NATO STANDARD

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ON-THE-MOVE CBRN PROOF HYDRATION SYSTEM

Edition A Version 1
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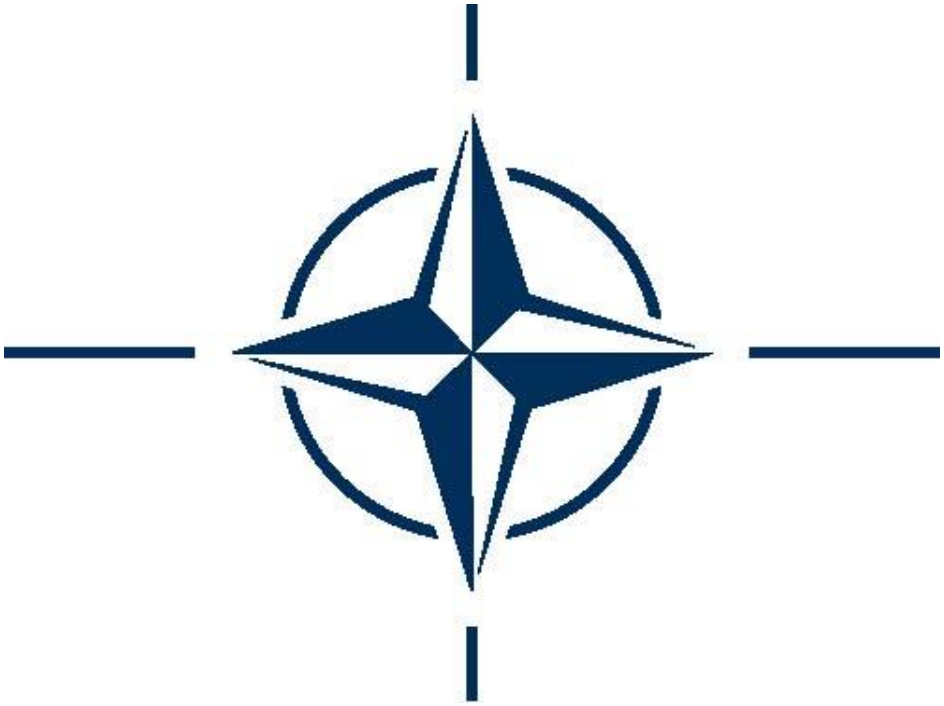

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NATO LETTER OF PROMULGATION

3 June 2021

1. The enclosed Allied Engineering Publication AEP-4810, Edition A, Version 1, ON-THE-MOVE CBRN PROOF HYDRATION SYSTEM, which has been approved by the nations in the NATO ARMY ARMAMENTS GROUP (NAAG), is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 4810.

2. AEP-4810, Edition A, Version 1, is effective upon receipt.

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

Zoltán GULYÁS
Brigadier General, HUNAF
Director, NATO Standardization Office

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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]
FRA	French law bans the use of Bisphenol A in materials intended to come into contact with food. If there is evidence that an on-the-move hydration system contains Bisphenol A, France will neither accept nor use it.
USA	i. Regarding page 3-1, 7th para, “The CBRN HS has to be marked permanently with its manufacturing and end-of-use date” and page 3-5 para 3.18, “The date of manufacture shall be marked permanently with expiration date”. The U.S. reserves the option to either permanently mark or not mark, the “end-of-use date” or “expiration date” based on current policy and guidance. ii. The U.S. expects that approved text will be harmonized with capstone and keystone Allied Joint Publications (AJPs) otherwise the U.S. will use national joint doctrine to overcome variances.
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CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION

The combatants of the armed forces of NATO countries could, in extreme weather conditions, carry up to six litres of water, which are usually carried on their load-bearing equipment, in a container such as the canteen. The use of the canteen entails the use of at least one hand while the water ingestion takes place. This does not allow the soldier to fulfil basic tasks and drink at the same time. The use of On-The-Move hydration systems is widespread among the armed forces of most NATO countries. No NATO CBRN protection requirements are set regarding these kinds of Hydration Systems. The use of a non-CBRN hydration system in an area contaminated with CBRN substances could cause internal CBRN contamination of soldiers via ingestion, reducing the military operational capability.

1.2 PURPOSE

The purpose of this Allied Engineering Publication (AEP) is to assist in the development, acquisition and evaluation of On-The-Move CBRN Proof Hydration System (CBRN HS). It will assist: the materiel acquisition community; those involved in setting requirements for personal protection; and in the research and development, testing and evaluation of CBRN protective equipment. This document is intended to be used in conjunction with the references cited below. Meeting the requirements of this document will provide NATO Forces the capability to hydrate, hands-free and on-the-move, as well as considering, as desirable, the capability of refilling or replacing the system in an area contaminated with CBRN substances, to maintain operational tempo in an area contaminated with CBRN substances.

- STANAG 2136: Requirements for water potability during field operations and in emergency situations (AMedP-4.9, Edition A, Ver.1).
- STANAG 2311: Principles Governing the Design of the Individual Load Carrying Equipment of the Combat Soldier.
- STANAG 2499: The Effect of Wearing CBRN Individual Protective Equipment (IPE) on Individual and Unit Performance During Military Operations (ATP-65).
- STANAG 2885: Emergency Supply of Water in Operations
- STANAG 4370: Environmental Testing - AECTP-100 - 600
- STANAG 4563: Tropical field clothing system climatic zones (B1 B2 B3)
- STANAG 4475: Interoperability Criteria for Mask Drinking Systems (MDS).
- STANREC 4548: Operational Requirements, Technical Specifications and Evaluation Criteria for CBRN Protective Clothing (AEP-38).

