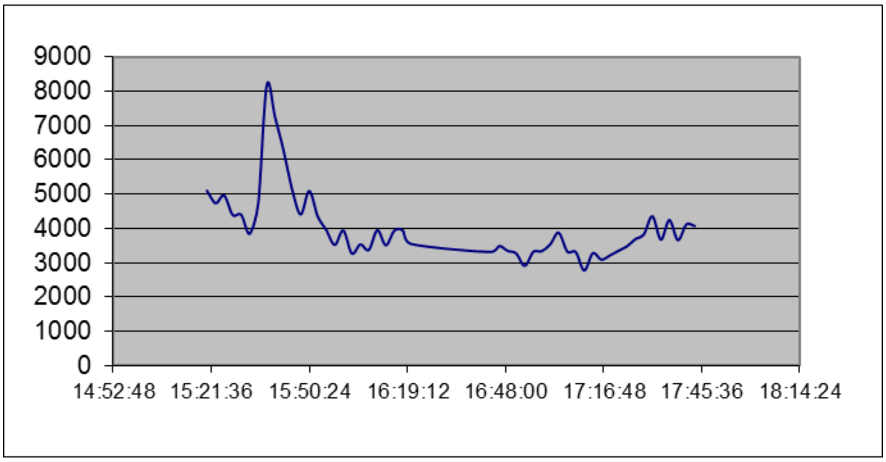
A diffusion charging particle sensor (**LQ 1**-DC Matter Engineering AG) was used to measure the active surface area concentration of (nano)particles as a function of time. The response time was set at 3 seconds. The output was transferred to and stored in a datalogger (Kistock KT100 KIMO) and the KILOG program installed on a PC was used for data output.

Available measurement results

Task registration

Activities			Task/ background	NAS	PAS
16:02	Taking a filled bag from the dryer system	2		X	
16:05	Placing an empty bag on the dryer system	2		X	
16:05	Bag filling	1		X	
16:06	Taking a filled bag from the dryer system	1		X	
16:07	Placing an empty bag on the dryer system	1		X	
16:09	Taking a filled bag from the dryer system	1		X	
16:09	Placing an empty bag on the dryer system	1		X	
16:12	Taking a filled bag from the dryer system	1		X	X
16:12	Placing an empty bag on the dryer system	1		X	X

Raw data



Results samples

Results from the TEM analysis performed on the grids (from the PAS and NAS measurements) indicate the presence of End-product and raw material. The end-product particles had an average size of approximately 1.1 x 1.6 µm on one grid (NAS). The average particle size of the raw material particles was approximately 0.78 x 1.4 nm (NAS). The grids were fairly clear of other types of particles.

NAS. The TEM grid did show aluminium magnesium and calcium based particles. Thirteen particles identified by energy-dispersive X-ray spectroscopy showed that approximately half of the particles were Al Mg and half were Ca based particles.

PAS. The TEM grid did show aluminium magnesium and calcium based particles. The EDX spectrum of some of the particles exhibited peaks for aluminium, magnesium as well as calcium elements.