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Barok Savunma Anonim Şirketi
Attn. Mr. Dilzod Urmanov
NİLÜFER SOKAK ESBAŞ BLOK NO:24 İÇKAPI NO: Z2 GAZİEMİR/İZMİR
Turkey

Date 28-8-2024
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Ref.no.: 76168
Doc.no: 79746

Subject: CBRN MASK full face including filter
Your reference: MF14-V
Contact person: Mr. Dilzod Urmanov

Dear Mr. Dilzod Urmanov,

At the request of Barok Savunma Anonim Şirketi (your reference MF14-V) ProQares performed gas adsorption experiments on activated carbon according to the MF14-V (Edition 2, October 2014) NATO Standard for colpro (collective protection) in a CBRN (chemical, biological, radiological and nuclear) environment. The aim of the investigation was to establish whether the carbon, when used in a colpro filter, will meet the stated requirements for the list of chemical warfare agents (CWA) and for the list of toxic industrial chemicals (TIC`s). The details of the received samples are presented in Table 1. The sample was received September 2nd 2024, the experiments were performed between November 21h 2024 and February 19th 2025.

Table 1: Received samples

Sample code ProQares	Description by customer
20 PQA 1817	Barok Savunma Anonim Şirketi Activated Carbon 12*30 Mesh NR-MARS-001

The requirements with respect to the various adsorption tests are stated in document MF14-V: collective protection (colpro) in a chemical, biological, radiological and nuclear (CBRN) environment, Edition 2, October 2014. These requirements are classified as NATO-confidential. Therefore the actual requirements cannot be stated in this report. In general it can be stated that the MF14-V prescribes tests with various components; the components should be adsorbed by the carbon at a given dose, expressed as a Ct-value (mg.min/m^3). For each component, two Ct-values are stated, an essential Ct-value and a desired Ct-value. The essential Ct-value is the minimum value that must be adsorbed by the carbon. The desired levels are higher.

It was agreed with BAROK to perform the experiments up to the point that a specific amount breaks through or when the challenge dose has reached the desired level without breakthrough plus at least 40%. In practice, this means that the experiments are performed by loading the carbon for a period of at least 70 minutes (some agents require 100 minutes). The influent concentrations are calculated by dividing the desired Ct-levels by a factor of 50. Should breakthrough occur, then the Ct-value can be calculated to investigate whether the essential Ct-value is met. If Influent concentration is lower during the experiment, the duration of the experiment is increased, that the required Ct challenge level is met.

The carbon will be used in a colpro filter at ProQares it is impossible to perform experiments with toxic substances on complete filters. Therefore a model is made of the filter; the model has a diameter of 5.0 cm. In the model experiments the linear velocity of the air, the residence time of the air etc. are exactly the same as in the actual filter. This method is generally accepted within NATO. From the data of the filter, provided by BAROK, the flow through the model was calculated. The results of this calculation are presented in Table 2.

According to the specifications of BAROK, the flow through the filter is 95 l/m; the carbon volume was 11074.5 cm^3. The bed height of the carbon was 170 mm, as specified by BAROK. The carbon volume in the test tube is 333.8 cm^3; at identical linear velocity, the flow through the tube is 45.2 L/min.

Table 2 calculation of the flows

Filter type	Flow through model (L/min)	Bed depth (mm)
95L /m	45.2	170

From several discussions within the NATO PPP panel, the carbon should be tested at the 2 extremes referred to in the document, the “wet” condition; in this condition the carbons had to be tested after equilibration with air of 23 °C and 80% RH. During the actual experiment, the conditions of the airflow are 23 °C and 80% RH as well. Also the “dry” condition is used for the experiments, which means that the carbon is tested as received, without any pre-conditioning and the conditions of the airflow are 23 °C and RH lower than 15%.

Some agents cannot be tested at high RH, due to reaction with water; as well safety as incorrect measurement caused by low generation as result (HCl clusters together with water and causes condensation of HCl solution in the test-equipment; PCl3 together with water can form an explosive mixture due to the extreme reactivity with water.

The results of the breakthrough experiments are presented in Table 3a and 3b. Table 3a shows the results of the “dry” condition Table 3b shows the results of the “wet” condition. In the tables is stated whether the carbon meets the essential level and/or desired level. The experiments are performed in duplicate (one dry and one wet, HCl and PCl3 are tested in duplicate in dry condition).

If breakthrough occurred and the critical Ct level in the effluent air is reached, it is displayed at what percentage of the required capacity, the Ct level is reached. So if it is reached between 100% and 140% of the required capacity, it would be stated “Pass”, but also the percentage of when the critical Ct level is reached. If it is reached before 100% of the required Ct level, it would state “Fail”.