- STANREC 4725: Fit and protection testing methods for negative-pressure respirators (AEP-71).
- STANREC 4727: Combined Operational Characteristics, Technical Specification and Evaluation Tests and Criteria for Protective Masks (AEP-73).
- STANREC 4741: Chemical, Biological and TIC Challenge Levels (AEP-72).
- STANREC 4780: Soldier Physical Load Configurations (AEP-4780).
- Regulation (EC) No 1935/2004: Materials and articles intended to come into contact with food.
- NSF/ANSI 61-2016: Drinking Water System Components – Health Effects
- Magnuson B. et al. (2013), Review of the regulation and safety assessment of food substances in various countries and jurisdictions, Food Additives and Contaminants Part A 30:7 1147-1220.
- ISO 527-3 Plastics -- Determination of tensile properties -- Part 3: Test conditions for films and sheets

1.3 DEFINITIONS

On-The-Move CBRN Proof Hydration System within the context of this document signifies the capability of an individual to consume water[1], directly or through the CBRN mask/respirator in an area contaminated with CBRN substances, from a hands-free device carried on him.

A refillable CBRN HS is defined as able to be replenished with fluid.

A replaceable CBRN HS is defined as the ability to quickly and efficiently switch or replace a used or expired CBRN HS with a new and full one.

A bite valve is defined as a device enabling hydration when the CBRN HS is not connected to a respirator.

A respirator adapter is defined as a mechanism fitted to the CBRN HS enabling it to be connected to a respirator.

1.4 CONCEPT

Operations have evolved such that a hands-free hydration system is desirable, allowing the soldiers to continue any task without interruption caused by water consumption. Water consumption, wearing a CBRN IPE, according to ATP-65, varies depending on the weather

[1] It is recommended that the system be only filled with water, however, other fluids may be used at the discretion of nations, noting that use of other fluids may increase the risk of bacterial growth in the system and so appropriate cleaning regimes should be used to mitigate this risk.

conditions and task performed. Varying operational and climatic conditions require a CBRN HS that allows soldiers to hydrate on their own safely in an area contaminated with CBRN substances, and through a respirator, if needed.

The CBRN HS consists of a reservoir with a filler opening cap, a hose with a mechanism to shut-off fluid flow from the reservoir, an optional bite valve and a respirator adapter to connect to the respirator. It could have a carry case and/or a protective cover if needed. The system, once contaminated and if not refillable or replaceable, is considered as disposable. It is desirable that the CBRN HS be refillable or replaceable in a contaminated area.

1.5 INTEROPERABILITY

This document aims to enhance interoperability between North Atlantic Treaty Organization (NATO) forces. For this, the CBRN HS should be compatible with different respirator models in service in the armed forces of NATO countries.

1.6 APPLICABILITY

The requirements, specifications, test methods and criteria in this document are intended primarily for use when designing, acquiring and evaluating CBRN HS for both general combat and CBRN specialist tasks.

1.7 SCOPE AND LIMITATIONS

When using the expression “On-The-Move CBRN Proof Hydration System”, at a minimum, the reservoir, the hose, shut-off mechanism and respirator adapter, are included. If the desirable refilling capability is provided, then the associated filling valve is part of the Refillable CBRN HS. Associated capabilities for the CBRN HS Refilling System are discussed in §2.3.3.

1.8 CONTEXT

NATO operations need to be planned and conducted against a background of the possible use of CBRN weapons, devices and substances.

Additionally, across the whole spectrum of conflict, there may be a risk of exposure to CBRN substances. NATO Forces, therefore, need to not only be capable of defending against conventional attacks but also be proficient in conducting operations in a CBRN contaminated area. These latter conditions can result either from the intentional use of CBRN substances or from the release of Toxic Industrial Materials (TIM).

1.9 OPERATIONAL ENVIRONMENT

NATO Forces should be able to use a CBRN HS in all operations throughout the battle space, whether on land, at sea or airborne. Therefore, it should withstand the conditions associated with such use and maintain its performance.

The CBRN HS will maintain operational capability regarding any operation, by providing the soldiers full freedom of action, as well as improving the ability of NATO Forces to survive and/or

operate in a CBRN contaminated area. This hydration system gives the opportunity to extend the operational capability time frame.

It is envisioned that it will be exposed to the environmental conditions discussed in the Allied Environmental Conditions and Test Publication (AECTP) (covered by STANAG 4370, Environmental Testing) to include, as a minimum, temperature and humidity extremes, high/low operational and storage temperature, temperature shock, vibration, solar radiation, salt spray/fog, seawater, rain, blowing sand and rain, dust, sweat, fungus, transit drop, as well as petroleum, oil, and lubricant contaminants.

An item that is disposable once contaminated and not refillable in a contaminated area will give the minimum capability; the desirable capability to refill in a contaminated area will extend that capability.

1.10 OPERATIONAL REQUIREMENTS

The CBRN HS provides Forces of NATO Countries the ability to hydrate at will during the performance of mission critical functions in an expeditious and convenient manner. CBRN HS allows the commanders to maintain the viability and functionality of the NATO Forces, at an operational pace, in all environments.

Examples of operational requirements that are addressed in this effort include: durability, reliability, maintainability, refillability/replaceability, and survivability in all operational environments.

This system could be used in both CBRN and non CBRN operations. Environmental conditions set in 1.9 “Operational Environment” and different types of TIM might affect the protection level offered by the hydration system depending on the materials used, therefore surface contamination has to be avoided e.g. by using an additional protective cover.

The reservoir may be insulated from extreme environmental influences (heat and cold) and allow a pressure compensation for the use in high altitude.

The CBRN HS needs to be manufactured from materials that fulfil these requirements; alternatively, the hydration system’s pouch/covering could provide the required protection.

1.11 CURRENT CAPABILITY

Although some NATO nations’ armed forces use a CBRN HS, many others use a CBRN proof canteen or an on-the-move non-CBRN hydration system. Such systems should provide freedom of action combined with high comfort and necessary volume of water to be carried on the individual. Non-CBRN proof hydration systems do not give CBRN Physical Protection. No NATO CBRN requirements are set regarding these systems.

1.12 CAPABILITY DESIRED

The CBRN HS provides higher level of CBRN Physical Protection to the contents compared to the non CBRN proof ones, as well as higher comfort, and freedom of action to the user compared to the CBRN canteen in use by NATO nations.

