NATO STANDARD

AEP-65

PERFORMANCE REQUIREMENTS AND TEST METHOD FOR PAINT SYSTEMS RESISTANT TO CHEMICAL AGENTS

Edition B, Version 1

AUGUST 2023

NORTH ATLANTIC TREATY ORGANIZATION

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NORTH ATLANTIC TREATY ORGANIZATION (NATO)

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NATO LETTER OF PROMULGATION

1 August 2023

1. The enclosed Allied Engineering Publication AEP-65, Edition B, Version 1, PERFORMANCE REQUIREMENTS AND TEST METHOD FOR PAINT SYSTEMS RESISTANT TO CHEMICAL AGENTS, which has been approved by the nations in the NATO ARMY ARMAMENTS GROUP (AC/225 NAAG), is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 4360.

2. AEP-65, Edition B, Version 1, is effective upon receipt and supersedes AEP-65, Edition A, Version 1, which shall be destroyed in accordance with the local procedure for the destruction of documents.

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4. This publication shall be handled in accordance with C-M(2002)60.

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Director, NATO Standardization Office

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Deputy Director
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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS
Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.	

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RECORD OF SPECIFIC RESERVATIONS

[nation]	[detail of reservation]
CZE	The testing of resistance to artificial weathering will not be provided by the method No. 6. The Armed Forces of the Czech Republic shall use standard CSN EN ISO 16474-2 instead. The total test time is 1000 hours.

Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.

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CHAPTER 1 SCOPE

1.1. Purpose

The aim of this Allied Publication is to guide project managers and paint specialists, to the test method defining the minimum quality of paint resistant to chemical agents for the protection of military equipment in accordance with the principles of AEP-7 and AEP-58. The method allows measurement on the same sample of the amount absorbed as well as the amount desorbed by the paint system in 15 minutes.

For the purpose of this document “chemical agent” is defined as “a chemical substance which is intended for use in military operations to kill, seriously injure, or incapacitate personnel through its physiological effects. The term excludes riot control agents, herbicides and substances generating smoke and flame.”

1.2. Application

The acceptance test procedures and acceptance criteria provided in this Allied Publication may be used by nations as a separate stand-alone requirement for paint systems and is not limited to joint NATO defence paint materiel projects which implement STANAG 4360 – 'Specification for Paint Systems, Resistant to Chemical Agents and Decontaminants for the Protection of Land Military Equipment.' The ratification of STANAG 4360 by any nation shall, however, automatically invoke this Allied Publication.

The procedures described in this document can also be used to evaluate other materials rather than being limited solely to a paint system.

1.3. Limitations

This test is a two stage procedure, firstly to measure the amount absorbed in a test panel and secondly to measure the amount of material transferred, in fifteen minutes, to a contact sampler held in intimate contact with the panel. The contact sampler is selected to be as representative as is practical of human skin – this is currently silica gel.

In an operational situation, unprotected personnel will come in contact with surfaces (post-decontamination) via sequences of “touches” of random frequency, duration and applied pressure. Several nations currently seek to relate the outcomes of laboratory test to the actual amount of agent accumulated by the individual in this operational context. Potentially, this work will allow a better definition of the actual contact exposure experienced by individuals. This will in turn allow a better pass/fail criteria for chemically resistant paints and coatings to be developed. It is recommended that

AEP-65 should be further revised when this work becomes mature enough for this to be achieved.

The current revision of AEP-65 allows candidate resistant paints to be ranked in terms of their performance, defining pass/fail criteria and giving a limited indication of the exposure that would be accumulated by an unprotected individual coming in contact with these materials in typical operational vignettes.

CHAPTER 2 REFERENCES

AEP–7 Chemical, Biological, Radiological and Nuclear (CBRN) Contamination Survivability Factors in the Design, Testing and Acceptance of Military Equipment

AEP-58 Combined Operational Characteristics, Technical Specifications, Test Procedures and Evaluation Criteria for Chemical, Biological, Radiological and Nuclear Decontamination Equipment”

ISO 1514:2016
Paints and Varnishes – Standard panels for testing

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CHAPTER 3 ACCEPTANCE CRITERIA

This Allied Publication contains the procedure for carrying out testing of the resistance of paints against all of HD, VX and GD.

