Reducing risks from occupational exposure to coal dust

Guidance for the purchase and use of dust masks in underground coal mines

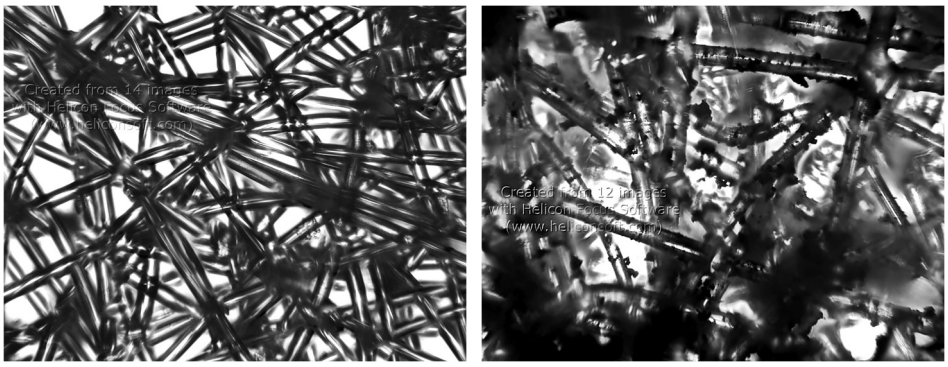
The knowledge presented in this pamphlet was gained from testing half masks, microscopic analysis and surveys of their use in the case study mines of the ROCD project

This pamphlet is aimed at persons responsible for purchasing protective equipment for employees working in underground mines. It is also applicable to anyone using a half-mask for protection against the inhalation of dust.

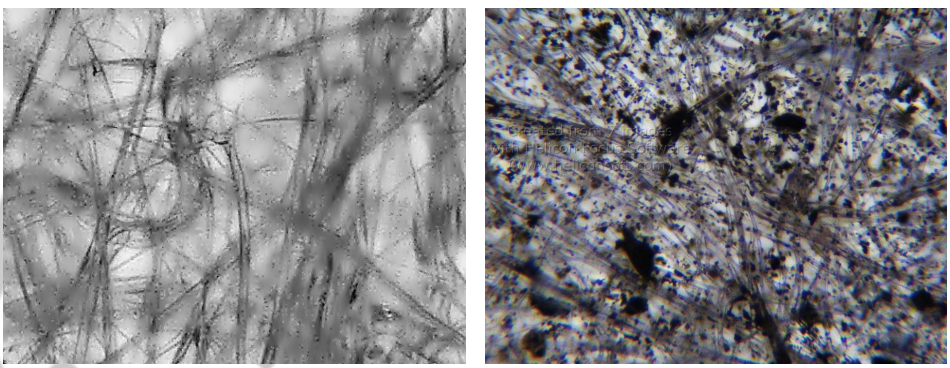
Respiratory protective equipment (RPE) is manufactured in two main forms: disposable half masks, and reusable masks with replaceable filter inserts. Half masks are divided into three basic categories, based on their efficiency:
FFP1 - captures about 80% of particles that are not smaller than 2 μm,
FFP2 - captures about 94% of particles that are not smaller than 0.5 μm,
FFP3 - captures about 99% of particles that are not smaller than 0.5 μm.

1. How do filters work?

The filter of the FFP3 masks usually consists of 3 layers. The first layer consists of synthetic fibres, with a thickness of 10-20 μm, which act as a primary barrier to the largest particles. The middle layer, which is the most important, is made of densely pressed thin fibres which have a thickness of 2-3 μm. The third layer, which is usually similar to the first, provides inner protection for the middle layer.



View of the first layer of an unused (on the left) and used half mask (on the right)



View of the middle layer of not used (on the left) and used half mask (on the right)

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2. Problems associated with using half-masks

• Filtration efficiency versus breathing resistance

It is obvious that a higher density of fibres in the mask filter (giving greater filtration efficiency) will cause an increase in breathing resistance (i.e. greater difficulty breathing) and therefore the choice of mask is a compromise between these features. The type of mask should be carefully selected according to the nature of the dust-related health hazard.

• Protection efficiency and fit to face

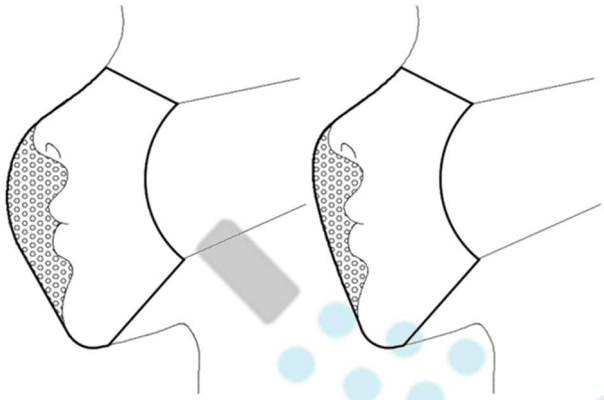
Even the best masks can have a lower filtration efficiency compared with lesser varieties if there are leaks between the face and the mask. Nose area fit is always critical which can be checked by pressing on the rim of the mask, mainly around the nose, but without covering the mask. If there is a significant difference in breathing resistance compared to when the mask was not being pressed in place, there is likely to be a poor seal between the mask and face. Forming stiffening is important and care should be taken that it is neither too slack nor too stiff.

