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## **Analysis report 834894-1**

### **Evaluation and analysis of fog fluid and the fog**

*Date*

18. October 2018

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## 1 Assignment

The fog liquid, *Xtratus*, produced by Protect A/S is used in anti-theft protection systems. In such system, when triggered, the fog liquid is rapidly heated to high temperatures, causing phase transition of the liquid. The vapor is rapidly cooled in the air, causing the vapor to condense resulting in the formation of a dense fog (aerosol).

Protect A/S has requested an evaluation and test of their fog fluid, *Xtratus*. The tests included quantification of condensate on test objects and microscopic inspection of electronics (circuit board) for corrosion after heavy exposure to the fog. The exposure of the circuit boards was performed at high fog density to simulate a worst-case scenario (room size less than 1/10 of that for which the product; *Xtratus*, was designed and thus below the general product recommendation by Protect A/S).

## 2 Conclusion

The fog fluid provided by Protect A/S (product name: *Xtratus*) contains three major components; propylene glycol, water and ethanol. Propylene glycol is on the list for approved food additives in the EU (E-number: *E-1520*) and is used as an excipient in medicinal products. The concentration of ethanol, originating from a single dose generated by the anti-theft protection system, is not estimated to be below the maximum average exposure level set by the Danish Working Environment Authority (1000 ppm, 1900 mg/m<sup>3</sup>). Visible amount of condensate was observed on all horizontal surfaces in the room after exposure. Condensate could be measured up to 24 hours after exposure, though, at almost half the amount compared to measurements made 60 minutes after exposure. After 7 days at room temperature, no condensate could be detected on the circuit boards with the used procedure.

Microscopic investigation of the circuit boards revealed no visible damage to the soldering or components.

## 3 Methods

### 3.1 Fog formation, setup and test-room specifications

The equipment for fog formation was delivered by Protect A/S. The fog liquid was the product: *Xtratus*. The fog formation was time-controlled to 16 seconds and according to Protect A/S, this dose is capable of filling a 250 m<sup>3</sup> room, lowering the line of sight to about 1.5 meters after a few minutes of equilibration time.

The size of the test room was 20 m<sup>3</sup> (dimensions: length; 282 cm, width; 282 cm, height; 252 cm), corresponding to a very dense fog and large amount of condensate. The equipment was placed in a corner of the room.

Test materials was positioned in the diagonal corner to the fog formation equipment. The room was not ventilated, and the room was closed, when fog-formation was triggered. 60 minutes after triggering, the ventilation (200 m<sup>3</sup>/h) was reenabled and after 12 minutes, the density of the fog was sufficiently low for the test materials to be collected.

### 3.2 Circuit board and condensate evaluation

Three pieces of circuit boards (dimensions: approx. 1 cm x 3 cm) with different components were weighed and placed in the test room. Another circuit board

(approx. 8 cm x 14 cm) were pre-inspected under microscope (at both 10x and 50x magnification) and likewise placed in the room. After having been exposed to the fog, the three small test objects were left at room temperature and weighed after 60 minutes, 24 hours and 7 days. The larger test object was inspected under microscope after 18 days.

## 4 Results

The fog fluid, *Xtratus*, contains three main compounds: propylene glycol, water and ethanol. Besides these main compounds, the product contains a small amount of scent additive (approx. 1 vol%), but only the main components are included in this evaluation.

### 4.1 General evaluation of major compounds

Propylene glycol has a low toxicity and is also found on the list of food additives approved for use in food in the EU (E-number: *E-1520*). According to *The European Medicines Agency*, propylene glycol is used as an excipient in medicinal products for human use.

The high temperatures used when forming the fog may cause some compounds to react, forming other compounds. Potential reaction products are not evaluated.

The evaluation of ethanol in the fog fluid is based on the stated number doses (fog-formations), which a single can of 400 mL can deliver (3-4 doses) and the ethanol content (by mass) of the product. Compared to the maximum average exposure level set by the Danish Working Environment Authority (1000 ppm, 1900 mg/m<sup>3</sup>) the dose emitted during the 16 seconds of fog formation does not contain enough ethanol to surpass this value (calculated from the mass of ethanol in one dose (estimated to 133mL)), even in the tested room which is less than 1/10 the volume of what the *Xtratus* is able to fill.

In the application as fog fluid, neither propylene glycol nor ethanol are evaluated to cause corrosion. Water can potentially cause corrosion; however, deposited condensate will be in form of very small droplets, which will quickly evaporate from the surface. Propylene glycol persists longer on the surface, but will eventually also evaporate (depending on the amount of condensate and size of the droplets, this can range from hours to days).

Since propylene glycol is water soluble, it can be removed from surfaces with general cleaning procedures.

### 4.2 Circuit board inspection, conductivity and condensate test

Inspecting a circuit board under a microscope before and after exposure did not reveal signs of corrosion to the circuit board components or soldering.

The conductivity of the fog fluid was measured to < 1 µS at 22.9°C. In comparison, the conductivity of tap water was measured to > 600 µS at 23.5°C.

The amount of condensate identified on the test objects are summarized in Table 1

Table 1: Amount of condensate identified on each test object 1 hour, 24 hours and 7 days after exposure to the fog.

<b>Test objects</b>	<b>Time after exposure</b>		
	<b>60 minutes</b>	<b>24 hours</b>	<b>7 days</b>
<b>Circuit board 1</b>	3 mg	1 mg	0
<b>Circuit board 2</b>	1 mg	1 mg	0
<b>Circuit board 3</b>	4 mg	3 mg	0
<b>Average (rounded)</b>	3 mg	2 mg	0

After a period of 60 minutes at room temperature, the test objects had an average amount of condensate of 3 mg with the measured values ranging from 1 mg to 4 mg. After 24 hours the amount of condensate had lowered and after 7 days at room temperature, no remaining condensate could be measured on the samples. The amount of condensate was found to be highly dependent on the total horizontal area of the boards as boards placed vertically during the exposure had lowest amount of condensate.