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COMBINED OPERATIONAL CHARACTERISTICS, TECHNICAL SPECIFICATIONS, TEST PROCEDURES AND EVALUATION CRITERIA FOR CHEMICAL, BIOLOGICAL, RADIOLOGICAL AND NUCLEAR DECONTAMINATION EQUIPMENT

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NATO LETTER OF PROMULGATION

13 October 2014

1. The enclosed Allied Engineering Publication AEP-58 Volume I, Edition B, , Version 1 ,on "COMBINED OPERATIONAL CHARACTERISTICS, TECHNICAL SPECIFICATIONS, TEST PROCEDURES AND EVALUATION CRITERIA FOR CHEMICAL, BIOLOGICAL, RADIOLOGICAL AND NUCLEAR DECONTAMINATION EQUIPMENT", has been approved by the nations in the NATO Army Armaments Group, is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 4653.

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS
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RECORD OF SPECIFIC RESERVATIONS

[nation]	[detail of reservation]
BEL	BEL can not fulfill these requirements: 1) Table 4-5 (Small Scale Capacity System) §2: Set-up and Strike Time 2) Table 4-7 (System for Aircraft) §2: Set-up and Strike Time 3) Table 4-8 (System for Ship and Maritime Equipment) §2: Set-up and Strike Time 4) Table 4-10 (System for Casualties) §2: Set-up and Strike Time 5) Table 5-1 (Water purification System) §2: Set-up and Strike Time 6) Table 5-1 (Water purification System) §3.4: Capability (Total Capacity)
CZE	Decontamination Systems for Ships and Maritime Equipment stated in paragraph 0408 will not be implemented. The Czech Republic will apply provisions of AEP-58(B) only for newly implemented or modernized equipment.
FRA	France considers that the purification of water is not an integral part of CBRN decontamination operations and reserves the right not to implement paragraph 0505.
LTU	Lithuanian Army has no means for decontamination of sensitive equipment and internal surfaces (buildings, vehicles, ships and etc). Lithuanian Army also has no possibilities to conduct tests and evaluation of decontamination equipment in accordance with AEP-58 requirements.
USA	The systems described are not appropriate for shipboard operations and, therefore, will be exempt from AEP 58.
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FOREWORD

1. This manual establishes the minimal operational characteristics, technical specifications and test procedures and evaluation criteria for all equipment necessary to conduct chemical, biological, radiological and nuclear (CBRN) decontamination in accordance with NATO doctrine stated in allied tactical publication ATP-3.8.1.

2. The manual is organized as follows:

   a. Chapter 1 gives the general purpose, scope and structure of the document;

   b. Chapter 2 explains the different CBRN hazards, which includes CBRN agents and Toxic Industrial Material (TIM). It describes the contamination and the transfer linked with such hazards.

   c. Chapter 3 describes the systematic approach used in chapter 4 to list the different operational, technical and test and evaluation criteria.

   d. Chapter 4, the main part of the document, lists all the decontamination systems and decontaminants through their requirements.

   e. Chapter 5 discusses specific matters related to decontamination.

   f. The annexes provide reference to laboratory qualification methods.

3. The document does not include waste management and environmental aspects.

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SECTION I - GENERAL

0101. General Purpose

The critical change in the NATO Security Environment, over the past decade, has required the review of much of NATO's policy and doctrine manuals. These combined operational characteristics, technical specifications and test procedures and evaluation criteria for CBRN decontamination were first issued in 1971 and, since then, important changes have taken place in the level of CBRN hazard to which NATO forces could be subjected to whilst on operations. These changes include:

a. That CBRN weapons and devices and their means of delivery are the subjects of continuous development, with consequent alterations to their employment characteristics and impacts.

b. The evolution is even more pronounced in the case of improvised CBRN devices, dependent as they are upon the local availability of materials and the imagination of their designers.

c. Similarly, the ever-growing number and widening global availability of toxic industrial materials makes a generic approach to the delivery of CBRN defence increasingly unsatisfactory.

d. Finally, the nature of military operations is itself in a period of rapid change, led in part by shifting public perceptions of acceptable risk and increasing concerns about the environmental impacts of military operations.

0102. Scope

1. The purpose of this document is to establish the minimal technical and operational performance characteristics, technical specifications, test procedures and evaluation criteria for all equipment necessary to conduct CBRN decontamination in accordance with NATO doctrine stated in ATP-3.8.1.Vol I , STANAG 2521.

2. Future revision of this document will have to take into consideration that its contents influence other NATO documents such as Long Term Scientific Study SAS 024, "Defence Aspects of Chemical and Biological Warfare" and radiological exposure criteria applicable for personnel given in STANAG 2473.

0103. Description

1. The information contained in this allied engineering publication (AEP) is presented in tables for each decontamination system and is described under the following headings:

a. Operational characteristics;

b. Technical specifications; and

c. Test procedures and evaluation criteria.

2. A separate table is included with specifications for decontaminants. Additional chapters provide guidance on decontamination of large installations, clearance decontamination, verification on the field, environmental aspects and water purification[1]. The applicable standards for decontamination efficiency are also included to ensure that NATO equipment and decontaminants meet acceptable performance efficiency requirements. These are listed in AEP-58 Vol II, CBRN Decontamination Efficiency Criteria.

0104. Decontamination (General)

Decontamination is the process of making any person, object or area safe by absorbing, destroying, neutralizing, making harmless or removing chemical or biological agents or by removing radioactive material clinging to or around it. Along with avoidance and protection, decontamination is an essential part of CBRN defence.

0105. Passive Decontamination

CBRN contamination reduces with time without any need of human activity. In the case of biological or chemical contamination the rate of hazard reduction is greater when equipment is exposed to high temperature, sunlight and wind. However, wind can also contribute to aerosolization of certain biological, chemical and radiological substances. Weathering is a time consuming process which requires no resources and will not, therefore, be considered a method of decontamination for the purposes of this document. The activity of radioactive contaminations decreases with decay of the respective nuclides according to their half life. Passive decontamination may also include approaches to include pre-treatment such as agent shedding, reactive, and exfoliating surface treatments and coatings that remove/destroy agents faster than normal weathering.

0106. Active Decontamination Operations

1. Active decontamination operations reduce hazard levels by removing or neutralizing liquid or solid contamination. They are carried out when CBRN contamination, which cannot be avoided, will adversely affect the unit's operational capability. Decontamination is a progressive operation that should be initiated as quickly as possible to be effective. Available monitoring and measuring devices will be used to separate contaminated from uncontaminated personnel, equipment, terrain and subjects to reduce the decontamination burden and will also be used to evaluate the efficiency of decontamination as far as possible. Allowing a lower residual risk may also be considered. Decontamination of personnel normally takes priority over the decontamination of equipment and terrain. The following represents the levels of active decontamination operations:

a. Immediate decontamination. Decontamination carried out by individuals upon becoming contaminated and may include decontamination of personal clothing and/or

[1] Depending on the national policy, water purification is not always on the scope of the CBRN units

equipment such as weapons or parts of IPE. The aim is to save lives, minimize casualties and limit spread of contamination and sustain personal protection.

b. Operational decontamination. Decontamination carried out by an individual and/or a unit and is restricted to specific parts of operationally essential equipment, materiel and/or working areas in order to minimize contact and transfer hazards and to sustain operations. This may include decontamination of the individual beyond the scope of immediate decontamination, as well as decontamination of mission essential spares and limited terrain decontamination. The aim of Operational decontamination is to remove or neutralize contaminants from the equipment, crew-served weapons, and vehicles that must be used by the unit in the execution of its operational role to limit the spread of contamination. As a minimum, the contact areas of weapons and equipment are decontaminated to restore immediate combat effectiveness.
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c. Thorough decontamination. Decontamination carried out by a unit, with or without external support, to reduce contamination on personnel, equipment, materiel and/or working areas to the lowest possible levels, to permit the partial or total removal of individual protective equipment and to maintain operations with minimum degradation. This may include terrain decontamination beyond the scope of operational decontamination. The aim of thorough decontamination is to eliminate the need for individual protective equipment. This level of decontamination is conducted out of contact with the adversary. The place where thorough decontamination is conducted should be under the protection against any adversary activities.

2. **Levels of Decontamination in Operations**. The levels of active decontamination described above remain valid for TIM. The need for decontamination and the degree of decontamination will vary considerably due to the wide range of chemicals, their toxicity and chemical, physical and toxicological characteristics.

0107. Clearance Decontamination

Clearance Decontamination is the decontamination of equipment and/or personnel on temporary or permanent removal from an operation to a standard sufficient to allow unrestricted transportation, maintenance, employment and disposal. It may be considered a special form of thorough decontamination and applies in case of temporary or permanent disengagement from missions. Clearance decontamination must conform to nationally established standards and policies so that the equipment can be transported through third party states and/or returned to the country of origin or to its final destination. This is a very challenging process and may involve the disassembly of equipment or even decision to scrap.

0108. Chemical Agent Decontamination

1. Historically, Chemical Agent Decontamination aims at the destruction and detoxification rather than the removal of the chemical agent. Recently, physical technologies such as evaporation by low pressure or submerging items in solvents have been considered.

2. To decontaminate, it would be sufficient to destroy the structure or that part of the molecule that causes the harmful property of the agent. Since these active centres vary

widely, chemical decontaminants today are mostly very aggressive compounds that target and destroy as large a spectrum of toxic chemicals or compounds as possible.

3. Very intense efforts to replace these decontaminants with over-the-board applicable, less hazardous and harmful substances have been under way for more than 15 years. However, the sheer number of TIC posing a threat to NATO forces as well as the wide variety of their physico-chemical properties make it extremely challenging to develop decontamination methods or decontaminants, respectively, that target all chemical agents as well as all relevant TIC.

0109. Biological Agent Decontamination

1. The doctrine for biological decontamination is not as well established. Nevertheless, the present document states that this doctrine or at least the technical actions relevant for biological (B) decontamination are very similar and shall be executed by the same systems and equipment as for radiological/nuclear (R/N) and chemical (C) decontamination. Concerning biological agents, chemical decontamination methods should be preferred to physical decontamination methods.
However, because of the potentially adverse effects of aggressive chemical decontaminants on sensitive military materials, alternative decontaminant procedures are being actively sought. These developments are particularly applicable to military systems such as aircraft where chemical decontaminants can damage electronics, degrade system performance, and reduce effectiveness of radar absorbing material. Sustained elevated temperatures have been shown to reduce significantly levels of environmentally resistant bacterial spores and these conditions are expected to be even more effective on vegetative cells and viral contaminants.

