Analysis of hazardous and carcinogenic substances (PAHs) on breathing masks before and after washing in a washing machine with Lejon Kemi’s cleaning agent, washing bags and washing programme for breathing masks

Lejon Kemi

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Analysis of hazardous and carcinogenic substances (PAHs) on used sooty (contaminated) breathing masks before and after washing in a washing machine with Lejon Kemi liquid detergent FPG Wash, washing bags and washing programme for breathing masks developed by Lejon Kemi.

Background

Smoke and soot from fires has been shown to contain many substances which are harmful to health, including substances which can cause serious diseases such as cancer, especially after repeated exposure over long periods, e.g., through skin contact or inhalation. Awareness of the health risks associated with exposure to soot and health hazardous substances in combustion gases has led to a range of protective measures. Examples of such measures include the division of premises into a contaminated side and a clean side; new, safer working methods and new, efficient and safe methods for washing and cleaning e.g., breathing apparatus, breathing masks, fire protective clothing, fire hoses and other equipment used by fire .

Several of the substances harmful to health occurring in combustion smoke and in soot are oil- and fat-soluble and some have a tar-like consistency with good adhesion to many materials. This makes them difficult to wash off, especially from certain types of plastics, rubber, painted and lacquered surfaces and certain types of synthetic textiles.

In recent years, some mechanical methods have been developed for washing breathing apparatus including, among other things, rebuilt commercial kitchen dishwashers, so-called PPE dishwashers, which are used to wash breathing apparatus, including breathing masks. A problem with this cleaning method is that dirty, sooty washing water ends up on the inside of the mask, leaving soot residues to dry on the mask unless the mask is manually rinsed very thoroughly immediately after washing in the machine. Soot residues on the inside of the mask can pose a health risk.

Images 1 and 2. Soot deposits on the inside of the breathing mask after washing in a PPE dishwasher.

In order to ensure that the least possible amount of dirty, sooty water residue remains on the inside of the breathing masks, some companies in the market have developed a method for washing breathing masks in washing machines where the breathing masks are placed in protective washing bags and a specially developed washing programme is used for the purpose.

The washing bags that have been on the market so far have been primarily intended to protect the breathing masks from mechanical wear and mechanical damage during the washing process. However, these washing bags are not optimally designed from a cleaning point of view and the cleaning agents used have not been optimised to wash away soot or hazardous oil- and fat-soluble substances such as e.g., PAHs from breathing masks.

New cleaning agents and methods developed by Lejon Kemi

Since the spring of 2011, Lejon Kemi has been developing cleaning agents and cleaning methods to effectively remove soot and hazardous substances from breathing apparatus, breathing masks, fire protective clothing (turn out gear), fire hoses and other equipment used by fire brigades. The development work has been carried out in consultation and cooperation with various manufacturers of PPE washing machines and washing machine, manufacturers of breathing apparatus, fire brigades, external analysis laboratories, chemists and other specialists in a number of different areas.

After several years of research, extensive development work and comprehensive full-scale tests at various fire stations, Lejon Kemi was able to offer a series of cleaning agents as well as washing programmes for cleaning different types of PPE in January 2018. Lejon Kemi's product programme includes cleaning agents and specially developed methods for washing breathing apparatus in PPE dishwashers (spray washers), for washing breathing masks and turn out gear in washing machines, and for cleaning of fire hoses, tools, working benches etc.

The new cleaning agents and cleaning methods (washing programmes) provide excellent cleaning results both visually and according to independent laboratory analyses. The cleaning agents and methods are developed and tested to be as gentle as possible on materials in the equipment and protective clothing being cleaned. Material impact tests have often been carried out in consultation and in collaboration with various manufacturers of e.g. breathing apparatus, protective clothing, fire hoses and with fire brigades.

Lejon Kemi's products are marketed under own brands via retailers/business partners in Sweden, Norway, Denmark, Iceland, Slovenia, Germany and are used by hundreds of fire brigades. Some of the products are sold by Interspiro, which is part of the Ocenco Group, under Interspiro's own brands. Interspiro markets and sells the products in several countries and primarily targets emergency services that use Interspiro's breathing apparatus and breathing masks.