This system allows for safer interoperability between NATO and its partners; facilitating and improving the speed and safety of on-the-move hydration of personnel whilst operating in an area contaminated with CBRN substances. This enables NATO equipment developers to maintain a material advantage for their forces against developing and maturing threats.

It provides the Commanders greater flexibility to face the complex battlefield conditions.

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CHAPTER 2 CBRN PROTECTION OF THE ON-THE-MOVE CBRN PROOF HYDRATION SYSTEM

2.1 CHALLENGE LEVELS FOR ON-THE-MOVE CBRN PROOF HYDRATION SYSTEM

AEP-72 sets the CBRN challenge levels to which protective equipment should be designed to allow unaffected operations. These levels are defined as the chemical, biological and TIC concentration, dosages and contamination densities over time that can be expected in the field during realistic attacks.

The challenge levels considered as essential and desirable are those related to a symmetric attack, which are set in AEP-72 Vol I.

2.2 TOXICOLOGICAL LEVEL

AMedP-4.9 establishes a standardised approach to ensure the quality of drinking water provided to the troops during all field operations (exercise, Article 5 or non-Article 5). It also establishes the minimum requirements for potability of drinking water provided to troops in a theatre of operations during emergency situations. Annex A of AMedP-4.9 includes Minimum Standards for Emergency Situation (MSES) for short term (≤ 7 days) water consumption. These MSES include, among other chemicals, arsenic, chloride, cyanide, lewisite (arsenic fraction), sulphur mustard, nerve agents, and T-2 toxins, as well as radiological specific activity (alpha, beta and gamma).

2.3 PROTECTION AGAINST CBRN HAZARDS

The various tests related to CBRN protection performance can be done separately but alternately in an accumulative way; in the latter case they could be carried out before or after any other mechanical tests required (e.g. environmental (3.9), drop (3.10), pressure (3.11, freezing (3.12)) .

2.3.1 RESPIRATOR CBRN PROTECTION

The CBRN HS will provide NATO nations´ armed forces with the ability to hydrate, with and without their protective respirator, and with no degradation of the respirator protection factor.

2.3.2 DURATION OF CBRN PROTECTION

Essential: Once removed from packaging and put into use, the CBRN HS will prevent contamination of the water by traditional CWA and TIM for 6 hours of continuous exposure.

Desirable: Once removed from packaging and put into use, the CBRN HS should prevent contamination of the water by traditional CWA and by TIM for 24 hours of continuous exposure.

Note: *This duration of protection may be achievable by various means, including TTP's that reduce the magnitude and duration of exterior contamination after it has occurred.*

2.3.3 REFILLING SYSTEM

If a refilling system is utilized the CBRN HS is designed to be used in both areas contaminated with CBRN substances, and non CBRN contaminated areas. This means that combatants could ingest water from the CBRN HS in a CBRN contamination area whilst minimising any added risk for their health. The CBRN HS shall be refillable under any light and weather conditions within the operational temperature range defined in section 3.9, and shall be compatible with military water container and/or commercial water reservoir (directly or through any adaptors that can make the connection to military and commercial water reservoir).

Note: *If the CBRN HS is designed to be able to be refilled in an environment contaminated with CBRN substances, it is anticipated that the CBRN HS will be supplied with appropriate interfaces and equipment to enable this to occur safely. For the purposes of this document this capability is referred to as the "Refilling System".*

Essential: A refillable CBRN HS that has not been exposed to CBRN substances must be refillable.

Desirable: A refillable CBRN HS that has been exposed to CBRN substances must be refillable in an area contaminated with CBRN substances, and it will prevent contamination of the water during connection, disconnection, and refilling.

It could be necessary that the CBRN HS be refilled in such area, if so, the Refilling System will meet the same CBRN protection requirements as the CBRN HS.

The Refilling System should be resistant to degradation from decontamination solutions.

The Refilling System shall be operable in Dress State 4R (wearing mask, gloves, suit and overboots).

Any portion of the Refilling System exposed to the contaminated area must prevent contamination to the same standard as the CBRN HS.

Note: *Chemical contamination of the CBRN HS contents could occur through both penetration through the system materials as well as during the refilling process. It is expected that in the case of radiological or biological contamination it is only during the refilling process that any contamination can be introduced into the potable water, as construction materials will be proof against penetration. Therefore, for such agents, it is the number of refills that is important. Nations may determine the balance of risk between the number of refills required versus the carriage burden imposed by the capacity of the reservoir for the specifics of the mission.*

2.3.4 REPLACEMENT SYSTEM

If a replacement system is utilized, the CBRN HS is designed to be used in both areas contaminated with CBRN substances, and non CBRN contaminated areas. This means that combatants could ingest water from the CBRN HS in a CBRN contamination area whilst

minimising any added risk for their health. The CBRN HS shall be replaceable under any light and weather conditions within operational temperature range defined in section 3.9.

Essential: A CBRN HS that has not been exposed to CBRN substances must be replaceable.

Desirable: A CBRN HS that has been exposed to CBRN substances must be replaceable in an area contaminated with CBRN substances, and it will prevent contamination of the water during connection, disconnection, and replacement.

It shall be possible to replace the CBRN HS in a CBRN contaminated area whilst in Dress State 4R (wearing mask, gloves, suit and overboots).

Note: *Chemical contamination of the CBRN HS contents could occur through both penetration through the system materials as well as during the replacement process. It is expected that in the case of radiological or biological contamination it is only during the replacement process that any extra contamination can be introduced into the potable water, as construction materials will be proof against penetration. Therefore, for such agents, it is the number of replacements that is important. Nations may determine the balance of risk between the number of replacements required versus the carriage burden imposed by the capacity of the reservoir for the specifics of the mission.*

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CHAPTER 3 DESIGN FACTORS FOR ON-THE-MOVE CBRN PROOF HYDRATION SYSTEM

The CBRN HS is manufactured from flexible and odourless food safe materials that must not be harmful to health. It must not impart an unpleasant or unpalatable taste.