2. However, the complexity of biological decontamination is greater than the military requirement for chemical decontamination. This is due to the potential ability of biological agents to continue to grow in some environments and present by this way a non negligible potential hazard for NATO forces. Hence, mere unconfined removal of biological agents is the least desirable approach. Effective and complete destruction of biological agent, however, may not be accomplished until thorough decontamination is undertaken, which may be delayed because of operational considerations. All levels of active decontamination remain valid for biological decontamination, except where they render equipment inoperable or incapable of carrying out the military mission."

0110. Radiological / Nuclear Decontamination

1. While chemical or biological decontamination generally means, that the agents will be destroyed or transformed to less harmful products, radiological contaminations can only be removed from the contaminated surface and cannot be converted to innocuous products.

2. The aim is to reduce the dose rate resulting from the contamination on the material thus reducing the external irradiation hazard, minimize contact hazard and prevent the re-aeroasolization of residual particles which may be an inhalation / ingestion issue.

3. Decontamination procedures for radioactive particles are mainly vacuuming (dry particles, smaller items) or washing/rinsing processes, supported by mechanical means such as high pressure, scrubbing or brushing. Chelating agents will improve the process by

forming chemical complexes with radionuclides that are stronger than binding forces to the surface and will also prevent the adhesion of solved nuclides to the surface during the decontamination process. Whole processes can be supported by using deactivation solutions as a foam (significant increase of efficiency)

4. Strippable coatings are either applied prior to engagement or applied after the equipment is contaminated to help collect and remove radioactive particles. In addition these coatings may also prevent re-aerosolization, thus reducing or avoiding an aerosol hazard.

5. Radioactive contaminations from nuclear fallout vary distinctly from those arising from Radiological Dispersion Devices (RDDs) or Nuclear Reactor failures (either accidental or intentional). While nuclear fallout consists generally of mainly insoluble larger (> 50µm) particles, particles from RDDs may range down to micron and sub-micron size, their solubility depends on the isotope and the properties of the radioactive source. Particle size and solubility impact the effectiveness of decontamination operations.
The levels of activity and the resulting dose rates in nuclear scenarios can be expected to be much higher than those of radiological contaminations. However, the limits for thorough nuclear decontamination are orders of magnitudes greater than those given in STANAG 2473 and by civil legislation. Thorough decontamination of insoluble nuclear fallout particles is quite easy to achieve. The diversity in the chemical and physical properties of radiological contamination and the low limits to be achieved for residual contamination make radiological decontamination much more demanding. Although the basic principle and procedures of decontamination are the same, radiological decontamination may require efforts that go beyond the standard military decontamination procedures. This could include the need for more time, more personnel, adapted techniques and equipment or specified decontaminants.

0111. TIM Decontamination

1. **Characteristics of Decontamination**. In the context of decontamination, the emphasis will be on the more persistent chemicals since highly volatile chemicals will evaporate and disperse rapidly, primarily necessitating protective measures such as IPE or other protective clothing, respirators, self-contained breathing equipment, etc.

2. In general, decontamination of TIM is the process of eliminating or removing the vapour and contact hazards presented by deposits of TIM to safe levels by any formulation or procedure. However, there may be instances in which large quantities of an evaporating chemical may be encountered which will require decontamination in order to reduce the continuing vapour hazard. This may include the encapsulation, coverage or absorption of such deposits to reduce or eliminate further evaporation. Encapsulation may also be an effective process in reducing the contact hazard presented by less volatile liquids and solids.

3. The range of physical, chemical and toxicological properties of TIM is much greater than for chemical and biological agents thus presenting a considerable challenge for their destruction and detoxification by decontamination formulations and procedures. In addition, because of the large number of potential compounds and their diversity of structure, consideration must be given to the nature of the products of reaction with chemical decontaminant formulations to ensure that one toxic hazard is not replaced by one or more toxic products.

SECTION II - DECONTAMINATION (TECHNICAL)

0112. Introduction

1. The properties of most CBRN agents are such that active decontamination is required to return contaminated personnel and materiel to a fully operational status within a relatively short time frame. This is especially true for radiological and persistent chemical contamination.

2. Active decontamination methods can be divided into three basic processes: physical, chemical and biochemical. Physical methods of decontamination aim at contamination removal or encapsulation to reduce exposure, and in the case of biological agents the application of heat and/or humidity to kill the biological agent. Chemical and biochemical methods of decontamination aim at modifying the structure of the contaminants to reduce or eliminate the inherent toxicity of the compounds or to facilitate their removal. For chemical agents the focus is on a change in the chemical structure of the agent molecules, for biological contaminants on the destruction of the cells. For RN agents, a change in the chemical compounds containing the radionuclide may facilitate the removal. Decontamination systems may employ a combination of these methods to achieve the desired degree of decontamination.

0113. Physical Decontamination Methods

1. Physical decontamination consists primarily, as indicated above, in either removing (relocating) or encapsulating contaminants. It is important to realize that, since usually no actual destruction or detoxification is achieved (unless heat and /or humidity are applied to kill a biological agent), the contamination problems is merely relocated. Subsequent treatment of the relocated agent will always be required to achieve complete decontamination. Unconfined agent, such as the vapours produced by thermal decontamination or agent solution generated by pre-washing which goes into the ground may be destroyed by natural weathering. For this reason, physical decontamination may be considered as a partial method, although the action of removing contaminants can still achieve the main aims of limiting the spread of contamination and reducing the associated risk through reduction of potential exposure. Thermal methods and methods using ultraviolet (UV) or plasmas that destroy chemical agent molecules are considered as chemical methods and are included in the next paragraph. A combination of physical and chemical method is generally necessary to active RN decontamination. Chemical means generally facilitate physical decontamination of RN contamination.

2. Well known examples of physical decontamination are:

a. Rinsing with water;

b. Rinsing with organic solvents and mixtures;

c. Washing / rinsing with surfactants;

d. Accelerated evaporation by heating; optionally combined with vacuum techniques;

e. Adsorption and removal with solid adsorbents (e.g., Fuller's earth);

f. Removal of protective layers applied prior to contamination;

g. Burying or sealing contamination;

h. Scrubbing with brush or abrasive material; and

i. Vacuum cleaning.

3. Rinsing or washing down of contaminated surfaces is most effective when carried out as soon as possible after contamination and usually acts on two levels. Not only does it remove (to a certain extent) all classes of contaminants, it can also provide a (slow) detoxification of chemical agents. The efficiency of rinsing methods is dependent on a number of factors. These can include variables such as the rinse pressure, the solubility of the agents in the rinse fluid and the degree of agent adsorption into contaminated surfaces. Techniques to enhance physical removal efficiency include the use of special additives to augment solubility (e.g. surfactants, organic solvents, chelating agents) or to enhance cleaning power (i.e. detergents) by lowering the surface tension to optimize the extraction of absorbed agents. High temperatures, use of steam or (near-) supercritical fluids, such as supercritical water (374°C) and supercritical carbon dioxide (31.1 °C), may also improve solubility (although the solubility of VX in an aqueous phase is reported to diminish with higher temperatures). The use of brushes, to provide scrubbing, or a spray washing system will always enhance physical removal.

4. Chemical agents tend to show greater affinity to organic compounds and thus rinsing with organic solvents normally results in improved physical removal. In addition, organic solvents also allow the extraction of ad-/absorbed agents from porous materials but may, as a result, damage certain substrates and/or coatings.

5. Thermal desorption of agents can be achieved by the use of heated air which results in evaporation of the contaminant. With this method, the toxic agent is released into the atmosphere and this may present an increased vapour hazard.

6. Solid adsorbent decontaminants are very useful in removing contaminants from surfaces. Activated carbon, certain polymer ion-exchangers and fuller's earth are typical examples of solids that adsorb agents and retain them, allowing for safe removal and subsequent disposal. The usefulness of solid compounds for the decontamination of large equipment or vehicles is limited due to the problems of application over large surface areas.

7. Coatings intended to seal or retain contamination can also be used to ease the burden of decontamination. Although covering or burying contaminated items to protect personnel is not a method of decontamination, this method may still meet operational requirements. Usage of contamination control procedures such as adsorbent layers and disposable covers that are removed after initial contamination can also reduce the subsequent decontamination burden.

8. Scrubbing of equipment has to be performed as soon as possible. It allows for the removal of unfixed or weakly fixed contamination mixed with dust, dirt deposited on the equipment. The use of brushes, abrasive sponge or/and surfactant or chelating agent can improve the process.

9. Heavy particles are difficult to remove from concave locations. Vacuuming may support the removal of particles and liquid droplets in the equipment.

0114. Chemical Decontamination Methods

1. Chemical decontamination methods rely on chemical reactions, which transform toxic molecules into less or non-toxic compounds; hence, they refer to the decontamination of both chemical and biological agents. These reactions may be triggered by suitable chemical compounds but also by irradiation with UV/VIS or the use of plasma. As stated before, thermal treatment of contaminated substrates may also lead to the chemical modification or destruction of the agent molecules. Due to the specific nature of most (chemical) agents, hydrolysis and oxidation are the principle reaction mechanisms that allow efficient decontamination. H- and V-type chemical agents have a sulphur atom that is very susceptible to oxidation, whereas both G- and V-type nerve agents are sensitive to hydrolysis at the phosphorus atom.

2. Chemical decontamination methods may belong to one or any combination of three processes:

a. Electrophilic (oxidation, chlorination);

b. Nucleophilic (hydrolysis or other nucleophilic attack, e.g. with oximate); and

c. Complete destruction (full oxidation, thermal degradation, plasma-induced radical reactions).

3. Sodium hypochlorite and calcium hypochlorite were among the first oxidants used in chemical decontamination processes for chemical and biological agents and are still in use today. Using a dilute aqueous solution of hypochlorite (typically 5 to 10 %) usually attenuates the potentially violent reaction with chemical agents; solubility into the aqueous phase may be augmented by the use of organic co-solvents and emulsifiers. The addition of surfactants to enhance cleaning power and to retain agents within the formulation is also a common feature of modern decontaminants. Other oxidizing decontaminants may rely on the action of chloride-dioxide, chloride-amines, peroxides and ozone.