The acceptance criteria, after the test procedure, are derived based upon an initial contamination equating to a 10 g / m² (1,000 µg / cm²) area density as detailed in AEP-7 Chapter 6. These criteria are detailed in Table 1 below:

Table 1 – Test Requirements

Agent	Pass criteria	
	Total Absorbed Quantity ($D_T/S + E_T/S$)	**Desorbed Quantity in 15 minutes (D_T/S)**
HD	≤ 60 µg / cm²	≤ 10 µg / cm²
VX	≤12 µg / cm²	≤1 µg / cm²
GD	≤12 µg / cm²	≤1 µg / cm²

Laboratories should report a pass or fail against AEP-65 for a specific paint system, based upon these acceptance criteria.

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CHAPTER 4 TEST MATERIALS AND PREPARATION OF TEST PANELS

4.1. Laboratory environmental conditions

Temperature of the laboratory should be controlled and between 23 ± 2 °C. If temperature control of the laboratory is not possible, the glassware used for contamination and the metal masses must to be conditioned to 23 ± 2 °C.

4.2. Materials and Products

The materials and products required for the test procedure are detailed as follows:

(a) Gas chromatograph;
(b) Thermo-regulated chambers (capable of maintaining 30 ± 2 °C);
(c) Multi-position magnetic stirrer or similar shake apparatus;
(d) Accurate gas tight precision syringes or calibrated pipettes for applying the chemical agent;
(e) Glass weighing bottles;
(f) Tweezers;
(g) Stopwatch;
(h) Measuring cylinder;
(i) Beakers, low form (250 ml capacity);
(j) Gastight flasks, weighing bottle or Erlenmeyer-type flask (100 ml capacity);
(k) Absorbent paper;
(l) Adsorbent material: aluminium sheet covered with silica (DC-Alufolien Kieselgel 60W, Merck), dimensions appropriate with those of painted test sample*;
(m) Metal masses (pressure applied: 2,000 Pa);
(n) HD, VX and GD chemical agents (minimum purity = 90 %);
(o) Solvent mixture for test panel extraction and HD and GD extraction from absorbent material:
    90/10 *v/v* mixture of *n*-heptane** and acetone**;
(p) Solvent mixture for VX extraction from absorbent material:
    99/1 *v/v* mixture of ethanol** and triethylamine**;
(q) Ethanol (95 % purity);
(r) Test Panels (25 cm^2);
(s) Print quality white paper.

* For the proper use of the absorbing material, the painted sample should be perfectly smooth. It is also necessary, when cutting the absorbing material, to avoid touching the area which will be in contact with the contaminated zone. Exposure of the sheet to high humidity should be avoided before the test, and the sheet should be stored in a desiccator for a minimum of 24 hours prior to use.
** Chromatographic grade.

4.3. Preparation and Painting of Test Panels

The quality of the prepared painted test panels is important for this test method. The panel substrate shall be Aluminium Alloy 5083 or 7020-T6 or Steel to ISO 1514. The 25 cm^2 test panels must be perfectly flat prior to the application of the paint system. The test panels, substrates and dimensions are shown in Table 2 below:

Table 2 – Test Panel Substrate and Dimensions

Substrate	Aluminium Alloy 5083 or 7020-T6 or Steel
Number of test panels required	18
Test panel dimensions	50 x 50 x 1* mm

* minimum thickness specified

Different sizes could be acceptable but this may affect reproducibility, it is a laboratory responsibility to conduct control measures as required.

Paint the 18 test samples in accordance with the paint manufacturers' instructions and according to ISO 1514:2016 for the paint system under test. The total thickness of the dry coating must comply with the requirements of the paint system under evaluation. The paint system must be surface clean, inclusion free with no other visual defects. All edges of the painted test panels must also be sealed with the paint system under test.