Detergent, washing bags and washing programmes for washing breathing masks

In order to achieve the best possible cleaning result when washing breathing masks in a washing machine, Lejon Kemi has developed a new liquid detergent, a new type of special microfibre protective washing bag for breathing masks and a new washing programme. The development of the cleaning agent, the washing bags and the washing programme are based on requirements and criteria from manufacturers of breathing apparatus, extensive laboratory tests and analyses and full-scale tests at several fire stations. The washing programme was developed in collaboration with leading washing machine manufacturers but is based on tests and analyses carried out by Lejon Kemi. The programme is available for several brands and models of washing machines, e.g., from Electrolux Professional and Miele Professional.

Lejon Kemi FPG Wash is a liquid detergent optimised for washing away e.g., soot and other dirt from breathing masks without damaging the materials in the breathing masks. The detergent contains special additives to encapsulate soot particles that are then washed away and additives that prevent re-soiling, which facilitates subsequent cleaning. In addition to mechanical protection for the breathing masks during washing, the washing bags in soft, environmentally approved microfibre material also provide the effective but gentle mechanical processing of the surfaces of breathing masks, which significantly improves the cleaning result. The washing programme is designed to produce an optimal cleaning effect without damaging the breathing masks through e.g., slow rotation of the washer drum and high water levels during both washing and rinsing.

Purpose of external analyses of the cleaning effect

It is very difficult, if not impossible, to see or to determine visually whether hazardous substances are present on surfaces which have been exposed to smoke and gases from fires. Against this background, Lejon Kemi hired an impartial accredited laboratory company to measure amounts of 16 different hazardous and carcinogenic polycyclic aromatic hydrocarbons (PAHs) in samples taken from clean breathing masks and from breathing masks heavily contaminated with soot, before and after washing in a washing machine.

The purpose of the analyses was to investigate how effective Lejon Kemi’s liquid detergent, FPG Wash is in combination with Lejon Kemi’s microfibre washing bags and a specially developed washing programme for breathing masks. Until now, breathing masks have largely been cleaned manually or by washing in so-called PPE dishwashers. Manual cleaning is labour-intensive and time-consuming, and the result will not be particularly good unless you are very careful when cleaning. When washing breathing masks in PPE dishwashers (spray washers), soot-contaminated washing water inevitably ends up on the inside of the mask, and if the masks are not manually rinsed very thoroughly after washing, deposits of soot and hazardous substances form on the inside of the breathing mask.

Selection of substances for analysis

The 16 polycyclic aromatic hydrocarbons (PAHs) analysed are normally formed when organic material is burned e.g., during fires in buildings. PAHs are a group of substances with two or more benzene rings. PAHs make up a total of some 500 substances which are more or less harmful to health and several types are carcinogenic, such as benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene and indeno(123cd)pyrene.

Several scientific studies show that exposure to e.g., PAHs can lead to increased risk of cancers and other health problems, particularly after long and/or repeated exposure.

Lighter PAH compounds are volatile and occur mainly in combustion gases, while heavier PAHs are low-volatility and bind more easily to various materials and airborne particles such as soot. The particles can in turn end up on various types of equipment and fire protection clothing (turn out gear) used by fire brigades. This means that exposure to PAHs can happen through inhalation, skin contact or ingestion.

Washing breathing masks in a washing machine

A total of six breathing masks contaminated with soot were washed in an Electrolux Professional washing machine. Lejon Kemi's liquid detergent, FPG Wash, Lejon Kemi's washing bags and washing programme for breathing masks were used. The cleaning agent was dosed at 0.4 %, based on the volume of water in the machine during washing. The washing temperature was 50° C and the washing time was 40 minutes, excluding four rinsing steps. A high-water level was used both during the washing phase and in all rinsing steps. After washing, the masks were taken out of the washing bags and allowed to dry at 50° C in a drying cabinet until completely dry before sampling for analysis.

Sampling and analysis details

Four samples for analysis were taken from new, unused breathing masks, four samples from artificially contaminated breathing masks and four samples from contaminated and subsequently washed breathing masks. The samples were taken by wiping certain specific and equally sized areas of the masks with a special wiping cloth soaked in highly purified ethanol. After sample preparation, the samples were analysed to find the content of 16 different types of PAHs. Additional samples were taken from two old, used and heavily contaminated breathing masks before and after washing. A total of 14 samples were taken for analysis of 16 different PAHs.