4. Hydrolysis reactions may be either acid or base (i.e. caustic). Acid hydrolysis is of less importance in field decontamination because of the limited reaction rate and the lack of efficient catalysts for these reactions. However, they may be an option for decontamination procedures that are not constricted by operational time-frames (e.g. clearance decontamination). Base hydrolysis is stimulated in caustic environments (pH > 8-10), in the presence of certain chemical catalysts (e.g. TiO_2 and Zn) and at high temperatures.

0115. Biochemical Decontamination Methods

1. Biochemical decontamination relies either on agent-scavengers or on enzymes that can catalyze specific neutralization reactions. The main advantage over the aforementioned chemical reactions is that enzymes are selective and also exhibit turnover (i.e. a single enzyme can perform the same decontamination reaction many times) whereas the

aforementioned chemical reactants are normally consumed during each reaction Thus, the logistic footprint of decontamination can be reduced if less material is required to perform the degradation reactions. Enzymes or scavengers may act directly on agents but may also act on reaction products from chemical neutralization reactions, increasing overall reaction rates through continuous removal of these reaction products.

2. As found with chemical decontamination methods, biochemical methods will always rely on a suitable medium (e.g. solvents, foams or emulsions with appropriate additives) to optimize solubility in the decontamination solution, extraction from the substrates to be decontaminated and retention of the agents into the decontaminant.

0116. Sensitive Equipment Decontamination

1. Sensitive equipment decontamination is related to those items that cannot be decontaminated by commonly used methods such as aqueous or organic-based decontaminants without causing damage to the items or at least degrading their performance. Sensitive equipment includes highly specific items of personal equipment of the individual soldier as well as materiel and equipment “critical” for mission assurance, whose functions may be indispensible to the effective operation of a system

Examples of sensitive equipment include but are not limited to:

a. Computers and electronics.

b. Optical and optronic devices.

c. Flight critical components within or on aircraft, both rotary wing and fixed wing. These components or equipments generally are difficult to decontaminate due to their construction characteristics and their situation.

d. Parts of a system or equipment comprised of materials with particular vulnerabilities to CBRN agents, decontamination processes or decontaminants.

2. Some decontamination methods with the potential to decontaminate sensitive equipment have been identified and are used in various decontamination systems

a. Gaseous methods (e.g., hydrogen peroxide).

b. Enzymatic decontamination.

c. Soft decontamination solution (peracid).

d. Solvent-impregnated wipes.

e. Thermal approaches.

f. Vacuum techniques.

g. pressurized multiphase (adsorbent, solvent/co-solvent and propellant) system

This list of potential methods is not exhaustive. Other methods may exist or be in development (plasma, powders…). Additionally, the method of choice depends on the properties of the item to be decontaminated and the type of contamination.

0117. Conclusion

1. The main functional properties that are to be considered when determining the composition of a decontamination formulation are:

a. Rapid and complete removal or destruction of any contamination;

b. Preferably, rapid and complete reaction to non-toxic or less toxic products (for reactive decontamination methods);

c. Rapid and reliable deactivation of all types of biological agents;

d. Use of components that readily form the decontamination product under different circumstances (temperature, quality of components, pH, water quality, etc.);

e. Maximum wetting of substrates to maximize physical removal (low contact angle);

f. Maximum extraction of adsorbed agents (low contact angle and small organic molecules);

g. Reduced off-gassing of agents during decontamination (use of foams and wetting additives);

h. Non-aggressive towards surfaces (use of selective active components, non-aggressive solvents);

i. Stable in storage and in use;

j. User-friendly and environmentally acceptable (use of non-toxic solvents);

k. Sufficient decontamination (detoxification) capacity at expected unit consumption per surface area, which is pertinent for stoichiometrically active decontamination formulations;

l. Wide range of applicability with regards to climatic or temperature conditions,

m. improvement of decontamination efficiency by innovative and prospective methods.

2. Modern decontaminants and decontamination methods are complex systems. The formulations in use since the beginning of the 20th Century are currently being replaced with formulations that show the same efficiency in removing and destroying agents but are less aggressive to substrates, less aggressive to the user and environmentally acceptable. A schematic overview of decontamination methods and processes is shown in Annex A.

CHAPTER 2 – CBRN SUBSTANCES AND HAZARDS

The information contained in sections I and II of this chapter mirrors in part data from ATP 3.8.1. Vol 1. Nevertheless it is included here as a source of information for potential industrial contractors.

SECTION I: THE THREAT OF CBRN WEAPONS, DEVICES AND TIM

0201. Introduction

1. Within the period of modern industrial history, the development and employment of CBRN technologies to facilitate military operations was essentially driven and controlled by nation-states with ever increasing emphasis on quality of design, delivery means and targeting techniques. In essence, the tendency was to field ever more capable CBRN weapons[2]. However, the increasing visibility of these activities, the growing global distribution of constituent materials, increasing access to manufacturing techniques and the migration of technical expertise has inevitably attracted the attention of non-state actors, prompting ambitions to field CBRN devices[3]. The latter are likely to be less efficient in operation than the weapons they imitate but will still present significant challenges to the conduct of military operations, both in the physical and psychological dimensions. They may also present novel challenges, for instance by employing TIM[4] that have traditionally fallen outside the capability envelopes of military CBRN defence equipments. Above all, they are likely to be seen as a means of compensating for a lack of conventional capabilities (asymmetrical warfare).

2. In consequence, the possible emergence of CBRN threats and hazards, as well as near-universal risks of encountering TIM, will be factors to be addressed by commanders in the planning and conduct of all future operations. Central to this process will be an understanding of the utilities and potential employments of each class of weapon and device.

3. A CBRN incident, its source of release, whether intentional or unintentional, and its potential resulting contamination (CBRN hazard, including hazards from TIM) can have a significant effect on any military operation, be it on land, in the air or at sea, and a decisive influence on a commander's decisions and estimates. In addition to CBRN incidents resulting from attack or release of CBRN substances, lessons identified from a number of military operations in recent years have shown that there are a broader range of battlespace hazards of which toxic industrial hazards (TIHs) form part.

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[2] CBRN Weapon: A fully engineered assembly designed for employment by the armed forces of a nation state to cause the release of a chemical or biological agent or radioactive material onto a chosen target or to generate a nuclear detonation. (AAP-21)

[3] CBRN device : An improvised assembly or process intended to cause the release of a chemical or biological agent or substance or radiological material into the environment or to result in a nuclear detonation. (AAP-21)

[4] Toxic Industrial Material : A generic term for toxic or radioactive substances in solid, liquid, aerosolised or gaseous form. These may be used or stored for use, for industrial, commercial, medical, military or domestic purposes. TIM may be chemical, biological or radioactive and described as toxic industrial chemicals (TICs), toxic industrial biologicals (TIB) or toxic industrial radiologicals (TIR).

4. The TIM release into the environment presents a growing risk to the conduct of military operations. Whilst excursions of toxic industrial chemical (TIC) and still more so toxic industrial biological (TIB) may be localized, the resulting hazards may nonetheless serve to deny the use of key facilities and routes, especially as many industrial plants are located in or near major conurbations and transportation nodes. Depending upon the selection of risk criteria, a toxic industrial radiological (TIR) hazard from a major nuclear facility could extend over the larger part of a theatre of operations, although most likely excursions would be on a very much smaller scale. Critically, the vast range of TIM present in modern industry denies the possibility of developing general-service equipment that will protect forces against all conceivable hazards although equipment may be optimized to the TIM most likely to be encountered in operations. The consequent need to enforce exclusion areas could have a severe impact upon a commander's plans. Accordingly, it will be important to scope likely TIM challenges within the intelligence preparation of the operational environment (IPOE) process at the planning stage of an operation, enabling the modification or procurement of appropriately capable equipment and the advance development of hazard and risk management techniques in anticipation of release. Therefore, commanders will need to make a risk assessment to minimize the possible impact of exclusion zones on their plans.

0202. Threat from Chemical Agents and TIC

1. Chemical Weapon.

a. In purely military terms, chemical weapons may be seen as essentially tactical weapons, though their use against some high-value targets (e.g., ports and logistics installations) could have operational-level impacts. Their casualty producing effect against forces ill equipped or trained to defend against them can be very great over substantial areas. This can equally be true against a well-prepared force caught unaware. The use of chemical agents, especially in persistent form, will significantly disrupt, degrade and above all slow down all forms of military activity without causing physical damage. The main effect of chemical warfare is to reduce the momentum of operations and greatly increase the physiological and psychological stresses on forces. Notably, these impacts can also result from the sustained precautionary use of protective measures in response to the mere possibility of chemical attack; the employment of risk management techniques is thus an important component of the total package of defensive measures.

b. In planning the use of chemical weapons it will be necessary for an adversary to match his available assets to the scale of effects that is sought. The creation of effective battlefield concentrations of chemical agents require large volume delivery and in consequence attacks against even small and closely defined targets will have significant resource implications. Additional considerations will include the desired speed of effect, whether immediate or delayed, and, if a persistent agent is used, the length of time for which the target and the resulting downwind hazard area will remain contaminated. The adversary will also need to assess the impact of climatic conditions whilst also seeking to avoid placing his own forces at undue risk particularly from downwind hazards.

2. **Chemical Devices**. Chemical devices may take many forms, ranging from stolen chemical weapons, through the manufacture of direct imitations to the ad hoc employment of TIC within crudely constructed dissemination systems. In all cases, devices of a size and weight comparable to those of properly-engineered weapons are likely to be of inferior dissemination efficiency and their payloads will often be of reduced quality. Nonetheless, they will continue to offer means of temporarily compromising the conduct of operations through their physical and psychological effects both on military forces and on local civilian populations. Furthermore, where TIC are incorporated in ad hoc devices, the substances involved may severely challenge CBRN defensive equipments that were designed primarily to counter recognized military agents. All this suggests that the primary employment of such devices by non-state actors will be aimed at disruption rather than mass effect and that the immediate targets are as likely to be the civil populace as engaged military forces.