Leave the test panels to dry in standardized conditions, 23 ± 2 ºC and RH = 50 ± 5 % for 24 hours after which force dry the panels for a period of 10 days at 35 ± 2 ºC. The panels shall then be immediately wrapped individually in print quality white paper to avoid plasticiser migration from the packaging to the paint surface and dispatched to the testing facility by the quickest possible means. On receipt at the testing facility the panels shall be immediately unpacked and allowed to condition for 48 hours under standardised conditions 23 ± 2 ºC and RH = 50 ± 5 %.

CHAPTER 5 CONTAMINATION AND DECONTAMINATION PHASES

5.1. Contamination

On completion of the 48 hours conditioning time (detailed in Chapter 4) and under the same temperature conditions, for each of the following chemical agents, contaminate the painted areas on a 25 cm² surface in less than 150 sec, as shown in Figure 1, of at least 5 test samples (the quantities used approximate to 10 g / m² area density as detailed in AEP-7 Chapter 6):

- 20 drops of 1 µl of HD
- 25 drops of 1 µl of VX
- 25 drops of 1 µl of GD

Place each contaminated test sample in a glass airtight container and place the “test sample/container” assembly in a thermo-regulated chamber at 30 ± 2 °C for 90 ± 2 minutes. The air volume available within the box shall be the minimum possible and the drops shall not contact with the box lid.

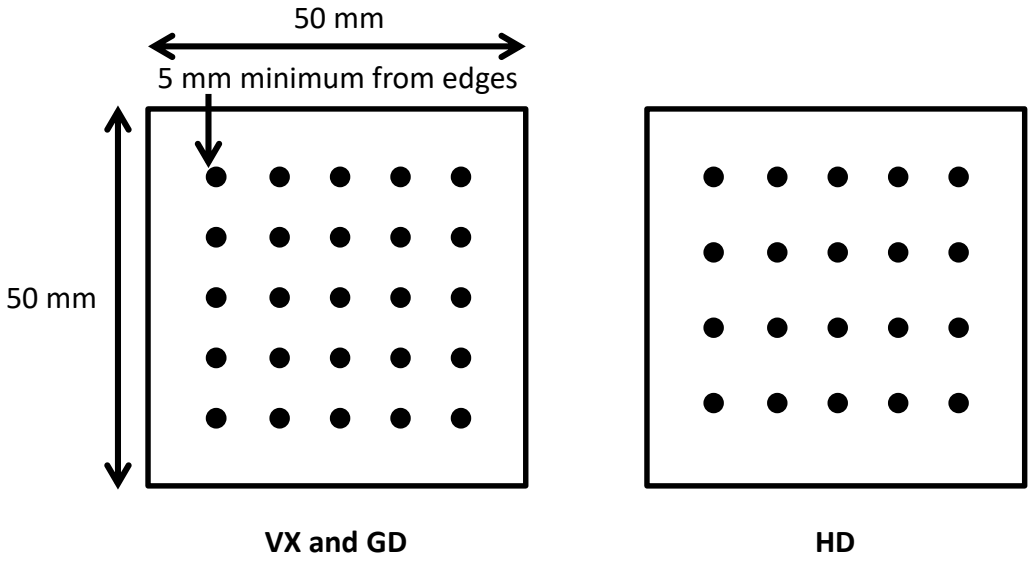

Figure 1 – Configuration of Contamination on Test Panels

5.2. Decontamination

After the contamination phase, immediately place each test sample in a 250 ml low form glass beaker containing 120 ml of ethanol at 95 % and placed on a multi-position magnetic stirrer or a shaking table. Ensure that the contaminated side of the sample is facing downward, and if using a magnetic stirrer ensure free movement of the magnetic stirrer bar beneath. The first contaminated sample is placed in the first beaker and timing commenced. Place the remaining contaminated samples within the remaining beakers.

After 30 seconds remove the samples from their beakers as quickly as possible, starting with the first contaminated sample, and dry *without rubbing* their surfaces, using absorbent paper.