The system could be covered by a pouch or a covering layer that protects the liquid storage from external CBRN contamination. The pouch or the covering must be compatible with NATO load carriage systems and will therefore have fastening elements. If applicable, the pouch or the covering will be designed so that it can be used (alternatively) without a load carriage system.

The design of the CBRN HS will be such that it will not increase the amount of air that is ingested with fluid as the reservoir is emptied.

All parts of the CBRN HS must be resistant to corrosion. All parts being in direct contact with drinking water should have a high effective antimicrobial and antibacterial coating (unless water has a residual chlorine concentration that meets potability standards) and during normal use must be disinfected after use, so they must be resistant to dry rot, mildew and disinfectants (calcium hypochlorite, sodium hypochlorite, lithium hypochlorite, chlorinated isocyanurates, hydrogen peroxide). The system has to be designed for easy cleaning. A cleaning kit and a drying tool could be part of each system.

The maximum material expansion of the reservoir may not exceed 15% (according to ISO 527-3).

The length of the hose should be long enough to allow the combatants to move properly but not so long as to hinder their movement, especially inside vehicles.

The CBRN HS has to be marked permanently with its manufacturing and end-of-use date. If applicable, maintenance instructions should be printed on the reservoir.

For the Refillable CBRN HS, the refilling valve must be proof against entry of contamination; it is expected that a combination of design and procedures may be required to maintain its integrity against contamination prior to and during the filling process.

3.1 TOXICITY (INTRINSIC)

All parts in direct contact with drinking water during normal use should be made of food grade material (food contact substance) in accordance with Regulation (EC) No 1935/2004 or equivalent requirement accepted by each Nation’s military (example: NSF/ANSI Std 61 or Magnuson *et al.* for a review of national regulations), through the life cycle.

3.2 VOLUME OF WATER

Essential: The CBRN HS will be able to transport at least 1 litre of water.

Desirable: The CBRN HS should be able to transport at least 4 litres of water.

3.3 FLOW

Essential: The CBRN HS shall meet the water flow requirements as defined in STANREC 4727 (AEP-73). The flow to the mask will not require inversion of the reservoir or require more than 3 kPa of suction to draw fluid through it.

3.4 FLUID REGULATOR

Essential: The CBRN HS will enable user to turn off the fluid flow. The regulator must be easily accessible and durable.

3.5 FLUID LEVEL INDICATOR/REFILL INDICATOR

Desirable: The CBRN HS should be designed with a fluid level indicator/refill indicator so that the user can easily determine when it requires refilling, when filling is complete and the rate of water consumption.

3.6 WEIGHT

Essential: The weight of the empty CBRN HS, without carrier, must be less than or equal to 500 grams.

Desirable: The weight of the empty CBRN HS, without carrier, should be less than or equal to 350 grams.

3.7 SERVICE LIFE

Essential: Once put into normal use, at least 30 days.

Desirable: Once put into normal use, at least 5 years.

3.8 VISUAL AND AUDITORY SIGNATURE

Consideration should be given to minimising the increase in visual and auditory signature of a user wearing the CBRN HS in the design of the system.

Essential: The CBRN HS must not increase the visual signature of the user

Desirable: The CBRN HS should not increase the likelihood of detection of the user.

3.9 ENVIRONMENT

Essential: The CBRN HS must be capable of being used by armed forces of NATO countries in any terrain type and climatic condition above 0ºC.

Desirable: The CBRN HS should be capable of being used by armed forces of NATO countries in any terrain type and climatic condition. Protection from freezing may be provided by a combination of design and TTPs.

3.10 DROP TEST

The CBRN HS must be designed to survive a Transit Drop test in accordance with Method 414 Procedure 1 of STANAG 4370 AECTP-400 (Mechanical Environmental Tests), in any orientation, with no leaks, when it is completely full of water. The test is to be conducted with the CBRN HS removed from its packaging and filled with water up to its maximum design water capacity. This is a deviation from method 414 Procedure 1 STANAG 4370 which calls for the system to be tested whilst packaged. Following completion of the tests the CBRN HS should be visually inspected to confirm that no water leaks have occurred.

Essential: The tests shall be conducted with the CBRN HS configured for use (including carriage system if integral to the system).

Desirable: The tests shall be conducted on the reservoir standalone configuration (i.e. removed from its carriage system).

3.11 PRESSURE

In order to demonstrate resistance to bursting when dropped or if the wearer falls onto the CBRN HS, it must survive a compression test.

The CBRN HS with the reservoir filled to capacity shall be laid flat and compressed at the centreline with a 150 mm diameter compression platen on a compression test machine. The compression platen should be sited such that it is in contact with a flat area of the reservoir and not in contact with any fittings (filling port, hose, etc.) where possible. The test machine shall be set to a 250 kg cyclic compression cycle. Any mechanical valves that restrict the flow of water shall be closed during the test. There shall be no damage or leakage from the CBRN HS after three compression cycles at a speed of 12 mm/minute.

Essential: The tests shall be conducted with the CBRN HS configured for use (including carriage system if integral to the system).

Desirable: The tests shall be conducted on the reservoir standalone configuration (i.e. removed from its carriage system).

3.12 FREEZING

Essential: The CBRN HS must survive expansion caused by freezing (filled to capacity) starting at 22 °C, and lowered to -20 °C, held until the contents are fully frozen. The CBRN HS must retain system integrity following freezing.

3.13 INTEGRATION WITH RESPIRATOR

Essential: During preparation and operation of the CBRN HS, the protection factor of the respirator must not fall below the minimum acceptable value as defined in STANREC 4727 (AEP 73).

3.14 CONNECTION

Essential: The CBRN HS should remain connected with the respirator during operational use and disconnect only when deliberately disconnected by the user. Connection of CBRN HS to the respirator must not require the assistance of another and must take less than 2 minutes.

Desirable: Connection of CBRN HS to the respirator should take less than 1 minute and not require the assistance of another.