3. **Toxic Industrial Chemical**:

a. Although natural chemical hazards do exist in the environment, those situations are relatively rare and should not normally pose an impediment to military operations. However, there are potential hazards from industrial chemicals that may impact directly on the conduct of military operations, from humanitarian assistance through to general war. In a theatre of operations military personnel may be faced with a potential hazard created by large quantity of TIC from production, storage, transportation or distribution. The civil chemical industry, world-wide, produces many thousands of TIC. Production, storage and transportation systems may hold hundreds or even thousands of tons of material.

b. TIC, if deliberately or inadvertently released, will pose hazards to the indigenous population and NATO forces operating in the area. Furthermore, the risk from TIC is not only linked to the risk from a single compound but from risks that result from explosion, fires and the associated by-products.

c. If breached, these facilities could result in localized hazards of high concentration, in some cases also extending downwind. The hazards could be of an incendiary, explosive or corrosive nature, rather than purely toxic, or could simply displace breathable air.

d. Few military CBRN defence equipments are designed to provide defence against TIC excursions. Therefore, the challenge to commanders at all levels is to convey the importance of being prepared and having knowledge of the potential hazards and to ensure the appropriate protective measures are established and executed when required. However, it is recognized that some facilities may lie in areas of high political and military significance, obliging a continued military presence. Not all types of IPE fulfil demands to provide adequate protection against TIC.

0203. Threat from Biological Agents and TIB

1. **Biological Weapons**. Biological weapons may be built inexpensively and with virtually no signature detectable by technical intelligence collection means. The amount of biological agents warfare material required to achieve significant effects is small, enabling these weapons to be easily portable. Finally, this type of warfare is exceptionally flexible. It can be

used throughout the entire spectrum of warfare from covert operations and terrorism to strategic scale attacks. Key considerations that are likely to influence the employment of biological weapons include:

a. Location. Even in small volumes, biological weapons can be imprecise and indiscriminate weapons, best suited for employment against area targets.. Significant opportunities for this form of employment would arise when substantial elements of a force were visibly concentrated en route to a theatre of operations or recently disembarked therein. The largest and most accessible target would be presented by the entirety of the force dispersed across the joint operations area (JOA) but not yet engaged in active hostilities and thus geographically separated from opposing forces. Both before and during hostilities there would remain significant opportunities for employment against readily identifiable and more or less static targets such as ports, airfields, headquarter (HQ) complexes and logistics sites.

b. Timing. The delayed time-to-effect of biological agents (except toxins) and difficulties in predicting wind changes at the local level argue against employment as tactical weapons. For greatest effect, biological agents are most likely in the early stages of conflict, intended to achieve surprise and generate casualties at the critical entry phase of an operation; this timing would also address the adversary's fear that his delivery means might be lost to conventional attacks.

2. **Biological Devices**. As in the case of chemical devices, the growth and dissemination of biological agents by non-state actors would probably be less efficient than in the case of comparable programmes sponsored by nation states. However, simple volume-for-volume comparisons do not hold good as a complete measure of the overall effectiveness of biological devices. Provided an agent remains viable for sufficiently long to be transported to its point of release and subsequently infect a significant proportion of a target populace (especially where it is transmissible) then the psychological effects will far outweigh any theoretical delivery deficiencies. The peculiarly threatening character of pathogens and the difficulties in detecting and in some case treating them will have an impact of their own. This suggests that employment will almost invariably be guided by the wish to induce fear in the target populace, with little concern for the actual number of people infected, their identity (civil or military) or the final rate of death or disablement. Limitations on use are thus likely to be severely practical, focusing on the means of carriage to the point of release without interception.

3. **Toxic Industrial Biological**:

a. Industrial biological agents are widely distributed and available in amounts that dwarf the amount of biological agents ever produced. Industrial/medical biological research and development is conducted world-wide and many biological substances are used in industrial functions, such as brewing and distilling. A TIB incident can occur from an attack or collateral damage at a facility producing or storing infectious material. Possible facilities include hospitals and other medical installations and research, production, storage or recycling facilities for the pharmaceutical or agricultural industries. The release of large volumes of TIB can produce environmental damage that could result in pollution of water supplies, long-term ecological damage, and present a significant hazard to military operations. Military protection, detection, and

medical countermeasures have been designed specifically to protect, detect and counter the effects of biological agents not the hazards from TIB.

b. The need to preserve the viability of TIB demands special environmental controls, enabled by containment and physical security measures. Finally, the inherent fragility of biological organisms makes it unlikely that they would survive the dynamic and thermal effects of explosions or fire. In light of these considerations, it is unlikely that forces will encounter viable TIB except where they enter specially designed medical or industrial facilities and even then the hazard may be restricted to specially assigned rooms or compartments. In consequence, the proper response to the very limited chance of encountering TIB lies in avoidance and exclusion from suspect facilities, pending inspection by specialist personnel.

0204. Threat from Radiological and Nuclear Material and TIR

1. **Nuclear weapon**[5]:

a. The history of nuclear weapons is quite different from those of chemical and biological agents insofar as both the theory and the means of development were conditioned by the emergence of structured scientific thinking within the period of modern history. In consequence, the first atomic device was not exploded until 1945 with the sole examples of military use occurring some three weeks later. Thereafter and from a narrow military perspective, development was principally focussed on the refinement – particularly in size, weight and yield - of the weapons themselves and of their means of delivery. Additionally, some efforts were made to adjust the balance of effects, especially in terms of radiation versus thermal and dynamic outputs. An example of this was the development so-called 'Neutron Bombs' that were designed to cause a maximum of immediate radiation casualties at a diminished cost in collateral damage.

b. In the Cold War period, the concept for the most effective battlefield use of nuclear weapons was to deliver a surprise and massive initial strike in order to shatter the opposition, reduce the time taken to advance through remaining forward defences, and limit casualties to own forces. Alternatively, they were seen as the ultimate counter to otherwise irresistible adversary advances. Nations with lesser nuclear capabilities than traditional possessors will be unable to deliver strikes of these dimensions but may still be attracted by the use of nuclear weapons as a tactic of last resort against technologically or numerically superior opponents.

c. The ability of nuclear weapons to cause area effects in the forms both of massive damage and residual radiation and the possibilities of tailoring both yield and energy outputs, enables them to be used with advantage at all levels of conflict.

[5] A nuclear weapon is defined as: 'a complete assembly (i.e., implosion type, gun type or thermonuclear type) in its intended ultimate configuration which, upon completion of the prescribed arming, fusing and firing sequence, is capable of producing the intended nuclear reaction and release of energy'.(AAP-21)

2. **Radiological Devices**:

   a. A radiological device is defined as: ‘any device, specifically designed to employ radioactive material by disseminating it to cause destruction, damage or injury by means of the radiation produced by the decay of such material.’ Different to a nuclear weapon a radiological device does not generate a complete nuclear reaction; hence, they will not display the explosive effects characteristic of a nuclear detonation. They may, however, have explosive or pyrotechnic components but these should present no greater threat than a conventional weapon of comparable size.

   b. There has long been a potential for states and non-state actors to develop radiological devices. Radioactive material may be accumulated within nuclear weapons programmes or nuclear power generation facilities or be drawn from other legitimate industrial, medical or academic sources. In this respect, the hazards presented by a radiological device would be similar to those resulting from the accidental release of TIR, albeit the former would offer greater efficiency of dissemination.

3. **Toxic Industrial Radiological**:

   a. TIR releases may arise from a wide variety of scenarios, ranging from the simple accidental distribution of a small quantity of radioactive sources or nuclear waste to a massive excursion from a power generation facility, akin to Chernobyl. The emergence of TIR hazards will embrace a variety of risks, conditioned by the form of release.

   b. In no case, however, will this result in a nuclear detonation akin to that associated with a nuclear weapon. Accordingly and aside from any fires or explosions that may have caused or been the secondary consequences of the incident, there will be no ‘Immediate Effects’ as associated with a nuclear weapon detonation. There will, however, be a spread of radioactivity ranging from a few square metres to thousands of square kilometres, depending upon the mechanism of distribution and the judgement of what is to be treated as a significant dose rate.

   c. In many cases, exposure to radioactive materials will have no early or visible effects upon personnel. However, it will present a challenge to health in the longer term. This, in turn, may force the temporary or permanent abandonment of contaminated equipment or ground.

SECTION II : CHARACTERISTICS AND EFFECTS OF CBRN SUBSTANCES

0205. General

The purpose of this section is to elaborate on the characteristics and effects of CBRN substances with regards to decontamination systems and procedures.

0206. Chemical Agents

1. Chemical agents are highly toxic inorganic or organic compounds or mixtures of such compounds. They can be delivered as vapour, solids, aerosols or slowly evaporating liquid droplets. Following a chemical attack personnel may be exposed to an inhalation hazard from chemical agent vapour that was re-aerosolized from contaminated surfaces or terrain and to a contact hazard to bare skin. Decontamination procedures should not only eliminate all free liquid and/or solid contamination, but also reduce the amount of contamination adsorbed and absorbed by materials, that may present both a residual inhalation and residual contact hazard to personnel.

2. **Characteristics of Chemical Agents**:

a. Persistency. Persistency is a measure of how long a chemical agent will present a hazard. In simple terms agents can be considered to fall into two types:

(1) Non-Persistent Agents. Non-persistent agents are delivered as aerosols or liquids. Aerosols are finely divided liquids or solids suspended in the atmosphere - rather like a fly spray. Liquids in an aerosol form will evaporate very quickly – rather like paraffin or ether - to form clouds of vapour. Non-persistent agents tend to produce only short-term hazards and cause little or no surface contamination because they do not settle or condense out on the ground or equipment.

(2) Persistent Agents. Persistent agents generally take the form of liquid droplets, and in some cases solid particulates, that contaminate surfaces and produce a contact hazard that will penetrate ordinary clothing and then the skin. They also evaporate to form a vapour hazard but this is likely to be less concentrated than the vapour formed by a non-persistent agent, although it too will be carried downwind. The vapour hazard will exist for as long as the liquid remains, and this can vary from as little as a few days to several days, depending on the agent and the climatic conditions (e.g. temperature). Low temperatures also may affect detectability.

b. Thickening. Thickening is the process of increasing the persistency of certain agents, thereby increasing the duration of the hazard. Thickened chemical agents are agents with increased viscosity due to the addition of certain polymers as thickeners. Due to the increase in viscosity, these agents adhere more tenaciously to surfaces, thus making them more persistent and more difficult to decontaminate.

0207. Biological Agents[6]

1. Biological agents can be delivered as aerosols, solids or liquids and pose an inhalation hazard as well as a contact hazard.

2. After a biological attack, the primary airborne hazard will naturally disperse or be filtered by protective equipment. However, to minimize the hazards presented by biological agents residual contamination, the secondary inhalation hazard requires active decontamination to allow personnel to remove individual protective equipment and restore operational effectiveness. The survivability of biological substances must be considered.

3. There are numerous types of targets which are vulnerable to the effect of agents of biological origin (ABOs): command centres; rear areas to disrupt logistic supplies; lines of communication; tactical or maintenance support services; operational reserves; large formation assembly areas; infiltration into food or water supplies, etc.