Table 3a: Test results "dry" condition

Component	Essential level	Desired level	Critical Ct level reached at (%) of required Ct level	Protection time (minute)
Ammonia @ 1250ppm	Pass	Pass	>140	≥ 120
Soman @ 750ppm	Pass	Pass	>140	≥ 120
Hydrogen cyanide @ 500ppm	Pass	Pass	>140	≥ 80
Chloro cyanide @ 500ppm	Pass	Pass	>140	≥ 70
Mustardgas @ 750ppm	Pass	Pass	>140	≥ 120
Chloropicrin @ 750ppm	Pass	Pass	>140	≥ 70
Bromine @ 750ppm	Pass	Pass	>140	≥ 70
Chlorine @ 750ppm	Pass	Pass	>140	≥ 70
Hydrogen chloride @ 500ppm	Pass	Pass	>140	≥ 210
Hydrogen fluoride @ 500ppm	Pass	Pass	>140	≥ 210
Hydrogen sulphide @ 500ppm	Pass	Pass	>140	≥ 210
Cyclohexane @ 1300ppm	Pass	Pass	>140	≥ 90
Phosphorus trichloride @ 750ppm	Pass	Pass	>140	≥ 70
Sulphur dioxide @ 750ppm	Pass	Pass	>140	≥ 180

For these agents the capacity of the carbon, tested in the "dry" condition is more than 1.4 times the desired Ct value to meet the essential and desired level.

Table 3b: Test results "wet" condition

Component	Essential level	Desired level	Critical Ct level reached at (%) of required Ct level	Protection time (minute)
Ammonia @ 1250ppm	Pass	Pass	>140	≥ 120
Soman @ 750ppm	Pass	Pass	>140	≥ 120
Hydrogen cyanide @ 500ppm	Pass	Pass	>140	≥ 80
Chloro cyanide @ 500ppm	Pass	Pass	>140	≥ 70
Mustardgas @ 750ppm	Pass	Pass	>140	≥ 120
Chloropicrin @ 750ppm	Pass	Pass	>140	≥ 70
Bromine @ 750ppm	Pass	Pass	>140	≥ 70
Chlorine @ 750ppm	Pass	Pass	>140	≥ 70
Hydrogen chloride @ 500ppm	N.A.	N.A.	N.A.	≥ 210
Hydrogen fluoride @ 500ppm	Pass	Pass	>140	≥ 210
Hydrogen sulphide @ 500ppm	Pass	Fail	100%*	≥ 210
Cyclohexane @ 1300ppm	Pass	Pass	>140	≥ 90
Phosphorus trichloride @ 750ppm	N.A.	N.A.	N.A.	≥ 70
Sulphur dioxide @ 750ppm	Pass	Pass	>140	≥ 180

**Carbon capacity meets essential level, but is only 100% of the capacity to meet the desired level*

According to test results report 3a and 3b, MF14-V mask is resistant and protects against harmful agents for a minimum of 70 minutes.

For these agents (except H_2S) the capacity of the carbon, tested in the "wet" condition is more than 1.4 times the desired Ct value to meet the essential and desired level.

The capacity of the carbon for Hydrogen sulphide (H_2S), tested in the "wet" condition, meets the requirement for the essential level, but does not meet the requirement for the desired level.

The general conclusion is that the carbon meets the criteria of the MF14-V with respect to chemical adsorption of the challenge agents specified; with respect to the carbon tested in the “dry” condition the essential level and the desired level is met as well.

The general conclusion is that the carbon meets the criteria of the MF14-V with respect to chemical adsorption of the challenge agents specified; with respect to the carbon tested in the “wet” condition the essential level and the desired level is met as well, except for Hydrogen sulphide, which only meets the essential level; the capacity of the carbon is approximately 100% of the desired level.

Accuracy and Disclaimer

The breakthrough time of a canister in case of an adsorption experiment depends on the following parameters:

- the air flow through the canister
- the influent concentration
- the temperature
- the relative humidity of the air
- the effluent concentration

When all uncertainties of the parameters are taken into account, the accuracy of the breakthrough time is determined to be ± 10%.

It should be noted that the above values have not been taken into account when making the assessment. The results that are reported in this document concern the samples with internal ProQares sample code 20 PQA 1817 only. The results do not necessary hold for other samples of the same type.

We trust all things are clear to you. In case of any questions, please do not hesitate to contact us.