Method of analysis

Determination of polycyclic aromatic hydrocarbons, PAHs (16 compounds (substances) according to EPA) follows methods based on US EPA 429 and ISO 11338. Measurements were carried out with high-resolution gas chromatography and mass spectrometry (GC-MS), which is an analysis method capable of measuring very low quantities of substances with very high precision.

Measurement uncertainty

Measurement uncertainty is expressed as an extended uncertainty (according to the definition in Evaluation of measurement data – Guide to the expression of uncertainty in measurement, JCGM 100:2008 Corrected version 2010) calculated with a coverage factor equal to 2, which gives a confidence level of approx. 95%. Measurement uncertainty is only stated for detected substances with levels above the reporting limit. Measurement uncertainty from suppliers is normally given as an extended uncertainty calculated with a coverage factor of 2. For further information, please contact Lejon Kemi.

Quantities per dm^2 of several types of PAHs on new, unused breathing masks and on washed breathing masks were below the detection level of the analysis method. In these cases, the value for the detection level was used when calculating the total amounts and in the compilation of source material. This means that the amounts of these PAHs per dm^2 can, at most, reach the detection level but can also be lower.

NOTE! It is not possible to analyse exactly the same sample twice and the amounts of PAHs per dm^2 can vary a great deal between different contaminated samples, even those taken next to each other on the same object. This means that the amounts per dm^2 of PAHs may vary from sample to sample after washing. For this reason, several samples from the same object are often analysed to obtain a more reliable average value. Samples taken from PPE which have been artificially contaminated gives more reliable results.

The analysis laboratory

Sampling and analysis were carried out by ALS Scandinavia AB, Box 700, 182 17 Danderyd, Sweden. Website: www.alsglobal.se Email: info.ta@alsglobal.com Tel: + 46 (0) 8 52 77 52 00 See the attached report T 1717259 from ALS Scandinavia AB.

Picture 3. Breathing mask on the left side is cleaned with Lejon Kemi detergent FPG Wash in a washing machine with washing bags and washing program developed by Lejon Kemi and the breathing mask on the right side is cleaned with an ordinary machine dishwashing agent during 6 minutes in a PPE dishwasher at 50° C.

Lejon Kemi's washing bags for washing breathing masks in washing machines

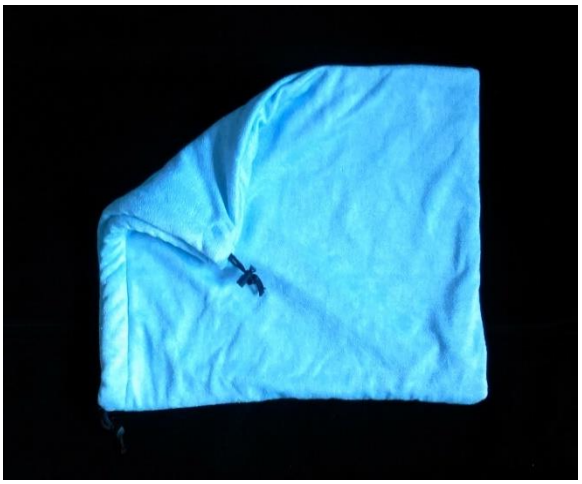


Image 4. Microfibre washing bag

Image 5. Washing bag and breathing mask

Image 6. Washing bag and breathing mask

Image 7. Breathing mask inside washing bag

Results

The results from the analyses show that the amounts of the 16 hazardous and carcinogenic polycyclic aromatic hydrocarbons (PAHs) were significantly higher in new, unused breathing masks after they were exposed to combustion smoke in a smoke filed room for training of fire fighters. After washing in a washing machine according to the method described in the report, the quantities of PAHs were very low and on a par with the amounts on the new, unused breathing masks.

Quantities of PAHs on old, used and contaminated breathing masks decreased very significantly after washing. The total amount of PAHs decreased by at least 96.4 % and the amount of carcinogenic PAH was reduced by at least 92.3 % on these masks. **See Chart 2.**

The analysis results show that it is possible to reduce the amount of hazardous and carcinogenic polycyclic aromatic hydrocarbons (PAHs) to a very low levels on par with new, unused breathing masks by machine washing of used contaminated breathing masks.
The cleanliness of the breathing masks was also assessed visually after washing and the result was assessed as very good.