3.15 USER PERFORMANCE

Essential: The CBRN HS will not prevent the user from accomplishing mission essential functions or degrade user performance (e.g. engaging targets, operating necessary equipment, vision, head movement, voice, etc.).

3.16 EQUIPMENT COMPATIBILITY

During accomplishment of mission critical functions, the flow rate will be unrestricted.

Essential: The CBRN HS will be fully compatible with all existing load-bearing equipment and CBRN individual protective equipment (respirator, headgear, CBRN suit, CBRN gloves, footwear, handwear) that contribute to providing full body protection.

Desirable: The CBRN HS should be compatible with procedures and devices meeting the requirements of STANAG 2885 (Emergency Supply of Water in Operations), and/or the Self-Contained Breathing Apparatus (SCBA) equipped with a connector that allows hydration.

3.17 FLAME RESISTANCE

It is desirable that the elements of the CBRN HS that are not covered by any kind of CBRN proof poncho, IPE or carrier, should perform in accordance with STANREC 4727 (AEP 73) regarding the flame and fire, in the case that they are hard or elastomeric materials. If they are fabric type, they should perform in accordance with STANREC 4548 (AEP-38), regarding the resistance to thermal radiation.

3.18 PACKAGING

Essential: The CBRN HS will maintain full capability throughout its stated shelf-life. The packaging will prevent the System from being adversely affected by prolonged storage under any climatic conditions (e.g. precipitation, salt spray, UV, hot/dry, or temperature/humidity cycling) or exposure to substances such as CBRN substances, petroleum/oil/lubricant (POLs),

flight line chemicals, etc. The date of manufacture shall be marked permanently with expiration date (if applicable) on each CBRN HS packaging, as well as the collective packaging.

Desirable: The CBRN HS will be packaged in chemical agent-resistant material, which can be decontaminated by an individual using the standard personnel equipment decontamination kit.

3.19 SHELF LIFE

Essential: The Shelf Life of the CBRN HS must be a minimum of 5 years.

Desirable: The Shelf Life of the CBRN HS should be a minimum of 10 years.

3.20 CARE AND MAINTENANCE

For non-CBRN Operations, the external surface of the CBRN HS must be easily cleaned using national field available means (e.g. cleaning solutions) without damage or deterioration of the materials.

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ANNEX A CHEMICAL RESISTANCE TESTING OF THE CBRN HS

A.1 INTRODUCTION

The entire hydration system will be evaluated to determine the CBRN HS protective capability against nerve agents and sulphur mustard after 6 hours (essential) or 24 hours (desirable) of exposure. Specifically, the calculated amount of CWA with its respective hydrolysis products found to permeate/penetrate the test samples, must be below that which is allowed by STANAG 2136 (AMedP-4.9) for 15 litres of water consumption (per day) by a 70 kg human per for up to seven (7) days. In the table below the values are presented, expressed in maximum allowable quantity (in µg) measured in the tests.

Chemical agent	(µg)	mg/L
Nerve agent	60	0.004
Sulphur Mustard	705	0.047

Each test will be conducted for six (6) hours (essential) or 24 hours (desirable), as these systems are designed to provide chemical protection for that amount of time.

For evaluation of the CBRN HS with nerve agent, the medium volatility agent Soman (GD) is selected as representative agent. Further, sulphur mustard (HD) is selected as being the most common blistering agent. Other agents (e.g. TGD) may also be tested in accordance with national requirements.

In paragraph 2 the standard test protocol is prescribed, being the evaluation of the chemical resistance of the complete water-filled CBRN HS with droplets of HD and Soman (GD). A sample of the water will be taken after 6 hours (essential) or 24 hours (desirable) and analysed for the presence of HD and GD and possible degradation products by means of analytical techniques.

Three additional alternative testing methods are presented after in paragraph 3:

- Quantitative swatch testing of the reservoir material with droplets of HD and GD. A liquid agent swatch test is carried out on samples of the reservoir material. The measured quantity of permeated agent is afterwards converted to a permeated quantity of the entire reservoir.
- Quantitative test of hose (with the reservoir connection) to respirator adapter with droplets of HD. A liquid test with HD will be performed on the hose and respirator adapter combination. This test is to verify the hose and respirator adapter combination as such.
- Qualitative swatch tests of reservoir material. The reservoir material (and seams) are tested with HD and detection will take place by means of detection paper (SD-method). This testing method can be used for production control or life cycle purposes of the reservoir material.

A.2 STANDARD TEST PROTOCOL

A.2.1 GENERAL

- Per CBRN HS design, six (6) pieces shall be tested with HD and six (6) pieces with GD.
- Droplets of agent shall be placed on the front and backside of the CBRN HS and, for practical reasons, three (3) systems per chemical agent will be contaminated on the front side and three (3) on the backside.
- Droplets of the chemical agents shall be placed directly onto the reservoir materials, so all covering parts (tube covers, carrier systems e.g.) shall be removed prior to placing the droplets. This represents a worst-case scenario.
- A contamination density of 5 g/m^2 (essential) or 35 g/m^2 (desirable) as defined in AEP 72 Vol 1 shall be applied and the droplets of HD or GD shall be evenly distributed over all parts of the system including seams, gaps/interfaces at the connectors, respirator adapters et cetera.
- To decide the quantity of droplets to be applied on a certain surface of the CBRN HS, an overview of the material surface of the several parts of the system shall be available.
- The droplet size shall be either 1 or 10 µl and the choice of droplet size depends on the material surface to be covered.
- Water samples from the reservoirs shall be analysed, depending on applied agent, for the presence of HD and its degradation product thiodiglycol (TDG), or of GD and its degradation products pinacolyl methyl phosphonic acid (PMPA) and methyl phosphonic acid (MPA).