Kind regards,

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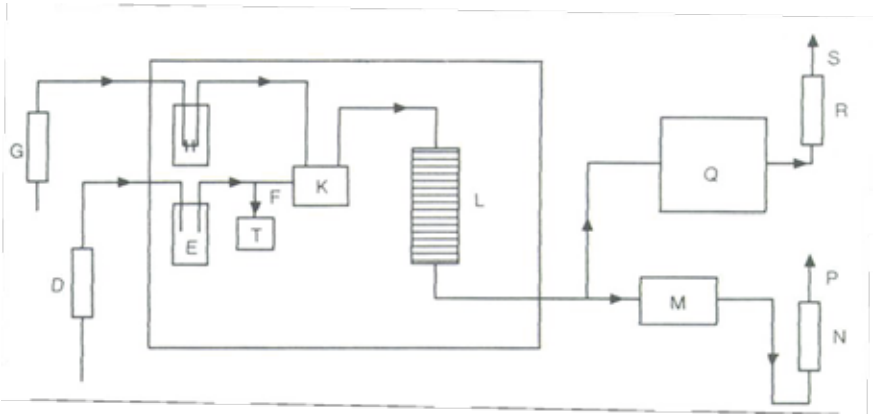
ANNEX 1 DESCRIPTION OF TEST METHODS

In this part the description of the test methods with various agents are described.

In Figure 1 the schematic set-up of the breakthrough apparatus is presented.

Figure 1: the schematic set-up of the breakthrough apparatus



D flow meter for air
E water saturator
F excess of air (not in use in case of sinusoidal flow)
G flow controller for vapour generating branch of airflow
H vapour generating system
K mixing chamber
L filter to be tested
M safety charcoal filter
N breathing machine
P vacuum system
Q analysis of effluent concentration
R flow controller for detection
S vacuum system
T measurement of T and RH

An excess of clean, dry air is led through a water saturator (E), which brings the air that will pass the carbon bed to the desired temperature and relative humidity; from there the air is led to the mixing chamber (K) where it is mixed with the generated component. The flow through the carbon bed is sucked by using a vacuum system. Temperature (T) and relative humidity (RH) of the air that passes the carbon are checked with a humidity and temperature gauge indicator and adjusted if necessary. The analysis system (Q) is connected to the apparatus just upstream of the safety charcoal filter.

The vapour of hydrogen cyanide, DMMP, cyclohexane, bromine, phosphor trichloride, chloropicrine, acrylonitrile, acroleine, mustardgas and sarin is generated by leading a known flow of air, controlled with controller (G), through a bubbler (H) that is kept at a constant temperature by using a cryostat. Knowing the vapour pressure of the

component at the set temperature and the airflow through the bubbler, the amount of generated vapour can be calculated. As the flow through the canister is known, the concentration could be calculated as well.

The vapour of formaldehyde is generated by evaporation of paraformaldehyde by heating. The influent concentration is measured with an acoustic infrared analyser. The effluent concentration is measured with an electrochemical sensor.

The vapour generation of chlorine, hydrogen sulfide, hydrogen chloride, nitrogen oxide, phosgene, ethylene oxide, sulphur dioxide, chloro cyanide, ammonia, isobutane and dimethylether are performed from a pressurised cylinder by using a calibrated mass flow controller. For phosphine and nitrogen dioxide calibration gasses are used to generate the required concentration.

Prior to the tests, the flow meters and the humidity and temperature gauge indicator are calibrated. The effluent concentrations of chlorine, hydrogen sulfide, hydrogen chloride, phosgene, nitrogen oxide, hydrogen fluoride, bromine, phosphor trichloride, ethylene oxide, sulphur dioxide and ammonia are measured with a calibrated electrochemical detector (Dräger polytron). The influent concentrations are not measured; they are calculated from the flow that is offered by the calibrated mass flow controller that is used for generation.

The influent concentration of cyclohexane, chloropicrin, hydrogen cyanide, DMMP, chloro cyanide, acrylonitrile, methyl iodide, mustard gas, sarin and acroleine is measured every 3 minutes using a gas chromatograph equipped with a FID detector. Sarin, mustard gas and DMMP effluent concentrations are measured with a MINICAM with the designated appropriate detector, the others are all measured using a gas chromatograph equipped with a FID detector.

For hydrogen cyanide and chloro cyanide the gas chromatographs are calibrated with pressurized cylinder containing a calibrated mixture of the hydrogen cyanide in nitrogen.

The breakthrough time of a filter or a carbon bed in case of an adsorption experiment depends on the following parameters:

1 the air flow through the filter
2 the influent concentration
3 the temperature
4 the relative humidity of the air
5 the effluent concentration

When all uncertainties of these parameters are taken into account, the accuracy of the breakthrough time is determined to be 10%.