PAHs on unused breathing masks, on contaminated breathing masks and on washed breathing masks

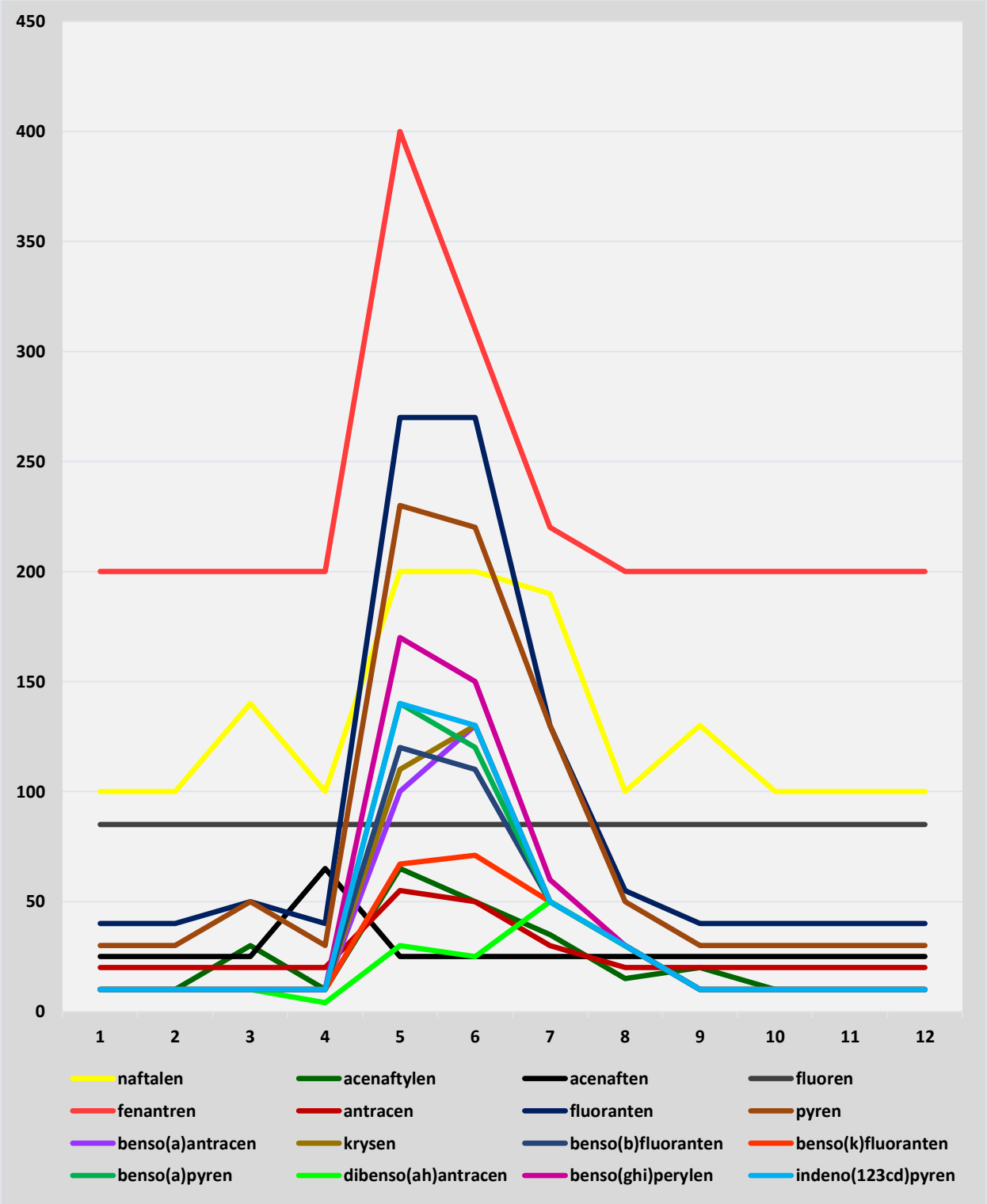
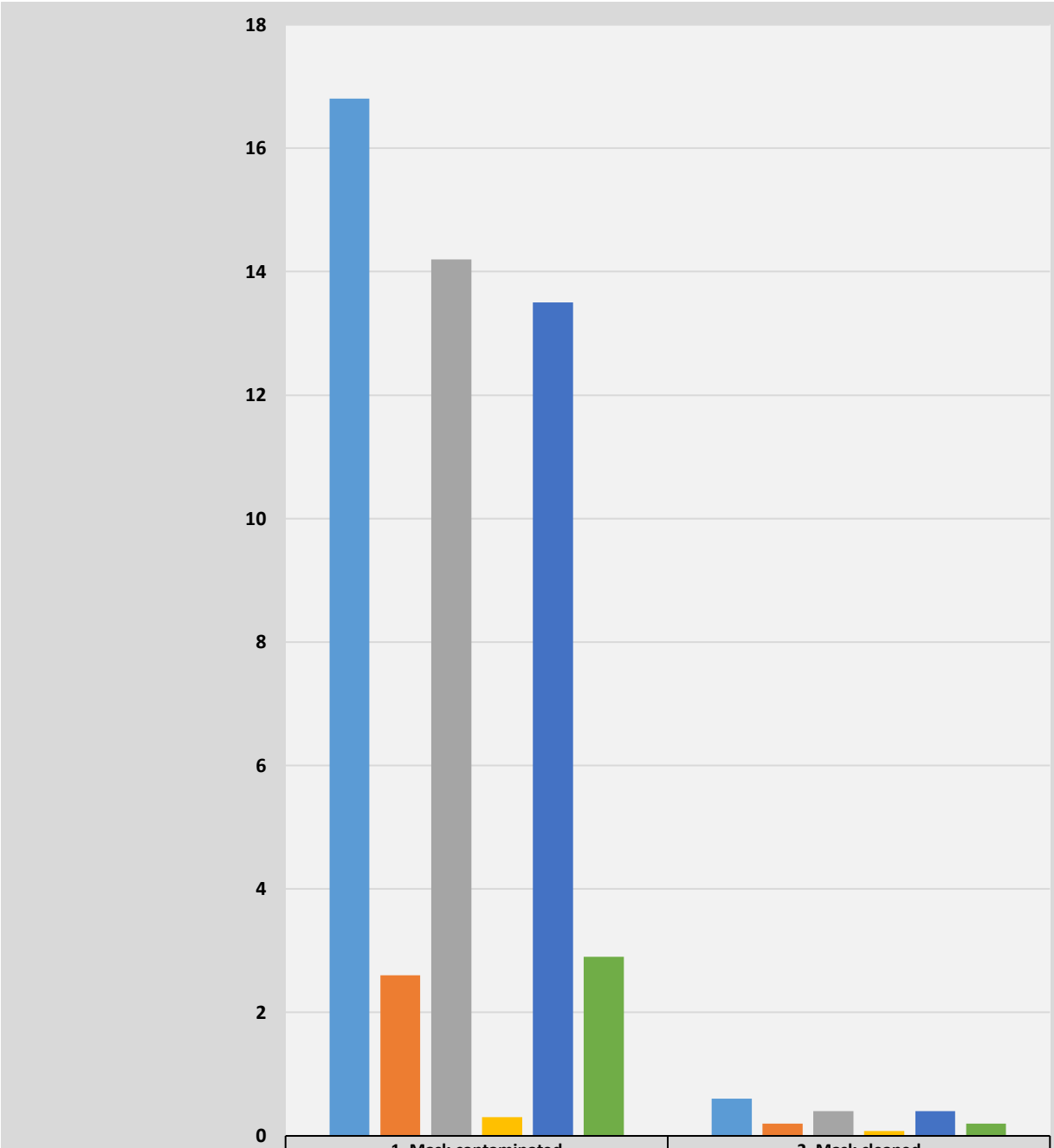