A.2.2 TEST EQUIPMENT

- Fume hood or climatic chamber: sufficiently large to accommodate six (6) samples in one (1) trial. The test chamber shall be capable of meeting the required environmental conditions and recording them at least every five (5) minutes.
- Agent dispenser. The purpose of the dispenser is to reproducibly and safely apply chemical warfare agent to the test items. Agent shall be applied using a dispenser capable of dispensing 1 and 10 µl drops (accuracy ± 5%). The purity of the agent shall be 95% or higher.
- Analytical Instrumentation to quantify any HD and GD (plus degradation products TDG, PMPA and MPA) present in the organic extract of the water samples taken from each test item. All instrumentation shall be calibrated for the specified compounds prior to any sample analysis.

A.2.3 TEST PROCEDURE

A.2.3.1 TEST ITEM RECEIPT INSPECTION

Upon receipt, each test item shall be inspected and verified to be undamaged and in working condition. All covering parts (tube covers, carrier systems e.g.) shall be removed prior to testing. A visual inspection and leak test shall be made of the test item prior to testing to verify

its physical integrity is intact. The leak test includes filling the reservoirs with water and visually looking for any water leaks. Test items that have rips, tears or other physical defects shall not be tested.

A.2.3.2 DROPLET DISTRIBUTION PATTERN

In order to realize an evenly distributed contamination over the entire system and all its parts:

- Calculate the total surface of the CBRN HS (reservoir, tube, seams, adapters et cetera) that can come into contact with chemical warfare agents. Count the values of all separate parts.
- Calculate the total volume of HD and GD that must be used to create a 5 g/m^2 (or 35 g/m^2) contamination density, taking into account the calculated total surface area of the system.
- Calculate the volume of HD and GD that needs to be applied on the several parts of the CBRN HS, based on the calculated surface area.
- If the volume to be applied is less than 10 µl, choose a droplet size of 1 µl for that area.
    - If the volume to be applied exceeds 10 µl, choose a 10 µl droplet size for that area. Additional 1 µl droplets can be added to get the correct volume of agent.
    - Due to rounding up the values, some deviation cannot be avoided and therefore a deviation of 5% of the total applied volume is allowed.
- Create a table containing the above information. An example of such a table is presented in Appendix 1 to Annex A.

A.2.3.3 SAMPLE PREPARATION

Each test CBRN HS is filled with one (1) litre of HPLC-grade water via the filling port; one (1) litre of water is used in order to meet the required detection limits. All air must be removed from the reservoir and tubing.

The test items must be placed in a fume hood or cabinet and the test temperature is to be controlled at (22 ± 2) °C. The test may also be conducted at alternative temperatures in accordance with national requirements. Air is drawn over the top surface with a speed within the range of 0.3 – 0.7 m/s. Place reservoirs in the fume hood or cabinet in a way that 3 reservoirs are positioned with the front side facing up and 3 reservoirs with the backside facing up. If a cabinet is used the vapour concentration within the cabinet may be monitored during the test.

A.2.3.4 AGENT APPLICATION

The agent is applied with a dispenser on the pre-defined areas of the test items using the calculated droplet volume and droplet quantity (see example table below) that will achieve the chosen contamination density. During the agent application of all of the test items, the start time of the first test item contaminated shall be recorded as the spiking start time. Once application to the first test item is complete, the time shall be recorded as the end of contamination. This process shall continue for all test items.

After the completion of contamination, the test start time shall be annotated. During the test, temperature and relative humidity shall be recorded and the data interval shall be no greater than five (5) minutes.

A.2.3.5 SAMPLING AND ANALYSIS

After 6 hours (essential) or 24 hours (desirable) a sample of 0.1 litre of water is taken from each test item via the drinking valve. The water sample is collected in a clean flask. Any contact with the outside of the systems is to be avoided. This sample represents the water present in the hose and respirator connection adapter.

After this first sample has been taken, the remainder of 0.9 litre water will then be drained from each test item via the drinking valve. This water sample is also collected in a clean flask. Any contact with the outside of the systems is to be avoided.

All water samples shall be analysed for the presence of HD and GD and also for its degradation products thiodiglycol (TDG) and pinacolyl methylphosphonic acid (PMPA) and methylphosphonic acid (MPA) by means of an appropriate analytical techniques.

A.2.3.6 QUALITY CONTROL

It is recommended to add a negative control to each test series. The purpose of the negative control is to identify any agent carryover caused by positive or negative analytical interference. The negative control is to be an additional CBRN reservoir, identical to the items under test, filled with one (1) litre of HPLC-grade water. At the end of the test, a 0.1 litre water sample followed by a 0.9 litre water sample is taken from the reservoir and analysed identically to the samples of the items under test.

A.2.3.7 RESULTS

A.2.3.7.1 MEASUREMENTS

The following measurements are made during each trial:

- Agent mass (both the intact agent and the degradation products) collected in each sample (tube and reservoir samples).
- Air temperature and relative humidity during the test.
- Result of negative control sample.
- Time of sample collection.

A.2.3.7.2 CALCULATIONS

The results for the test items are reported as total concentration of agent per litre of water. Quantity of degradation products is converted into the quantity of the intact agent.
To obtain the correct values, the following 4 steps are made:

1. Convert measured mass of each measured compound from µg into µmol:

Moles (µmol) = Mass (µg) / Molecular Weight (µg/µmol)

Molecular weight (µg/µmol) of the different compounds are:

HD	159.07
TDG	122.18
GD	182.17
PMPA	180.18
MPA	96.02

Note: if results are below minimum detectable level of the analytical equipment, the minimum detectable value is used to make the calculations.

2. Count total moles for HD and GD test:

   Total moles HD test (µmol): Moles HD + Moles TDG

   Total moles GD test (µmol): Moles GD + Moles PMPA + Moles MPA

3. Convert moles into total mass of HD and GD

   Total mass HD (µg): Total moles HD test (µmol) * Molecular Weight HD (µg/µmol)

   Total mass GD (µg): Total moles GD test (µmol) * Molecular Weight GD (µg/µmol)

Example:

A reservoir filled with 1 L of water was tested with HD and a total mass of 5 µg of HD and 10 µg of TDG was detected during analyses.

