Analysis of substances which are harmful to health and carcinogenic (PAHs) on contaminated breathing apparatus before and after pre-treatment and washing in a PPE dishwasher using Lejon Kemi cleaning agent and washing programme

Lejon Kemi

Report: ALS T1822525. I.L 4.
Date 2018-10-03
Supplemented 2022-09-10

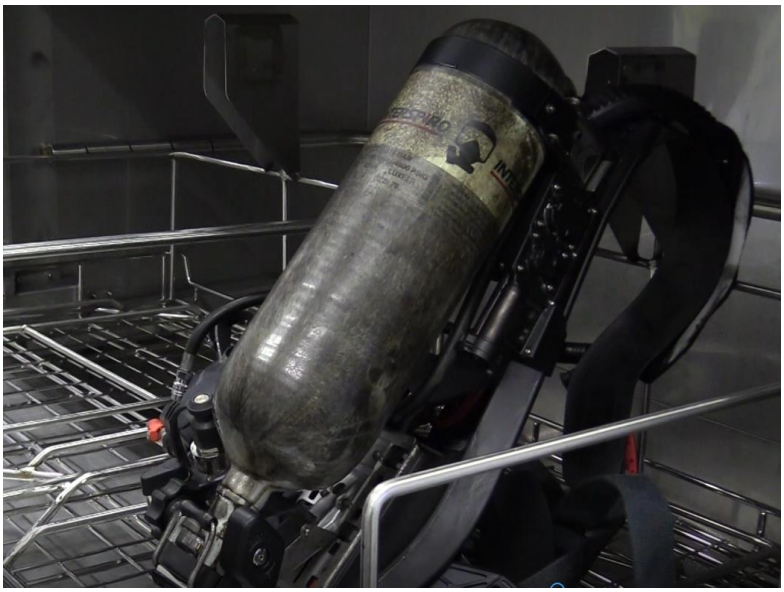
Analysis of substances which are harmful to health and carcinogenic (PAHs) on contaminated breathing apparatus before and after pre-treatment and washing in a PPE dishwasher with Lejon Kemi FFE Cleaner and washing programme

Background

Soot and smoke from fires has been shown to contain many substances which are harmful to health, including substances which can cause serious diseases such as cancer after repeated exposure over long periods, e.g. through skin contact or inhalation. The awareness of the health risks of exposure to hazardous substances found in soot and on equipment exposed to combustion smoke has led to a greater need for effective and safe methods for cleaning e.g. breathing apparatus used by fire service personnel.

In recent years, some automated mechanical methods have been developed for washing breathing apparatus where, among other things, rebuilt commercial kitchen dishwashers, so-called PPE dishwashers, are used for washing breathing apparatus, including breathing masks.

So far, short washing times have been normal, 3–9 minutes excluding rinsing, and conventional dishwasher detergents were used, which had been developed for purposes that were completely different from the removal of soot from breathing apparatus.



Images 1 and 2. Contaminated and sooty breathing apparatus and parts of the harness before washing

A breathing apparatus is made up of many different materials, such as plastics and various types of rubber, metal and composites. Some parts are painted or lacquered or have other forms of surface treatment. Some of the materials will not withstand cleaning temperatures above 50°C, and some cannot withstand cleaning agents found in many conventional dishwasher detergents and degreasing agents. This imposes a considerable limitation on the choice of cleaning agents and on temperatures at which breathing apparatus can be washed. These limitations, in combination with the fact that soot and oil- and fat-soluble dirt from fires is very difficult to remove without mechanical scrubbing, which means that it has been difficult and time consuming to find effective and safe cleaning agents and automated methods for cleaning breathing apparatus.