Chart 1. Amounts in ng/dm^2 of 16 analysed hazardous and carcinogenic substances (PAHs) on new, unused breathing masks, on breathing masks contaminated with soot and on washed breathing masks.
1 – 4 refer to analysis values from samples taken on clean, unused breathing masks.
5 – 8 refer to analysis values from samples taken from contaminated breathing masks.
9 – 12 refer to analysis values from samples taken from washed breathing masks.
After washing in a washing machine with Lejon Kemi detergent FPG Wash, washing bags and a washing program especially developed for washing breathing masks by Lejon Kemi the levels of PAHs were reduced to very low levels in line with new unused breathing masks.

PAHs on used, contaminated breathing masks before and after cleaning



	1, Mask contaminated	2, Mask cleaned
PAH, sum 16 mg tot	16,8	0,6
PAH, sum carcinogenic mg tot	2,6	0,2
PAH, sum others mg tot	14,2	0,4
PAH, sum L mg tot	0,3	0,08
PAH, sum M mg tot	13,5	0,4
PAH, sum H mg tot	2,9	0,2

Chart 2. Total amounts in mg/dm^2 of analysed hazardous and carcinogenic PAH from samples taken from old, used, sooty (contaminated) breathing masks before and after cleaning. The total amount of PAHs decreased by at least 96.4 % and the amount of carcinogenic PAH was reduced by at least 92.3 %. The amounts of PAH were significantly higher on old, used breathing masks contaminated with soot compared to new breathing masks that were artificially contaminated in smoke filled training facility for fire fighters.

Cleaning results after machine washing of contaminated breathing masks

Image 8. Sooty breathing masks before washing washing.

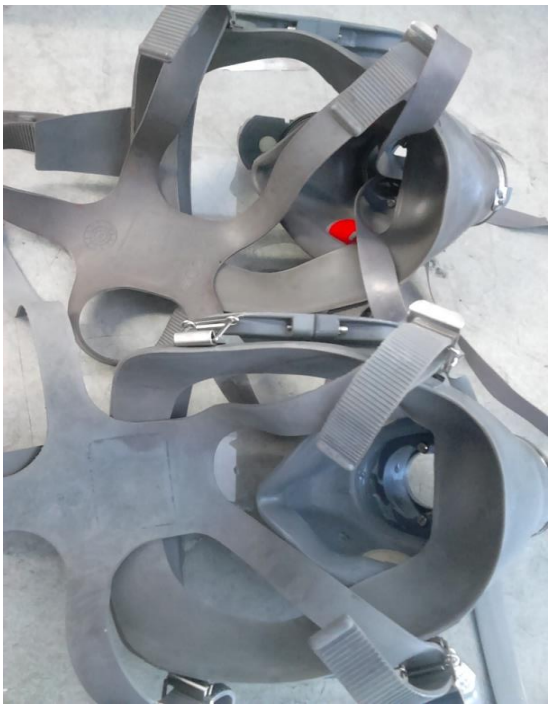


Image 9. Breathing masks from image 8 after washing.

Dirty and sooty breathing masks (image 8) were washed in protective microfibre washing bags with Lejon Kemi liquid detergent, FPG Wash at 50° C for 40 minutes, followed by four rinses (washing programme specially developed by Lejon Kemi for washing breathing masks). The masks became significantly cleaner (image 9).

Summary

When washing breathing masks in PPE dishwashers (spray washers) intended for cleaning breathing apparatus, sooty and dirty washing water inevitably ends up on the inside of the breathing masks. Due to the design of the breathing masks with many nooks and crannies, it is not practically possible to rinse out all the washing water from the inside of the masks in a PPE dishwasher (spray washer). If the breathing masks are not manually rinsed out very thoroughly, immediately after washing in the machine, the remaining sooty washing water will evaporate and form deposits of health hazardous and carcinogenic substances on the inside of the breathing mask.

By instead washing breathing masks in washing machines where the breathing masks are placed in protective microfibre bags, and where specially developed detergent and washing programmes are used for the purpose, it is possible to achieve excellent cleaning results without deposits of soot and health hazardous substances on the inside of the masks after washing.

In washing machines all parts of the breathing mask come into contact with the cleaning liquid which, in combination with an efficient and gentle mechanical processing of the surfaces by the microfibre material in the washing bags, removes almost all the soot from the masks. Several rinsing's with large amounts of clean water after washing ensures that washed away dirt and soot are also removed from the inside of the masks.

Analyses of samples taken from new, clean, unused breathing masks, from soot contaminated breathing masks and from breathing masks washed in a washing machine using the method described in this report show that the amounts of PAHs decreased significantly after washing. The total amount of PAHs decreased by at least 96.4 % and the amount of carcinogenic PAH was reduced by at least 92.3 % on contaminated breathing masks after washing.

The method is simple, practical, time saving and safe to use. In the large washing machines from leading manufacturers of washing machines, it is possible to wash up to 12–14 breathing masks at a time.

It is important to keep in mind that the cleaning result is always dependent on the type and content of the cleaning agent (chemistry), the washing time, the washing temperature, the mechanical processing and the rinsing. The cleaning agent forms a “unit” with the washing machine and the washing programme.

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