4. It is likely that some agents can remain infectious while residing on inert supports, materials or soils for a sufficiently long time to present a secondary hazard. This hazard could be through either direct contact (contact through broken skin) or inhalation of biological species**.** The biological inhalation hazard is far greater than contact hazard, and a biological inhalation hazard also exists from re-aerosolization, The inhalation hazard is the greatest challenge.

5. ABOs can be divided in three generic types of agents[7]:

a. Bacteria**.** Bacteria are single-celled organisms which are capable of replication in a host or, in most cases, a suitable culture medium. Potential bacterial agents include, but are by no means confined to, *Bacillus anthracis* (the causative agent of anthrax), *Yersinia pestis* (the causative agent of plague) and *Francisella tularensis* (the causative agent of tularemia). These three biological agents have been studied in the Challenge Sub-group (CSG) study on biological agent challenge levels. *Bacillus anthracis* and other species possess the ability to form spores, existing effectively in a state of "suspended animation" in which they can survive for decades, returning to the vegetative form and multiplying in the presence of a suitable host or culture medium. The vegetative form is generally considered to be fragile and cannot survive long periods, although the survival times can be increased by a favourable dispersion medium or by encapsulation techniques (Survival time: hours to weeks). The spore form is significantly more robust than the vegetative form and can survive for very long periods. This form is more resistant to decontamination processes. As such, these agents probably present the greatest long term residual biological hazard. The main example of this form is anthrax spores (Survival time: years to decades).

(1) Rickettsiae are organisms that belong to bacteria family but with some viral properties.

[6] A biological agent is defined as: ‘a micro-organism which causes disease in personnel, plants or animals or causes the deterioration of materiel’

[7] A list of potential biological agents is given in the AMedP-6 Volume 2.

(2) Chlamydia are obligatory intracellular parasites incapable of generating their own energy source. Like bacteria, they are responsive to broad spectrum antibiotics. Like viruses, they require living cells for multiplication.

b. Viruses**.** Viruses are organisms capable of replication only within a living host cell. They are therefore more difficult to produce as a biological agent than bacteria and require a more advanced biotechnology. Viral biological weapons are therefore likely to be found only in the arsenals of the more technically advanced potential adversaries of NATO. The viruses typically do not survive well in the environment, and are therefore less likely to present a persistent hazard than the bacterial agents nevertheless the survival time can be increased by either using a favourable dispersion medium or by encapsulation methods or when at low temperatures (Survival time : hours to weeks).Viruses characterized with a high persistency may be the orthopox viruses, which are relatively hardy. Potential viral biological weapon agents include smallpox, equine encephalitis viruses including the Venezuelan (VEE), Eastern (EEE) and Western (WEE) variants as well as filoviruses.

c. Toxins. Toxins are not organisms and are therefore not capable of self-replication. They are toxic chemicals produced by living organisms, or by synthesis. They are typically more durable in the environment than most of the viruses and the non-spore forming bacteria. Numerous organisms, e.g. bacteria, fungi, algae and plants, produce toxins. Many of them are extremely poisonous, with a toxicity that is several orders of magnitude greater than the nerve agents.

0208. Radiological and Nuclear Material

1. With respect to radiological contamination, the hazards presented by nuclear weapons would be similar to those resulting from the accidental release of TIR, albeit the former would offer greater efficiency of dissemination. Further, should an attack succeed on the containment or safety systems on a nuclear reactor or plant there would be a possibility of widespread contamination.

2. For planning purposes, uncertainties about the materials employed within radiological devices make it impossible to describe the precise form (s) of the hazards that may be presented. That said, it is reasonable to assume that they will comprise a mixture of radioactive contaminants and be a spread of radioactivity ranging from a few square metres to thousands of square kilometres, depending upon the mechanism of distribution and the judgement of what is to be treated as a significant dose rate. These materials would be deposited on terrain, equipment or other surfaces. Some of these will emit penetrating radiation, other emissions may lack the energy to seriously harm the body unless left on the skin, inhaled, or absorbed via wounds, food or water. Examples within this category are alpha and beta particles.

0209. Toxic Industrial Material

1. The number of TIM which could threaten NATO forces is considerable. They range from volatile pressurized gases/liquids to semi-volatile liquids to low volatility solids. They could present percutaneous/contact hazard threats, respiratory threats, corrosivity threats,

flammability threats and depletion-of-oxygen hazards. They present lethality threats as well as creating heavy tolls on medical supplies and resources.

2. The significant aspects of these classes of compounds are:

   a. Universality. TIM are in use all over the world and sometime in very large quantities and are contained in production and storage facilities, manufacturing, agriculture, petrochemical, mining, and other resource sectors. They are sold to the general public in the retail area. They are transported by road, rail or ship in large quantities.

   b. Legitimacy. Since TIM are critical components and starting materials in so many sectors of industrial society, their possession is assumed to be for legitimate purposes, even when present in large quantities.

3. **Toxic Industrial Chemical**:

   a. Inhalation Hazard. Many TIC are volatile gases, liquids or solids which, on release, will present considerable inhalation hazard. The suitable mask/filters can protect the exposed personnel against some TIC, depending to the canister capacity and the substances". The continued requirement to wear protective gear may hinder decontamination efforts because of the unsuitability of the filters for long-term protection against TIC. If continuous high TIC concentrations become a heavy burden on the gear, it will eventually reduce protective posture and sustainability.

   b. Contact Hazard. The same situation as noted for protective gear against inhalation hazards also pertains to contact hazard. Protective military items such as masks, clothing, CBRN hand and foot protection may not be designed to withstand prolonged exposure to these toxic liquids or solids because their protective capability will have been optimized for CBRN agents. This may dictate that thorough decontamination will need to be undertaken in instances in which operational decontamination against chemical and biological (CB) agents may have been sufficient for continuance of the mission. Thus, the hazard from overall toxicity of the chemical or material itself is further exacerbated by possible lack of longer-term protection and survivability of the protective gear worn.

   c. Toxicity Considerations. The toxicity of many of the high volume toxic chemicals can be readily ascertained from compilations such as those listed above or from material safety data sheets (MSDS) or related databases such as http:/ www.epa.gov/cepo/pubs/title3.pdf. Such documentation often indicates not only the toxicity but also other factors such as corrosivity, reactivity, volatility, flammability, etc. This information should provide the required information as to level of hazard which would be presented by large quantities of the material.

   d. Persistence. From a knowledge of the chemical or material volatility , indications about the persistence can be derived which may influence decisions about the need for decontamination. For instance, if the chemical vaporizes rapidly and prevailing winds remove the vapour in a short time, decontamination may be unnecessary. On the other hand, if the solid or low-volatility chemical poses a significant hazard for

extended periods and access to the area is essential, then decontamination may be required at the Operational level.

e. Re-aerosolization /Secondary Hazards. For solids or semi-volatile liquids, the hazards from TIM are similar to CB agents in that subsequent movement through the area or wind could present a hazardous level of chemical due to re-aerosolization. Dependent on the level of protection and survivability of CB protective gear worn, this hazard may also require that some level of decontamination be performed to prevent casualties.

f. TIC of Concern. For purposes of this document, the list presented in Annex E Appendix 1 is considered to be the priority interest to CBRN defence. However, in the decontamination context, not all entries in Appendix 1 will need to be addressed. Two of the main considerations for assessing the need for decontamination are toxicity and persistence.

4. **Toxic Industrial Biological.**

A TIB incident can occur from an attack or collateral damage at a facility producing or storing infectious material. Possible facilities include hospitals and other medical installations and research, production, storage or recycling facilities for the pharmaceutical or agricultural industries.

5. **Toxic Industrial Radiological**:

a. TIR may be any source of ionizing radiation in solid, liquid, aerosolized or gaseous form to be used, or stored for use, for industrial or research purposes. TIR can be further classified as being from radiological sources such as: medical application; industrial; natural; research, calibration sources, military application (Other then nuclear and other small sources). Common nuclides, listed by International Atomic Energy Agency (IAEA) Technical Documents (TECDOC) IAEA-TECDOC-1344 Categorization of radioactive sources, are ^{90}Strontium(Sr), ^{60}Cobalt (Co), ^{137}Cesium (Cs), ^{192}Iridium (Ir), ^{170}Terbium (Tm), ^{169}Ytterbium (Yb), ^{75}Selenium (Se), ^{241}Americium (Am) (as well as Am/Beryllium (Be)) and ^{252}Californium (Cf). It is important to note that these are also associated with specific uses, such as radioisotopic thermoelectric generators, irradiators and industrial radiography to name a few.

b. The above materials exist in a variety of physical and chemical composition, such as, but not limited to: ceramics, salt, metal and oxides. The form will depend somewhat on the origins of the material, and/or method of dissemination and/or environmental factors. The selection of recognized hazard levels are detailed in and guided by STANAG 2473. These management criteria may only be capable of implementation via the use of specially provided detectors operating below the ranges of general service radioactive detection, indication and computation (RADIAC) equipment.

c. Physical and chemical properties of radiological (R)-agents can be modified to improve decontamination, but the radiation can not be prevented.

SECTION III - CBRN SUBSTANCES AND THEIR IMPACT ON DECONTAMINATION SYSTEMS AND PROCEDURES

0210. General

1. This section will identify the impact of the characteristics and effects of CBRN substances on the technical elaboration of decontamination systems.

2. Military personnel must be trained and equipped to operate effectively in a CBRN environment and must be able to sustain operations during and after a CBRN incident. Accordingly, materiel to perform mission-essential functions must be capable of withstanding a CBRN incident and, if feasible, of being restored to their pre-incident condition. It is important to note that these requirements are not only met by appropriate selection of decontamination equipment and decontaminants but also by adequate selection of materiel STANAG 4521, covering AEP-7.

3. **Groups**. From the decontamination perspective, CBRN substances can be divided into three groups:

a. Chemical. Chemical agents including thickened chemical agents; as well as TIC.

b. Biological. Biological agents including pathogens and toxins; as well as TIB.

c. Radiological. Radioactive material and nuclear (fallout); as well as TIR.

0211. Impact of Contamination by Chemical Agents

1. Contact hazard implications on materiel and off-gassing: The solvent action and penetrating powers of some liquid chemical agents will affect a variety of non-metallic materials used in service equipments. A notable exception to this is Perspex, particularly when stressed as in aircraft cockpit covers. This will craze when contaminated by drops of certain chemical agents, such as mustard. Pure chemical agent will have little effect on metals but the acid impurities present in operational agents may cause a corrosive reaction.