CHAPTER 6 DESORBED CHEMICAL AGENT QUANTITY

6.1. Desorption procedure

On completion of the contamination and decontamination of the test panels (detailed in Chapter 5), for each of the chemical agents, operate on at least 5 contaminated test samples and proceed as follows:

(a) Place each test sample in a glass weighing bottle;
(b) Place the adsorbent material on each test sample, with the same dimensions as the sample and exert a pressure of 2,000 Pa (20 g / cm^2) on the entire assembly “test sample/adsorbent”, using a metal mass;
(c) Place the “test sample/adsorbent/mass” assembly in a thermo-regulated chamber at (30 ± 2) °C for 15 mins;
(d) Remove the “test sample/adsorbent/mass” assembly from the chamber.

Then carry out the following cycle of operations:

(a) Place each adsorbent material sample in an airtight weighing bottle containing 25 ml of appropriate solvent mixture;
(b) Place the closed bottles on a shake apparatus and leave to vibrate sufficient time to ensure extraction rate > 95 % from absorbent material;
(c) Remove immediately the adsorbent material samples and close the bottles;
(d) Determine the amount of chemical agent extracted (D_x)

Determine $D_{T(ave)}$, the *mean average* value of the D_x measurements, and determine the upper and lower 90% confidence interval. The appropriate value of D_T to use in calculations is the *upper* confidence limit.

6.2. Desorbed Chemical Agent Quantity calculation

Calculate the desorbed chemical agent quantity using the following formula:

$$\text{Desorbed Chemical Agent Quantity in 15 minutes } (\mu g / cm^2) = \frac{D_T\ (\mu g)}{S\ (cm^2)}$$

Knowing that S = 25 cm^2 (contaminated surface area).

6.3. Reference sample

Repeat the extraction using a reference sample of adsorbent material, which has been in contact with an uncontaminated painted test sample and compare with the gas chromatography results for contaminant extraction. This will account for any anomalies that may be inherent within the paint formulation or any other foreign matter.

CHAPTER 7 ABSORBED CHEMICAL AGENT QUANTITY

7.1. Extraction procedure

On completion of the desorption procedure of the test panels (detailed in Chapter 6), for each of the chemical agents, operate on the previous test samples just after desorption operation, and proceed as follows:

(a) Place each test sample in separate airtight weighing bottles containing 25 ml of solvent mixture;
(b) Place the closed bottles on a shake apparatus and leave to vibrate for 90 mins;
(c) Remove the test samples and close the bottles;
(e) Place each test sample in another bottle containing 25 ml of solvent mixture and repeat (a) – (c) until extracted amount is negligible;
(f) Determine, using validated gas chromatography methods, the amount of chemical agent extracted (E_x).

Determine $E_{T(ave)}$, the *mean average* value of the E_x measurements, and determine the upper and lower 90% confidence interval. The appropriate value of E_T to use in calculations is the *upper* confidence limit.

7.2. Extracted Chemical Agent Quantity calculation

Calculate the quantity of the extracted chemical agent per surface unit, using the following formula:

$$\text{Extracted Chemical Agent Quantity } (\mu g / cm^2) = \frac{E_T\ (\mu g)}{S\ (cm^2)}$$

Knowing that S = 25 cm^2 (contaminated surface area).

7.3. Reference sample

Repeat the extraction procedure using one uncontaminated painted test panel and compare with the gas chromatography results for contaminant extraction. This will account for any anomalies that may be inherent within the paint formulation or any other foreign matter. The number of extractions carried out on the reference panel shall be the same number as the one used for the contaminated test panels.

7.4. Total Absorbed Chemical Agent Quantity calculation

Calculate the total quantity of the absorbed chemical agent per surface unit. To do this, sum the chemical agent quantity per surface unit extracted from the test samples following the desorption procedure and the chemical agent quantity per surface unit desorbed in 15 minutes from the test samples. The formula to use is as follows:

$$\text{Total absorbed Chemical Agent Quantity } (\mu g / cm^2) = \frac{E_T}{S} + \frac{D_T}{S} = \frac{E_T + D_T \text{ (ug)}}{S\ (cm^2)}$$

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