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Subject: Low / high temperature H₂S adsorption experiments
Your reference: PO : POHC0100001901
Contact person: M. de Jonge

Ref.no.: 25542
Doc.no: 25279

Dear Mr. Hine,

At the request of Avon Protection (your reference PO : POHC0100001901) ProQares performed adsorption capacity experiments with Hydrogen sulphide (H₂S) on filter pads designated for NH15 escape respirator - hood. The experiments are based on EN14387, class 2 but performed at different temperatures between – 30 C and + 50 C stated by AVON. The details of the received samples are presented in Table 1, the experimental requirements are presented in Table 2 and all test results are presented in Table 3. The detailed description of the test procedures is presented in the Annex. Note that the test results are only applicable to the tested materials, mentioned in Table 1.

The requested temperature during the experiments cannot be maintained in our original test set-up, the equipment had to be brought into a climate chamber to be able to control the temperature. In the climate chamber, the relative humidity cannot be controlled, but was measured during the experiment. Additionally a reference experiment in the standard test equipment has been performed at standard controlled EN14387 experimental conditions at 20 C and 70% RH. The end product consists of two filter-pads, therefor the flow through the filter-pad during the experiment is proportional recalculated.

Table 1: Received samples

Sample code ProQares	Description by customer
14 PQA 1508 – 1 / 26	NH15 filter pad

For all experiments, the samples are not preconditioned, but the samples are brought to the designated temperature in their package. The flow through the samples is proportionally recalculated to 15 L/min according to EN14387 to take account that the end product is a twin-filter configuration.

Table 2: Experimental requirements

Experiment	Agent	Temperature (°C)	Influent concentration (ppm)	Breakthrough concentration (ppm)
1 & 2	H ₂ S	-30	5000	10
3 & 4	H ₂ S	-10	5000	10
5 & 6	H ₂ S	0	5000	10
7 & 8	H ₂ S	30	5000	10
9 & 10	H ₂ S	50	5000	10
11 ^A	H ₂ S	20	5000	10

A : One single experiment at 20 C, 70% in standard test equipment

The experiments have all been performed in a climate chamber, except for the single experiment at 20 C, the breakthrough times and the measured relative humidity are presented in Table 3. The detection system is positioned outside the climate chamber.

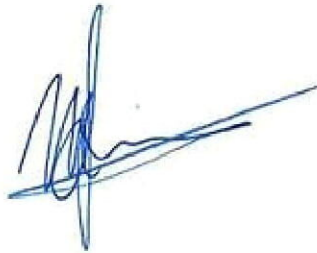
Table 3: Test results

Sample code	Temperature (°C)	Breakthrough time (min)	Relative humidity (%)
14 PQA 1508 – 1	-30	65	88
14 PQA 1508 – 14	-30	70	88
14 PQA 1508 – 3	-10	76	92
14 PQA 1508 – 4	-10	72	92
14 PQA 1508 – 11	0	77	90
14 PQA 1508 – 12	0	79	90
14 PQA 1508 – 8	30	149	59
14 PQA 1508 – 13	30	171	59
14 PQA 1508 – 9	50	236	48
14 PQA 1508 – 10	50	221	48
14 PQA 1508 – 16	20	119	70

At lower temperatures, the filter still meets the requirements of EN14387, class 2 for Hydrogen sulphide. Although the capacity for Hydrogen sulphide at lower temperatures decreases, it is still meeting the requirements of the standard.

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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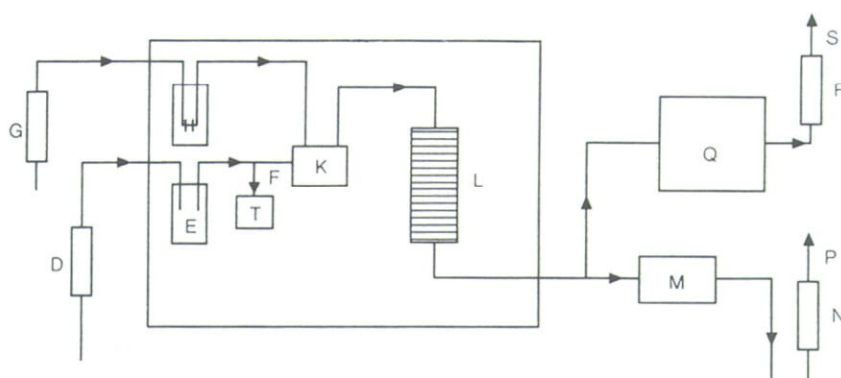
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ANNEX 1 DESCRIPTION OF TEST METHODS

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 (Vaisala) 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 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

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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 dissolved in water. The solution is led through a heated chamber with a syringe pump. The influent concentration is measured prior to the experiment; the effluent concentration is measured every minute with an acoustic infrared analyser.

The vapour generation of chlorine, hydrogen sulfide, hydrogen chloride, nitrogen oxide, hydrogen fluoride, phosgene, ethylene oxide, sulphur dioxide, chloro cyanide and ammonia are performed from a pressurised cylinder by using a calibrated mass flow controller.

Prior to the tests, the flow meters and the Vaisala humidity and temperature gauge indicator are calibrated. The effluent concentrations of chlorine, hydrogen sulfide, hydrogen chloride, nitrogen oxide, hydrogen fluoride, bromine, phosphor trichloride, 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. For phosgene, ethylene oxide and acrylonitrile an infrared detector is used to measure the effluent concentration.

The effluent concentration of chloropicrine and acroleine is measured every 3 minutes using a gas chromatograph equipped with a FID detector. The effluent DMMP and sarin concentrations are measured for subsequent periods of 5 minutes by bubbling 1 L/min of effluent air through a bubbler that is filled with 10.0 ml P.A. grade Isopropyl Alcohol (IPA). To the IPA an internal standard of tri-methyl phosphate (TMP) was added; 1 µl IPA is injected into a gas chromatograph and analysed. The gas chromatograph is equipped with a nitrogen-phosphorous detector (NPD). The ratio of the surface area of TMP and DMMP is a value for the amount of DMMP that is present in the solvent. The influent DMMP concentration is measured by weight prior to the series of tests.

The influent and effluent concentrations of hydrogen cyanide and chloro cyanide are measured every 3 minutes with a gas chromatograph, equipped with a FID. Every day the gas chromatographs are calibrated with pressurized cylinders containing a calibrated mixture of the component 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 estimated to be $\pm 5\%$.

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