1. Convert measured mass of each measured compound from µg into µmol:

   Moles HD = 5 µg / 159.07 µg/µmol = 0.031 µmol

   Moles TDG= 10 µg / 122.18 µg/µmol = 0.082 µmol

2. Count total moles for HD test:

   Total moles HD test: 0.031 µmol + 0.082 µmol = 0.113 µmol

3. Convert moles into total mass of HD

   Total mass HD (µg): 0.113 µmol * 159.07 µg/µmol) = 18 µg

A.3 ALTERNATIVE TEST

If for some reason system testing of the reservoirs as described above is not possible, three alternative testing methods are presented below:

A.3.1 QUANTITATIVE SWATCH TESTING OF THE RESERVOIR MATERIAL

A.3.1.1 TEST ITEM RECEIPT INSPECTION

Upon receipt, each test item shall be inspected and verified to be undamaged and in working condition. All covering parts (tube covers, carrier systems e.g.) shall be removed prior to testing. A visual inspection shall be made of the test item prior to testing to verify its physical integrity is intact. Test items that have rips, tears or other physical defects shall not be tested.

A.3.1.2 GENERAL

A piece of flat material, cut from the reservoir material, is fixed in a sample holder and the assembled test cell is checked for leak tightness. Per CBRN HS design, three (3) pieces shall be tested with HD. A contamination density of 5 g/m^2 (essential) or 35 g/m^2 (desirable) is applied. Each swatch is challenged with droplets of agent laid by means of a dispenser-syringe combination in a predefined pattern, with the droplets separated as widely as possible. Droplets of the chemical agents shall be placed directly onto the reservoir materials, representing a worst-case scenario.

Then the cell is placed in the testing equipment at a temperature of 22 ± 2°C. A sampling flow of 100 ml/min of air is applied underneath the material for HD tests, and 50 ml/min for GD tests. A wind speed between 0.3 and 0.7 m/s is applied over the material. The amount of penetrated agent in the lower stream is collected and analysed afterwards with appropriate analytical techniques.

A.3.1.3 RESULTS

The test result is expressed in permeated quantity of HD and GD per square cm of reservoir material. This value can be converted into a total permeated mass, by multiplying the value with the (estimated) reservoir material surface. Note that this only gives an estimation of the potential CWA quantity in the drinking water, as all connectors, tubing and adapters are not included in this swatch test.

A.3.1.4 QUALITY CONTROL

It is recommended to add a negative control to each test series. The purpose of the negative control is to identify any agent carryover causing positive or negative analytical interferences. Samples for negative controls are taken from a CBRN reservoir, identical to the items under test. At the end of the test, collected sample is analysed identically to the samples of the items under test.

A.3.2 QUANTITATIVE TEST OF HOSE AND RESPIRATOR ADAPTER

A.3.2.1 GENERAL

- Per CBRN HS design, three (3) pieces shall be tested with HD.
- Droplets of agent are placed on the top of the hose and respirator adapter of the hydration system.
- A contamination density of 5 g/m^2 (essential) or 35 g/m^2 (desirable) is applied and the droplets of HD are evenly distributed over all the hose and respirator adapter combination (including bonding area, welds and raw materials).
- To estimate the quantity of droplets to be applied on the hose and respirator adapter combination, an overview of the material surface of the several parts of the system shall be available.
- The droplet size must be either 1 or 2 µl and the choice of droplet size depends on the material surface to be covered.
- Droplets of the chemical agents shall be placed directly onto materials, representing a worst-case scenario.

A.3.2.2 TEST ITEM RECEIPT INSPECTION

Upon receipt, each test item shall be inspected and verified to be undamaged and in working condition. All covering parts (tube covers, carrier systems e.g.) shall be removed prior to testing. A visual inspection shall be made of the test item prior to testing to verify its physical integrity is intact. Test items that have rips, tears or other physical defects shall not be tested.

A.3.2.3 TEST EQUIPMENT

- Fume hood or climatic chamber: sufficiently large to accommodate three (3) samples of hose and respirator adapter in one (1) trial. The test chamber must be capable of meeting the required environmental conditions and recording at least every five (5) minutes.
- Agent application. The purpose of the dispenser is to reproducibly and safely apply chemical warfare agent to the test items. Agent is to be applied using a dispenser capable of dispensing 1 µl and 2 µl drops (accuracy ± 5%). The purity of the agent shall be 95% or higher.
- A system to provide the required sampling air through the item under test (vacuum pump with mass flow controller e.g.).
- Analytical Instrumentation to quantify any HD present in sampling air flow (e.g. Tenax® adsorption tube, bubbler filled with absorption liquid) taken from each test item. All instrumentation shall be calibrated for the specified compounds prior to any sample analysis.

A.3.2.4 PRE-CONDITIONING

Each sample (hose and respirator adapter combination) is flushed with clean air several hours (for example 24 hours) before droplet application to remove any traces of potentially interfering components.

A.3.2.5 TEST PARAMETERS

- The duration of the test is 6 hours (essential) or 24 hours (desirable).
- The test is carried out at a temperature of 22 ± 2°C and ambient relative humidity.
- A contamination density of 5 g/m^2 (essential) or 35 g/m^2 (desirable) is applied.
- A sampling flow of 50-100 ml/min is applied through each sample.

A.3.2.6 DROPLET DISTRIBUTION PATTERN

In order to realize an evenly distributed contamination over the entire hose and respirator adapter of hydration system (bonding area, welds and raw materials):

- Calculate the total area of the hose and of the respirator adapter that can come into contact with chemical warfare agents. Count the values of all separate parts.
- The contamination of the hose being only on the top, assume one quarter of the previously calculated area to determine the contamination total amount to be applied.
- Calculate the volume of HD that shall be used to create a 5 g/m^2 (essential) or 35 g/m^2 (desirable) contamination density, taking into account the calculated area of each part.
- The size of each drop of chemical agent deposited is 2 µl on the hose of hydration system.
- The size of each drop of chemical agent deposited is 1 µl on the respirator adapter of hydration system.