2. Following attack and even where decontamination has been largely effective, liquid or solid chemical agents retained in cracks and crevices of equipments may be revealed when doors, hatches or covers are opened or removed. Additionally, many materials such as rubber and alkyd paint readily absorb liquid agent, which will then desorb and evaporate from the surface.

3. The resulting localized vapour hazard (so-called ‘off-gassing’) will remain until the processes of passive decontamination or ‘weathering’ are complete. The likely duration and concentration of off-gassing has not been fully defined and is in any case subject to a number of variables including the quantity of agent absorbed, its precise formulation, sun, wind, heat and precipitation.

0212. Impact of Contamination by Toxic Industrial Chemicals

1. In the context of decontamination, the emphasis will be placed on the more persistent chemicals since highly volatile chemicals will evaporate and disperse rapidly, primarily necessitating protective measures such as protective clothing, respirators, self-contained breathing equipment, etc. In general, decontamination of TIC is the process of eliminating or removing the vapour and contact hazards presented by deposits of TIC to safe levels by any formulation or procedure. However, there may be instances in which large quantities of a normally gaseous chemical may be encountered which will require decontamination to reduce the continuing vapour hazard. This may include the encapsulation, coverage or absorption of such deposits to reduce or eliminate further evaporation. Encapsulation may also be an effective process in reducing the contact hazard presented by less volatile liquids and solids. The range of physical, chemical and toxicological properties of TIC is much greater than for chemical agents thus presenting a considerable challenge for their destruction and detoxification by decontamination formulations and procedures which may well be effective for chemical agent contamination. In addition, because of the large number of potential compounds and their diversity of structure, consideration must be given to the nature of the products of reaction with chemical decontaminant formulations to ensure that one toxic hazard is not replaced by one or more toxic products.

2. Decisions for the need to decontaminate TIC can be arrived at by several means: overall toxicity, quantities of material encountered, persistence of the material and whether temporary avoidance of a heavily contaminated area can be undertaken. To evaluate these factors requires a knowledge of the TIC involved, i.e., identification of the chemical or material. This may be evident from labels, signage, intelligence reports, local inhabitants, etc. or by physical characteristics and appearance. However, if identification cannot be made, the decision on the need for and extent of decontamination will be more problematic. If the material will vaporize in a short period of time and is not aggressively corrosive to equipment or personal protective gear, the exposure may be acceptable provided that respiratory protection is sufficient over the short term to avoid casualties. On the other hand, if contamination by a gaseous release could lead to extensive corrosion or permanent disabling of protective or other critical equipment, then decontamination may have to be implemented. For semi-persistent liquids and low volatility solids which may be encountered, the decision to decontaminate will depend on the toxicity and hazard presented to personnel in protective ensembles and to the corrosivity/damage to equipment. If either or both of these aspects are considered as serious, decontamination may have to be carried out or, if possible, complete avoidance procedures implemented.

3. Avoidance and decontamination require the capability to detect very low levels of contamination to verify success. It is also very difficult, if not impossible, to access and check for decontamination in all the places it may be deposited within equipment, to verify very stringent levels of decontamination. All extreme avoidance measures with current equipment are subject to a risk of undetected failure, as the achievement of ‘certain’ avoidance can only readily be achieved via exclusion from the contaminated theatre.

4. Depending upon the nature, volume and the form of release, TIC may present similar although usually less potent challenges compared to chemical agents. However, accidental and incidental releases are likely to be localized in extent albeit they may be highly concentrated at or near the point of emission.

5. Regarding the broad variety and different physical and chemical properties of TIC, no decontamination unit is or will be able to effectively decontaminate the entire spectrum. However, the effectiveness of decontamination against TIC is to be addressed in the course of development and procurement of decontamination systems. Against which TIC the decontaminant is to be effective is to be addressed in the appropriate NATO documents.

6. As solids, aerosols or liquid droplets all of the above chemicals may adhere and/or spread over surfaces and penetrate capillary spaces such as chemical agent and thickened chemical agent may also be absorbed into permeable and porous materials. From an operational point of view all of these substances pose a direct threat to the personnel due to the possibility of direct exposure (primary exposure due to an attack or an accidental release, but also a secondary threat after the initial incident. Decontamination serves mostly, as a protective measure in the control of CBRN contamination, to reduce or eliminate this secondary threat. Additional information on these substances is provided in STANAG 4521, covering AEP-7.

7. The list provided by the Annex E. is the primary one of interest to be addressed in this document, implications on the need for decontamination of TIC will concentrate on this list.

0213. Impact of Contamination by Biological Agents

1. Doctrine for biological decontamination is not established. Nevertheless the technical actions relevant for biological decontamination are very similar to and shall be executed by the same systems and equipment as for decontamination of chemical and radiological hazards. Concerning biological agents, chemical decontamination methods should be preferred to physical decontamination methods. Biological decontamination is the process of killing (live), destroying (toxins), or removing the ABO to an acceptable level by any product or method.

2. The complexity of biological decontamination is greater than the military requirement for chemical decontamination. This is due to the potential ability of bio agents to continue to grow in some environments and present by this way a non negligible potential hazard for NATO forces. Hence, mere unconfined removal of bio agents is the least desirable approach. Effective and complete destruction of biological agent, however, may not be accomplished until thorough decontamination is undertaken, which may be delayed because of operational considerations. All levels of active decontamination operations remain valid for biological decontamination.

3. Characterization of Biological Particles. Different from chemicals well known as liquid or vapour (rarely as aerosol), biological agents would be preferentially delivered as liquids or dry aerosols of varying respirable particle sizes (10 µm or less).

4. Weaponization. Micro-encapsulation of agents could provide enhanced resistance of the agent to decay, both in the aerosol phase and when deposited on surfaces, and may also provide protection against decontaminants. Additives to the agent may also increase resistance to both UV and decontamination. Some commercial products present such characteristics (e.g. *Bacillus thuringiensis* used as pesticide).

5. Long-term survival of infectious agents, preservation of toxin activity during extended periods, and the protective influence of dust particles onto which microorganisms adsorb

when spread by aerosols have all been documented. The potential exists, therefore, for the re-suspension of infectious particles from previously contaminated surfaces. To a lesser extent, particles may adhere to an individual or to clothing creating additional but less significant exposure hazards. Porous materials and crevices may trap biological agents and shelter them from UV radiation and the decontaminant. Hardening against CBRN contamination, in accordance with AEP-7, should avoid such traps.

6. Large concentrations of aerosolized agent may be generated very quickly by an On-Target-Attack, whether from spraying or bursting munitions, exposing personnel to high levels of inhaled challenge. Protection against such challenge levels may require the combined employment of medical prophylaxis and full respiratory protection (individual or collective) for as long as the primary aerosol persists in location, until dispersed, diluted or possibly decayed, which may take several hours, particularly in atmospherically stable conditions.

7. There may be a significant downwind hazard for many kilometres, exact area depending on wind speed, direction, and size of release. Significant differences in the effect of weapons are seen with different atmospheric conditions including humidity, ultraviolet light (sunlight), temperature and time of day. In addition, pockets of aerosolized biological aerosols may persist for longer periods of time within confined spaces: buildings, shelters and vehicles, even after the primary aerosol has dispersed or moved on.

8. Residual Contamination. While data on the significance of residual contamination following a biological aerosol attack is incomplete, it is anticipated that any on-target delivery system will produce a degree of surface contamination close to the point of release. Relative to the primary aerosol, the immediate hazard associated with contamination will be considerably less than that of the primary aerosol, unless there is a risk of percutaneous exposure, for example through wounds sustained during the attack. The persistence of residual contamination is uncertain, but will be substantially longer than the biological aerosols in aerosol form. Once the primary aerosol has moved from the location residual contamination will represent a continued decreasing hazard, for several hours to days, either from localized re-suspension, cross-contamination, ingestion or percutaneous inoculation. Even relatively low levels of residual contamination may be viewed as significant if personnel remain contaminated or are required to continue operating in the contaminated area. Protection against inhaled and percutaneous hazards may be afforded by the use of medical prophylaxis, the continuous use of appropriate Physical Protection (with associated operational degradation) and high standards of personal and unit hygiene.

9. Re-aerosolization. Residual contamination may be re-aerosolized from the ground, especially in the vicinity of agent release by the movement of both vehicles and personnel. Contaminated equipment or clothing may present a re-aerosolization hazard, especially if brought into enclosed spaces.

10. In order to measure decontamination efficiency of biological decontamination, biological agents have to be characterised from a point of view of decontamination operations. As a guidance, the document "Guide of post-Attack Biological Warfare Hazards", AC/225(LG7)D(2002)9 from the Challenge Sub Group can be used.
Deposition of biological agent from the primary aerosol cloud may occur up to many kilometres from the source of an aerosol spray. However, the contamination densities which

result from an elevated line spray source are likely to be much lower than those which result from sub-munitions.
Biological aerosols might be trapped differently than chemical vapour or liquid. Therefore a selection of different representative matrices of biological aerosol absorbent has to be listed (mud, clay, grease, fans, engine filters, crevices on paint or others). Studies need to be initiated to determine hazards of biological agents in such matrices.

0214. Impact of Radiological Contamination

1. The hazard associated with nuclear material and TIR is the ionizing radiation field emitted in the form of alpha, beta, gamma radiation or neutrons. Compared to chemicals or biological, the ionization radiation is emitted by the source of the hazard (contamination or sealed sources) thus the hazard is still present even though there is no contact between the receptor (individual(s)) and the source of the ionizing radiation. The hazard increases if the receptor comes in contact or internalizes that source of ionizing radiation. In addition, the hazard increases by the square of the distances when approaching a small source. The hazard is quantified by the amount of energy (Sievert, Sv) deposited by the ionizing radiation. In other words, the higher the energy (eV) of the ionizing radiation, the higher the hazard. In addition the higher the energy the farther the ionizing radiation can travel in air or through shielding material. In human tissue, energy from these fields is locally absorbed and results in the destruction of cells and the overall biological effect of nuclear radiation. These fields can be classified into two categories, depending on the type of radiation: direct ionizing radiation (alpha, beta, and protons) and indirect ionizing radiation (neutrons, and gamma).