• Factors affecting the masks working time

The working life of masks before their efficiency drops below acceptable levels depends on breathing rate and the concentration of airborne dusts. During intensive work in dusty conditions, the filter material quickly becomes wet and choked with deposited dusts which increases breathing resistance. The use of a valve in the mask to freely exhale air is advantageous as it reduces resistance to breathing out and the wetting of the filter. The use of two valves in some types of mask, however, is not usually justified as, in practice, one of the valves remains idle, except for situations (e.g. very high physical activity) where there are extreme rates of exhalation. Moreover, it should be remembered that the second valve unnecessarily reduces the active area of the filter for dust capture and reduces its effective working life. The effective lifetime of a half-mask or a set of replaceable filters in dusty conditions may be from 30 minutes to several hours. Mine employees have indicated a practical working life of between 2 and 4 hours.

• Increased CO_2 content in exhaled air when using a mask

You may be surprised to know that the use of half masks increases CO_2 concentrations in inhaled air. This is because there is a space with a volume of around 40-100 cm^3 between the face and the filter material of the half-mask. Immediately after exhaling, a trapped portion of air, with an increased concentration of CO_2, will remain in this space, which is subsequently inhaled. Increased concentrations of CO_2 can lead to fatigue and a reduction in concentration. When choosing a mask, it is therefore important to choose one that will ensure that the space mentioned is not too big (i.e. as in the right-hand image above).



At the same time, remember that the mouth should be at a distance from the filter material and under no circumstances they can touch the mask interior during mouth movements for example when talking.

3. Disposable or reusable masks?

The time of effective use of a disposable mask or a set of filters in a reusable mask can be as little as 30 minutes. It is difficult to imagine the operator of a coal face shearer taking 10 disposable masks to cover their shift. The best practical solution is to wear a reusable mask and to carry additional replacement filters in an air-tight container. A skilled person can easily replace a filter or filters whilst holding their breath in dusty conditions, or can wait until dust levels subside, for example when the cutting machine is not in use. Disposable masks kept in sealed bags can act as a backup.

4. Half-masks for protection against coronavirus

During the first spike of the Covid-19 pandemic (mainly April-May 2020), the test stand presented further was used to evaluate many different masks, even self-made. It was determined that the efficiency of the filter material of popular surgical masks is four times lower than filter material taken from an industrial vacuum cleaner bag, with comparable breathing resistance. Against this background, the masks used in mines are much more efficient. The most effective of the commonly used half masks in occupational settings is type FFP3, which captures 99.95% of particles larger than 0.5 μm in diameter. The problem is that coronavirus has a size range from 0.06 to 0.14 μm so in theory could pass straight through the filter. An additional factor is that it is thought to be transmitted through the air mainly within droplets of fluid released as a result of coughing and sneezing, and possibly by talking. Because the droplets are significantly larger than the virus, ranging from a few to several dozen μm, they will be mostly retained by all types of half-masks, and most of the viruses will adhere or be trapped in the hair-like structure of the filter. The problem arises when droplets on the surface or within the filter evaporate to release the virus which may then pass through the filter. For this reason, it is important to regularly change and not to reuse your half mask. In practice, after a period of quarantine in isolated, warm and dry conditions, to allow the virus to die (4 days is thought sufficient), the mask can be reused for protection against viruses and dusts.

Remember !

A good quality mask, type FFP2 and FFP3, will effectively protect you and if you are infected the people around you. When using the self-made cloth masks and even surgical masks, you protect mainly the people around and less you.

Handling of half masks is also very important. After its use, especially in the area with a large number of people you should avoid touching the filter outside as there may be viruses !

If your mask is to be reused, you also shouldn't touch the inside as there may be viruses on your hands!

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5. Assessing the quality of half-masks

To assess the quality of half masks, we are mainly reliant on data provided by the manufacturer, i.e. on the type and efficiency of the filter (FFP1, FFP2 or FFP3). Apart from this, we can assess the quality of its fit-to-face using the method described in 2, and we can determine whether the space between the face and the mask is unnecessarily large. You can also inhale and exhale a few times through a well-fitted mask to see if you are breathing relatively freely. The problem with this, however, is that breathing freely can also be a feature of poor quality filters, i.e. which don't have a sufficient density of fibres for effective capture of dusts.

6. Where to go for advice when choosing half masks

As a result of the ROCD project, KOMAG has designed and built a test stand to assess the quality of half-masks used in Polish and Slovenian mines. From this they have created a database to compare the attributes of half-masks and their filters. The test stand is equipped with a dust chamber, an artificial human head, artificial lungs and a climate chamber in which air to be exhaled is humidified.

KOMAG's test stand for half masks

KOMAG offers a comprehensive half-mask testing facility, mainly for testing the filter protecting efficiency.