New cleaning agents and methods developed by Lejon Kemi

Since the spring of 2011, Lejon Kemi has been developing products and methods for effectively removing soot and hazardous substances from breathing apparatus and other equipment used by fire services. The development work has been carried out in consultation and collaboration with various dishwasher and immersion washer manufacturers, manufacturers of breathing apparatus, emergency services, external analysis laboratories, chemists and other specialists in a range of different fields. After extensive laboratory work and full-scale testing at different fire stations, Lejon Kemi is able to offer safe and effective cleaning agents and washing programmes for use when cleaning breathing apparatus in specially constructed dishwashers and breathing masks in immersion washers. These new cleaning agents and methods produce highly satisfactory results, both visually and according to independent laboratory tests. The cleaning agents and cleaning methods have been carefully tested on several makes of breathing apparatus.

The cleaning agents are marketed by Lejon Kemi via retailers under their own brands in Sweden, Norway, Denmark, Iceland, Slovenia, Germany and the Netherlands. The products are also sold in several countries by Interspiro, which is part of the Ocenco group, under Interspiro's brands. Interspiro targets emergency services who use Interspiro breathing apparatus.

The purpose of the external analysis of the cleaning effect of the washing of breathing masks

It is not possible 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 per dm^2 of a number of different hazardous and carcinogenic polycyclic aromatic hydrocarbons (PAHs) on breathing apparatus, before and after cleaning. The aim of the analyses was to investigate how effectively the cleaning agent and cleaning method removed a number of PAHs in addition to visible dirt and soot.

Selection of substances for analysis

The 16 substances that were analysed were polycyclic aromatic hydrocarbons (PAHs). These substances were selected for analysis because they are often formed in fires, and are found in soot and on surfaces which have been exposed to smoke and gases from fires. They are also classified as harmful to health and carcinogenic and include benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene and indeno(123cd)pyrene.

Sampling and analysis details

Eight samples were taken from different surfaces and materials from new and unused breathing apparatus to obtain reference values, with which the results could be compared after cleaning. The breathing apparatus were very heavily contaminated with soot in a smoke chamber designed for fire fighter exercises and then a further eight samples were taken from the same places as on clean breathing apparatus. Finally, eight samples were taken after the breathing apparatus had been pre-treated and washed in a PPE dishwasher. Surfaces of different materials on the breathing apparatus were wiped from exactly the same size surface area with a special cloth soaked in high-purity ethanol. The samples were placed in clean glass containers that were sealed. After preparation for testing, all 24 samples were analysed by gas chromatography – mass spectrometry (GC-MS).

The cleaning process

The heavily soot-contaminated breathing apparatus were pre-treated by spraying a 10 % solution in water of Lejon Kemi FFE Cleaner on the breathing apparatus and leaving it to work for about five minutes before washing in a PPE dishwasher. In the PPE dishwasher, FFE Cleaner was used, dosed at 1% with 20 minutes' washing time, followed by rinsing with approx. 18 litres of clean water. Washing and rinsing temperature of the water was 58–60°C. After washing, the breathing apparatus were allowed to dry completely before samples were taken. Pre-treatment was carried out on the grounds that the breathing apparatus were extremely dirty and sooty after exposure to smoke during most of the smoke-diving exercises over a period of two weeks. With a lighter degree of soiling, no pre-treatment or only simpler pre-treatment would normally be necessary. FFE Cleaner is a water-based alkaline detergent, initially developed and optimised for manual and automated cleaning of breathing apparatus in PPE dishwashers. The cleaning agent is not suitable for washing breathing masks with anti-fog film at temperatures above 52 °C. Breathing masks should instead be washed in an washing machine with Lejon Kemi FPG Wash, where the masks are in protective washing bags developed by Lejon Kemi and using a washing programme developed for the purpose.

Method of analysis

Determination of polycyclic aromatic hydrocarbons, PAHs (16 compounds (substances) according to EPA), following 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.

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 1822525 from ALS Scandinavia AB.