2. A reduction of hazard is normally associated with a removal/reduction in individual protective equipment (IPE) requirements. This is only partly true for the hazard associated with TIR due to nature of the hazard. Most IPE are only effective in preventing inhalation or direct contact with the source of radiation. IPE will not protect an individual from the penetrating ionizing radiation (gamma and neutron and some high energy beta).

3. Decontamination provides protection from damaging residual (external) radiation by removing radiological matter and from long-term exposure to internal irradiation by preventing the intake of re-aerosolized residual particles.

4. It is also important to note that ionizing radiation cannot be felt by any of the senses. The source of the ionizing radiation is normally small and may come in a variety of forms. One common form is a stainless steel capsule which is a few centimetre in length and diameter. The shape and size depends on the original use of the source of ionizing radiation. The IAEA has several publications and examples of sources and uses of ionizing radiation such as; IAEA-TECDOC-1344 “Categorization of radioactive sources” and IAEA Nuclear Security Series No. 5 “Identification of Radioactive Sources and Devices”.

5. Contact Hazard. For ionizing radiation contact hazards are of concern for beta, gamma and neutron emitting sources. Beta “Hot Particles” can be very hazardous. These are small particles which are highly radioactive and emit large quantities of beta radiation. These will lead to radiation burns on the skin. An alpha source can lead to a contact hazard through absorption of the source (depending on the chemical form) via skin or wounds (this becomes a internalization hazard).

6. Internalization Hazard. For ionizing radiation the internalization due to inhalation (suspended or resuspended particles), ingestion (food contamination or hand contact) and/or absorption is a higher hazard for alpha and beta emitting radiation, but is also a hazard for gamma and neutron emitting radiation.

CHAPTER 3 - LIST AND REQUIREMENT

0301. General

1. This section contains the recommended structure of the various requirements applied to each equipment framework and the numbering convention employed.

a. The title reflects the stage of decontamination for which the equipment pertains, i.e. immediate, operational, thorough or clearance decontamination and its purpose, i.e. personnel, vehicle, ship, etc.; and

b. A preamble contains a short capability statement.

c. The tables in Chapters 4 and 5 establish the minimal operational characteristics, technical specifications, test procedures and evaluation criteria for all equipment necessary to conduct chemical, biological, radiological and nuclear (CBRN) decontamination in accordance with NATO doctrine stated in allied tactical publication ATP-3.8.1.

2. For biological agents, it is assumed that the decontamination system shall not induce re-aerosolization hazards which can cause inhalation exposure above negligible level.

0302. Recommended Structure

Table 3-1 Recommended Framework and Requirements Explanation

Framework	No	Requirement
Mobility (between theatres	1.1	The capability of the system to be strategically deployed and transported by air, land and sea.
Mobility (within theatre)	1.2	The capability of the system to be tactically deployed within the theatre of operations/battles space.
Set-up/Strike time	2	The set-up and strike time reflects the delay from arrival at the decontamination site to operational status and vice- versa.
Capability (efficacy)	3.1	The ability of the system to affect decontamination of all chemical (C), biological (B), radiological (R) and nuclear (N) agents (multipurpose). It also indicates the effectiveness of decontamination to be achieved.
Capability (system capacity)	3.2	The surface area or the number of personnel, vehicles and/or equipment to be decontaminated per hour.
Capability (decontamination process)	3.3	Any limitations to the type of decontamination process to be employed. (optional).
Capability (surface area)	3.4	The surface area of vehicles, equipment and terrain or the number of personnel to be treated with the initial system capacity, without re-supply

Framework	No	Requirement
Capability (target materials)	3.5	The types of material which may or may not be treated by the system, e.g. painted surfaces, terrain, sensitive materials, etc.
Capability (location)	3.6	Where the system is to be located to accomplish its decontamination mission, e.g. inside or outside of theatre, forward or rear area of the combat zone.
Reliability	4	The system reliability expressed in terms of time the system will be expected to perform without failure, e.g. the mean time between failures (MTBF) criterion and availability expressed in % of time.
Compatibility (NATO decontaminants)	5.1	For equipment, the ability, where applicable, to employ decontaminants of other NATO member nations. For decontaminants, the compatibility with existing equipment of other NATO nations.
Compatibility (inter-operability)	5.2	The ability of the equipment to interface with systems of other NATO nations, e.g. water connections, power requirements.
Compatibility (with other equipment/ systems)	5.3	The non-interference with the functionality or operation of other equipment/systems in the battlespace, e.g. detection systems, communication systems, IPE, imaging or infrared (IR) signature.
Survivability (decontamination system)	6.1	The degree of CBRN and physical hardening of the decontaminating apparatus to withstand contamination hazards, the possible degradation from decontaminants and weather, etc.
Survivability (target equipment)	6.2	The ability of the system to avoid degradation to the material being decontaminated and to quickly prevent the target equipment from further degradation by the contaminant.
Support/Logistics (personnel)	7.1	The level of manpower required and the degree of expertise and training required to operate the system, including any additional personnel required for initial installation/setup.
Support/Logistics (hardware/ consumables	7.2	The re-supply and support service requirements to maintain the tempo of the decontamination operation, e.g. re-supply, engineering services.
Environmental Concerns	8	The ability of the system to operate within existing, proposed health and safety and environmental requirements.
Documentation	9	All necessary documentation required to operate and maintain the system, e.g. training and instruction manuals, parts lists, maintenance schedules.
Operational Parameters (Climatic conditions)	10.1	The ability of the system to be employed in climatic conditions as defined in Allied Environmental Conditions and Test Publications AECTP 200 – Environmental Conditions.
Operational Parameters (Shelf life)	10.2	The expected shelf life of the system. This will normally be a national statement.

Framework	No	Requirement
Operational Parameters (Stability of Decontaminants)	10.3	The degree of degradation in performance during deployment from permanent storage to employment at the operational site.
Training	11	System training requirements, e.g. simulation, computer based training (CBT).

CHAPTER 4 - DECONTAMINATION SYSTEM

SECTION I - EQUIPMENT

0401. Immediate Decontamination Individual Kit

1. Immediate decontamination is carried out by individuals upon becoming contaminated and may include decontamination of personal clothing and/or equipment as well as parts of human skin in case of contamination. The aim is to save lives, minimize casualties and limit the spread of contamination. This kit does not specifically address the problem of (large capacity) decontamination system requirements for medical support units.

2. The individual decontamination kit should address as many types of CBRN agents as practical and may also be effective against TIM. The contamination levels to be considered in the design and evaluation of the kit are the standard NATO contamination density levels.

Table 4-1 Immediate Decontamination Individual Kit - Requirements

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
1.1 Mobility (between theatres)	The kit shall be easy to move and allow a configuration that they can be readily deployed in the field in bulk.	The kit shall be small, lightweight and allow stacking for transport.	Evaluate the kit configuration in relation to available means of transport (air, land and sea).
1.2 Mobility (within theatre)	The kit is carried by individuals and shall not interfere with the normal performance and duties of the soldier.	The kit shall be small, lightweight and highly portable by the individual.	Evaluate shape and weight in relation to the normal performance and duties of the soldier.
2 Set-up time	Usage of the kit shall allow for rapid and immediate decontamination of exposed surfaces for all potential agents.	The kit must be completely self- contained and ready to be used within 10 seconds.	Evaluate by opening the kit by hand in IPE.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
3.1 Capability (efficacy)	The kit shall be effective against all known, suspected or potential agents, including as many toxic industrial materials as possible.	The kit shall be effective against chemical agents such as the mustards (e.g. HD), nerve agents (G and V series), biological (viruses and bacteria) and remove radioactive particles . The kit may also be effective against toxic industrial materials.	Evaluate decontamination efficiency for selected agents. Initial contamination (C and toxins) shall quantitatively be reduced to below the incapacitating dose for 5% of the exposed population (ID5% for a 70 kilogramme (kg) individual) for the decontaminated surface. Test procedures and evaluation criteria, for biological and radiological agents are also needed
3.2 Capability (system capacity)	The kit shall be designed for single person use only (when in IPE), either to decontaminate oneself or another individual (buddy-aid).	The kit must allow the decontamination of a single person in IPE with personal equipment within the following required time-frame: Maximum time for complete skin decontamination : two minutes. Maximum time for complete immediate decontamination: ten minutes.	Evaluate using laboratory and fields trials in IPE.
3.3 Capability (decontamination process)	The kit must allow an immediate decontamination, through physical removal, physical encapsulation and/or chemical or biological neutralization or destruction of the contamination.	Usage of the kit must result in efficient removal, encapsulation and/or destruction of all known, suspected or potential agents and may result in efficient removal, encapsulation and/or destruction of common toxic industrials materials.	Assess concurrently with requirements 3.1 and 3.2.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
3.4 Capability (surface area)	The kit shall allow rapid decontamination of exposed skin such as hands, face, neck, hair, etc. It shall also allow the rapid decontamination of selected portions of the protective clothing and personal equipment of the individual.	Usage of the kit must result in efficient and sufficient removal, encapsulation and/or detoxification of all known, suspected or potential agents on exposed bare skin and selected portions of personal clothing and equipment.	Evaluate decontamination efficiency for selected agents on selected, representative substrates, for a representative surface of 0.5 square meters (for example 2 packages for 0.25 m^2 each).
3.5 Capability (target materials)	The kit must be able to decontaminate bare skin and selected portions of protective clothing and personal equipment.	The kit must not damage bare skin and may not degrade materials commonly found in protective clothing and personal equipment.	Laboratory trials shall be used to evaluate degradation of target materials.
3.6 Capability (location)	Every individual carries out immediate decontamination as soon as possible following a contamination.	Usage of the kit is likely to occur in a contaminated environment and in a forward area of the combat zone.	Design of the kit must allow for execution of the decontamination procedure in a hostile and contaminated environment.
4 Reliability	The kit should be 100% reliable and require no maintenance.	The kit should be 100% reliable for all tests. Packaging of both individual kits and packets shall be robust enough to survive normal handling in the field. The kit shall not require any maintenance.	
5.1 Compatibility (other NATO formulations)	The system must be compatible with other decontaminants fielded by NATO members.		Compatibility testing with other decontamination systems and/or formulations.
5.2 Compatibility (interoperability)	Not applicable (N/A)		