A.3.2.7 SAMPLE POSITIONING

The items under test will be positioned into the fume hood or test cabinet or climatic chamber. The connection at the end of the hose that connects to the reservoir will be connected to the air inlet, and the respirator adapter is connected to the outlet of the test device, being the Tenax® tube or the bubbler filled with absorption liquid. Air flows through the hose of the hydration system in the direction from the reservoir - hose connection to the respirator adapter connection.

A.3.2.8 AGENT CONTAMINATION

The agent is applied with a dispenser or a syringe on the pre-defined areas of the test items and the calculated droplet volume and droplet quantity are applied. After contamination, the test start time is annotated.

A.3.2.9 SAMPLING AND ANALYSIS

After contamination of the item under test, the air flow of 50-100 ml/min is applied through the sample and the permeating agent is collected onto the Tenax® tube or in the bubbler for 6 hours (essential) or 24 hours (desirable).

After completion of the tests, the quantity of agent is analysed by means of appropriate analytical techniques.

A.3.2.10 RESULTS

The test result is expressed in permeated quantity of HD per hose and respirator adapter combination. This value can be used to estimate the total quantity of agent that may enter the system via the hose and respirator adapter.

A.3.2.11 QUALITY CONTROL

It is recommended to add a negative control to each test series. The purpose of the negative control is to identify any agent carryover causing positive or negative analytical interferences. The negative control is to be taken from a CBRN reservoir, identical to the items under test. At the end of the test, collected sample is analysed identically to the samples of the items under test.

A.3.3 QUALITATIVE METHOD WITH HD ON RESERVOIR MATERIAL

A.3.3.1 GENERAL

Samples of the reservoir material (with and without seam) can be tested with liquid HD according to AEP-38 Vol 1 Section F.6. This method can be applied for production control reasons and a quick verification of the material behaviour compared to previously tested materials (for life cycle purposes for example).

- Per CBRN HS design, three (3) samples of each material shall be tested with liquid HD.
- The duration of the test is 6 hours (essential) or 24 hours (desirable).
- The test is carried out at a temperature of 37°C (±1°C) or 22°C (±2°C) and ambient relative humidity.
- A contamination density of 5 g/m^2 (essential) or 35 g/m^2 (desirable) of toxic agent is applied.
- Droplets of the chemical agents shall be placed directly onto materials, representing a worst-case scenario.

A.3.3.2 RESULTS

Result is expressed as a breakthrough time of HD on the tested material. The temperature at which the test was conducted is also to be reported alongside the breakthrough time result.

A.3.3.3 QUALITY CONTROL

It is recommended to add a negative control to each test series. The purpose of the negative control is to identify any agent carryover causing positive or negative analytical interferences. The negative control is to be taken from a CBRN reservoir, identical to the items under test.

ANNEX A APPENDIX 1 EXAMPLE CONTAMINATION OF A TOTAL SYSTEM WITH GD – 5 g/m² CONTAMINATION

	Side		Estimated area (cm^2)	% of total (cm^2)	µl GD	Droplets of 10 µl	Droplets of 1 µl
Reservoir material	Front	flat material	650	31.07	325	33	
		seal	110	5.26	55	5	5
	Back	flat material	730	34.89	365	37	
		seal	110	5.26	55	5	5
Filling port	Front	weld	60	2.87	30	3	
Cap	Front	outer ring	30	1.43	15	1	5
		inner ring	20	0.96	10	1	
		gap	1	0.05	0.5		1
Tube	Front		300	14.34	150	15	
Tube connector (Exit)	Front	body	10	0.48	5		5
		weld	20	0.96	10	1	
		gap	1	0.05	0.5		1
Gas mask link	Front	body	20	0.96	10	1	
		gap / valve	10	0.48	5		5
Drinking valve	Front		20	0.96	10	1	
Total			**2092**	**100**	**1046**	**103**	**27**
Total amount of GD needed (mg)			1046				

ANNEX B System test of on-the-move hydration system with methyl salicylate in vapour phase

B.1 Introduction

To make sure the on-the-move hydration system with its connection to the respirator is leak tight also when drinking, simulated drinking is done in an atmosphere of methyl salicylate.

B.2 General

The hydration system is filled with water and the whole system up to connection to the mask is placed in an exposure chamber. A pump simulates drinking and the water is collected and analysed for methyl salicylate contents.

B.3 Test protocols

Three on-the-move hydration systems are tested. The on-the-move hydration system is filled with water of drinking quality to its specified maximum volume and closed according to operator's manual. The system is connected via a hose to the drinking connection of the respirator. A pump with the possibility to pump 200 ml/min is connected to the drinking device via a transparent tubing. The transparency gives the possibility to visually detect bubbles from larger leakages in the connectors. A flow check is done and then the on-the-move hydration system is filled to its maximum volume and then closed again.

The on-the-move hydration system with the drinking tube and drinking connector is placed in a test chamber with temperature 22±2 °C and a mixing fan to achieve a stable concentration in the chamber. Methyl salicylate is generated to a concentration of 100±15[2] mg/m^3 in the chamber. The concentration of methyl salicylate in the chamber is verified by air sampling during the exposure time. After 6 hours exposure of the system (essential time in §2.3.2) or 24 hours exposure (desired time in §2.3.2), then start the pump, and at a flow of 200 ml/min simulating drinking, water is collected in a closed reservoir. Sampling is done from the reservoir then the sample is prepared and analysed with appropriate analytical method.

B.4 Sample preparation and analysis

For the sample preparation and analysis, use standard analysis methods. The preparation of the water sample depends on the chosen analytical method. Appropriate analytical methods may be i.e. GC/MS, GC/MS SPME, LC/MS.

For example, analysis with GC/MS: Transfer the collected water sample to a separating funnel, add a small amount of dichloromethane and shake is gently for at least five minutes. Separate liquid phases, and transfer dichloromethane phase to a vessel and add an internal standard. Transfer a subsample to an analysis vial; analyse the concentration of methyl salicylate and potential degradation products on a GC/MS using an internal standard method.

[2] Concentration from MIST test ASTM F2588.

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