Analysis results

The results of the analyses show sharply increased levels of the 16 analysed hazardous and carcinogenic substances (PAHs) after the new, unused breathing apparatus had been exposed to smoke but that the levels were as low as on the unused breathing apparatus after pre-treatment and washing. A large proportion of the analysis results from samples taken on new, unused breathing masks and from pre-treated and washed breathing masks were below the detection limit of the analysis method. In these cases, a detection limit value has been used, which means that the amount per dm^2 can amount to the highest detection limit value but can also be lower. After pre-treatment and washing, the total amount of PAHs decreased by at least 97.8% and the amount of carcinogenic PAHs was reduced by at least 96.5%. The amount of PAHs after cleaning was on a par with new, unused breathing masks.

The analysis results show that it is possible, through pre-treatment and washing in a PPE dishwasher with the cleaning agent and methods described in this report, to lower the amounts of hazardous and carcinogenic polycyclic aromatic hydrocarbons (PAHs) per to very low levels.

Cleaning results after pre-treatment and washing in a dishwasher

Images 3 and 4. Breathing apparatus and part of a harness from Images 1 and 2 after pre-treatment and washing.

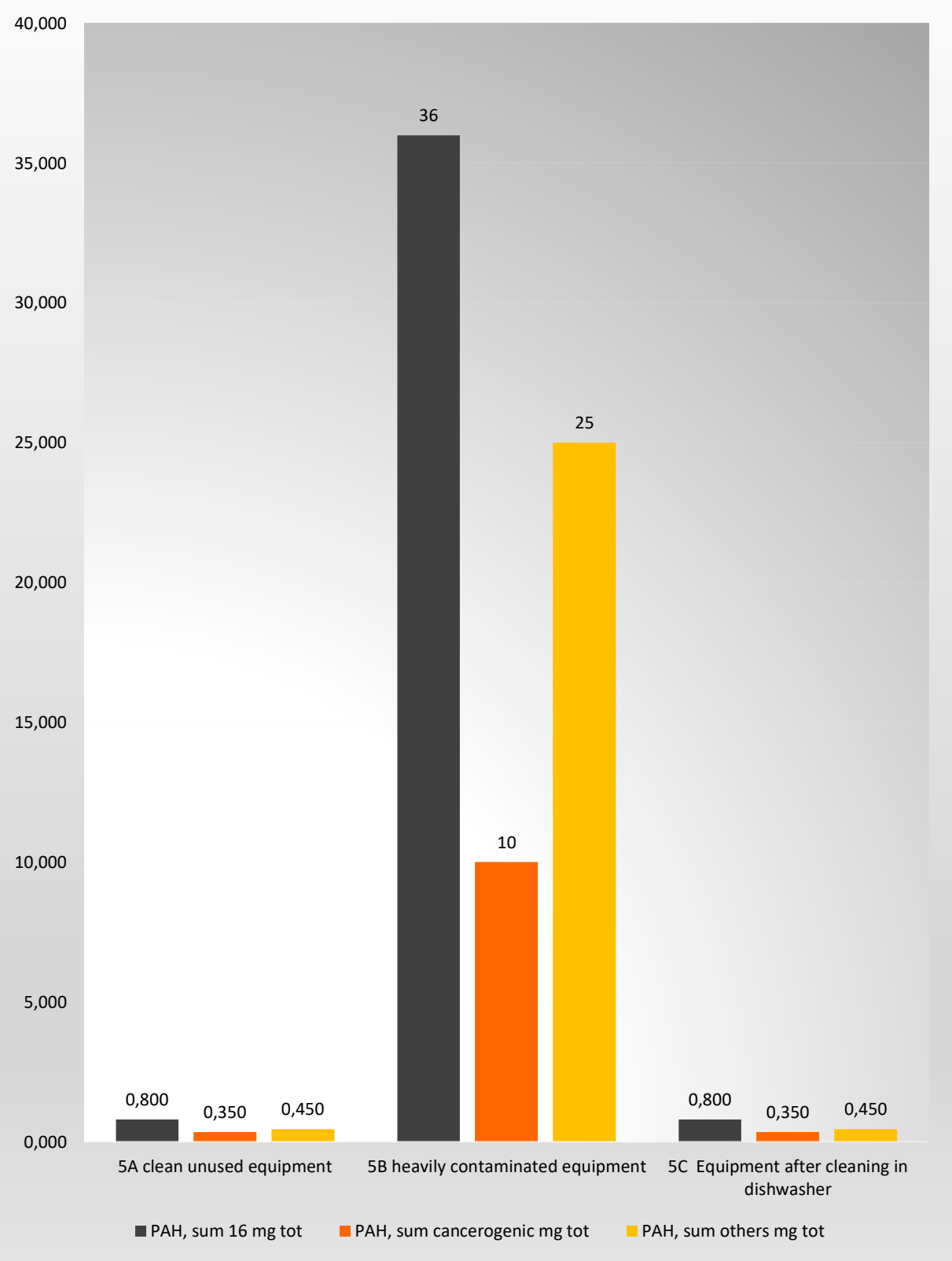


Diagram 1. Total levels in mg/dm^2 of 16 analysed hazardous and carcinogenic substances (PAHs) from new, unused breathing apparatus, from heavily soot-contaminated breathing apparatus, and from pre-treated and washed breathing apparatus. **Note** that the total content of 16 different PAHs on new, unused breathing apparatus and on cleaned breathing apparatus is below the detection limit (< 0.05 mg) for the method of analysis, i.e. below total quantities of 0.8 mg, below 0.35 mg and below 0.45 mg.

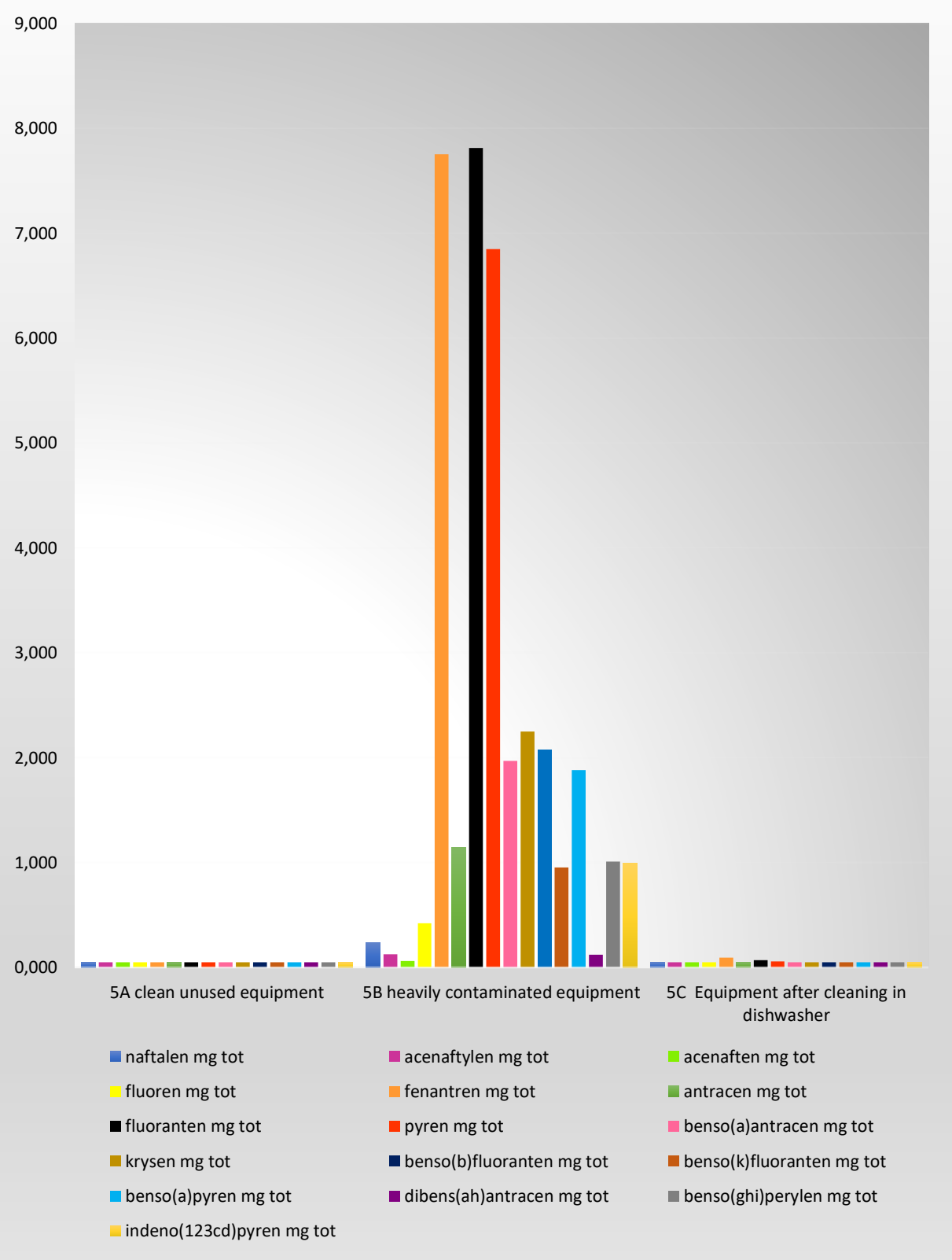


Diagram 2. Total levels of 16 analysed in mg/dm^2 hazardous and carcinogenic substances (PAHs) from new, unused breathing apparatus, from heavily soot-contaminated breathing apparatus and from pre-treated and washed breathing apparatus. **Note** that the total content of the 16 different PAHs on new, unused breathing apparatus and on cleaned breathing apparatus is below the detection limit of 0.050 mg for the method of analysis used, with the exception of a few values, which were close above the detection limit.

Harnesses for breathing apparatus inside the washing compartment of a PPE dishwasher

Image 5. Harnesses from breathing apparatus after pre-treatment and washing in a tank washer.

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 (detection 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 AB.

Note that samples taken from a specific surface cannot be analysed twice, as the sample is destroyed during sample preparation and analysis. Analyses of samples taken on other occasions have shown that the levels of e.g. PAH can vary widely on contaminated surfaces, even if samples are taken next to each other. This means that the starting levels of samples taken on contaminated objects can vary, which means that even the levels after cleaning can vary, and for this reason, several samples are often analysed to obtain more reliable analysis results.

Summary

By pre-treating breathing apparatus before washing in specially made so-called PPE dishwashers constructed for cleaning breathing apparatus, it is possible to obtain very good cleaning results with the cleaning agents, pre-treatment methods and washing programme developed by Lejon Kemi. Analyses of samples taken from new, clean, unused breathing masks, from breathing masks heavily contaminated with soot and from pre-treated and washed breathing masks show that the total amount of PAHs decreased by at least 97.8 % and that the amount of carcinogenic PAHs was reduced by at least 96.2 %. The amounts of individual PAHs after pre-treatment and washing were in several cases below the detection level of the analysis method and at the level of new, unused breathing apparatus.

It is important to keep in mind that the cleaning result is always dependent on several factors such as the type and content of the cleaning agent (chemistry), the washing time, the washing temperature, the mechanical processing (e.g. high pressure washing) and rinsing. The washing programme in the PPE dishwasher controls dosage, washing time, washing and rinsing water temperatures and rinsing. This means that the cleaning agent forms a “unit” with the PPE dishwasher and the washing programme.

Lejon Kemi AB

Website: **www.lejonkemi.se**
Email: **info@lejonkemi.se**
Tel: + 46 (0)76 827 00 96

Rapport no: ALS T 1822525. I.L 3.
Approved by: Ingemar Lejon
Date: 2018-09-10. Supplemented 2023-03-30.