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
5.3 Compatibility (with other equipment/ systems)	The use of the kit shall not interfere with standard operation of other military equipment and procedures including detection, protection, prophylactic and therapeutic treatment for agent exposure.		Compatibility testing with other systems and/or equipment.
6.1 Survivability (decontamination equipment)	The packaging of the kit shall comply with the standard CBRN hardening criteria.	See STANAG 4521, covering AEP-7.	See STANAG 4521, covering AEP-7.
6.2 Survivability (target equipment)	The use of the kit on bare skin shall not cause any injury or irritation; it shall not have any toxic effect nor increase the permeability of skin to potential agents.	The substance(s) used as decontaminant(s), their components, reaction and degradation products shall not be irritant, toxic or carcinogenic.	MSDS for every substance / component. Skin irritation testing, medical approval. Verify non-reduction in functionality of selected portions of IPE and personal equipment to be treated with the kit during immediate decontamination.
7.1 Support/ Logistics (personnel)	The kit is to be used by a single person in IPE.	See requirement 3.2.	See requirement 3.2.
7.2 Support/ Logistics (hardware/ consumables	The kit is completely self-contained.	See requirement 2.	
8 Environmental concerns	In operation and storage, the system should meet the environmental regulations of the hosting nation and the owner.	See Chapter 5 (Environmental considerations) of this AEP.	See Chapter 5 (Environmental considerations) of this AEP.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
9 Documentation	Usage of the kit shall be self- explanatory. Operating manuals should be in French or English as well as the national language of the owner.	Each kit shall be marked with simple pictograms to indicate proper usage to an inexperienced user. Instructions concerning use, handling and storage are to be located on the packaging.	Evaluate usage by inexperienced soldier(s).
10.1 Operational parameters (climatic conditions)	The kit shall be capable of being deployed without essential loss of effectiveness within standard NATO conditions A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation (reference AECTP 200 – Environmental Conditions or see Annex H).	When unused, the kit and any of its components shall not degrade over a period of minimum five (5) years under field conditions.	Evaluate efficiency after (unused) exposure to extreme conditions within stated ranges of temperature and humidity (A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation (reference AECTP 200 – Environmental Conditions or see Annex H)).
10.2 Operational parameters (shelf life)	Shelf life, as defined in the glossary of this document, must be in compliance with national regulations.	The kit and any of its components must not degrade below minimal requirements over a period equal to the required national shelf life. The kit must meet minimal requirements during storage.	Evaluate efficiency after ageing under shelf life conditions.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
10.3 Operational parameters (stability)	The kit shall not decrease in effectiveness for a period of at least thirty (30) minutes after opening in NATO conditions A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation (reference AECTP 200 – Environmental Conditions or see Annex H).	The kit shall retain full effectiveness for thirty (30) minutes when exposed to air, light or humidity.	Evaluate efficiency after opening and after exposure to extreme conditions within stated ranges of temperature and humidity (A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation (reference AECTP 200 – Environmental Conditions or see Annex H)).
11 Training	See requirements 3.2 and 9.	See requirements 3.2 and 9.	See requirements 3.2 and 9.

0402. Operational Decontamination System for Platforms

The decontamination system should be capable of carrying out the operational decontamination of a platform in the battlespace by one man with the aim of preventing spread of contamination during entry, replenishment, and essential maintenance and repair to the platform and while using it.

Table 4-2 Operational Decontamination System for Platforms - Requirements

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
1.1 Mobility (between theatres)	The system must be capable of being stored in and/or on any platform, and be man-portable.	The size or weight of the system components shall be compatible with standard transport vehicles	Specifications of dimensions for platform fitting. User trials to determine man-portability.
1.2 Mobility (within theatre)	The system must be capable of being stored in and/or on any platform, and be man-portable.	The system must be of minimal size and weight to ensure it can be carried by two persons. It is desirable that it can be carried by one person.	Specifications of dimensions for platform fitting. User trials to determine man-portability.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
2 Set up/ Strike time	The system must be operational within 5 minutes. The system should not have complicated start-up procedures.	The system must be fully operational in as short a time as possible. Preferably it should be immediately operational. The system must be derigged and stowed within 5 minutes after decontamination operations are concluded.	Field trials and exercises shall be used to determine capability and establish set up and strike time.
3.1 Capability (efficacy)	The system must be effective against all known CBRN agents including as many toxic industrial materials as possible.	The system must be effective in decontaminating chemical and biological agents and removing radiological and nuclear material and toxic industrial materials.	See Vol. II and annexes for laboratory and chamber test methods and associated criteria.
3.2 Capability (system capacity)	Each system should permit decontamination of the essential areas of the target platform without being resupplied.	The system must decontaminate a platform to operational levels within 30 minutes.	Capabilities shall be verified in field trials.
3.3 Capability (decontamination process)	The system must effect operational decontamination.	The system must perform decontamination by means of chemical neutralization, physical removal, encapsulation or any combination of these processes. The system must eliminate transfer hazard over the area of application.	Confirm by decontamination effectiveness studies performed on selected target materials. See Vol. II for methodology and criteria.
3.4 Capability (surface area)	Each system should be able to decontaminate the essential areas of the target platform. It is likely that this total area will be composed of several smaller areas.	The system must decontaminate a minimum area of 5 m^2 without replenishment.	Assessment by user trials.
3.5 Capability (target materials)	The system must be able to decontaminate surfaces commonly encountered on the target platform.	The system must be able to decontaminate key surfaces of the target platform.	See Vol. II. User trials to determine efficacy shall confirm capability.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
3.6 Capability (location)	The system must be able to perform operational decontamination in forward areas of the battlespace.	The system must be able to be used on key surfaces of the target platform without regard to the location of the platform.	Assessment by user trials.
4 Reliability	The system should operate reliably during battlefield missions. The equipment must be robust enough to survive normal handling in the field.	The system should be 100% reliable on initial use.	Assessment by user trials.
5.1 Compatibility (other NATO formulations)	The system should be compatible with other decontaminants and decontamination systems fielded by NATO members.	It is desirable that the system can be used with other decontaminants.	Countries should provide to other NATO countries, to the extent possible, formulation data of in-service decontaminants and delivery systems to facilitate compliance with this technical characteristic. Assessment by laboratory trials
5.2 Compatibility (interoperability)	The system should be interchangeable with corresponding systems of other NATO countries.	It is desirable that the system can be readily stored or fitted into a variety of platforms.	Assessment by user trials.
5.3 Compatibility (with other equipment systems)	The system shall cause no degradation to the mission essential functionality of the platform being decontaminated.	The system shall not interfere with the operation of other NATO equipment including communications, fire control, CB detection/monitoring and similar battlefield items. System must not degrade the IPE worn by operators or other associated personnel.	The system shall be tested by operating it in proximity to these items and examining them for interference or performance degradation.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
6.1 Survivability (decontamination equipment)	The system shall comply with standard CBRN hardening criteria and should not be compromised by CBRN contamination.	The container and equipment must have the appropriate degree of chemical hardening and comply with STANAG 4521.	Assessment of hardness and material compatibility.
6.2 Survivability (target equipment)	The decontamination system must not cause unacceptable degradation of the surfaces or target material properties that are commonly encountered on platform interiors and exteriors.	The system should not degrade surfaces such as glass, painted metal, bare metal, plastics and rubber. The system should not degrade camouflage and concealment properties or the original functionality of the target platform.	All material compatibility issues shall be addressed with appropriate testing during item development. (Reference STANAG 4521).
7.1 Support/ logistics (personnel)	The equipment must be operable by one person with limited training wearing full IPE.	Inexperienced personnel in full IPE should be able to operate the decontamination system.	Field trials and user exercises to determine capability.
7.2 Support/ logistics (hardware/ consumables)	The system should be self contained and not rely on additional equipment or sources of power.	The system must be capable of being dismantled for recharging by operators in IPE. Additional decontaminant should be supplied with the system. Aqueous based decontaminants should be capable of being reconstituted from river, ditch or sea water with no adverse effects on performance.	Field trials and user exercises to determine capability.
8 Environmental concerns	In operation and storage, the system shall meet the environmental regulations of the hosting nation and the owner.	See Chapter 5 (Environmental considerations) of this AEP.	See Chapter 5 (Environmental considerations) of this AEP.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
9 Documentation	Complete instruction, maintenance and training manuals are to be supplied. Operating manuals should be in French or English as well as the national language of the owner.	Each system shall be marked with simple pictograms to indicate correct operation to an inexperienced user. Instructions concerning use, handling and storage are to be located on the package.	Assessment by user trials.
10.1 Operational parameters (climatic conditions)	The system must operate in the standard NATO climatic conditions A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation (reference AECTP 200 – Environmental Conditions or see Annex H).	The system must not require special storage conditions or deteriorate in the field under standard climatic conditions A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation.	Testing shall be conducted within stated ranges of temperatures and humidity outside or wherever possible (reference AECTP 200 – Environmental Conditions or see Annex H).
10.2 Operational parameters (Shelf life)	Shelf life should comply with national regulations. Any mechanical elements shall have a life expectancy meeting national requirements with normal intermittent use.	The system should have a shelf life as determined by individual nations. The system should meet the minimum efficiency requirements for operational decontamination throughout its shelf-life. Mechanical elements in the system shall meet the performance criteria applicable to new equipment throughout the shelf life.	Long term storage trials, followed by effectiveness testing.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
10.3 Operational parameters (Stability of decontaminants)	The decontaminant in the system must be stable enough for effective decontamination for 24 hours after being activated	The decontaminant in the system should be stable for at least 90 days after deployment, 3 days unsealed and 24 hours after activation. If the decontaminant is water-based, reconstitution by all types of water including salt water must not affect the stability.	Storage trials, followed by effectiveness testing.
11 Training	No specialist training should be required. The system shall be capable of being frequently operated for the purposes of training without degradation to performance (see also requirement 9).	Any decontaminant or simulant supplied for training purposes must meet requirements 8 and 9 above to permit frequent use in training.	(See requirement 9).

0403. Thorough Decontamination Large Capacity System

1. This large capacity system is required to perform thorough decontamination of large robust pieces of military equipment within the framework of a dedicated, if temporary, decontamination site or as a part of the decontamination systems to be used at large essential installations.

2. Further the equipment will be returned to combat for use by troops who are not outfitted in full individual protective equipment. The system will be used by specially trained soldiers at a temporary site remote from combat activity. Two basic types of systems can be considered for this purpose: liquid and energetic. Liquid systems are more traditional and utilize chemically reactive mixture(s) to dissolve and, optionally, neutralize the agents. Energetic systems are typified by those which employ forced hot air to evaporate chemical or biological agents from the surface or remove non-fixed radioactive contaminations. Future energetic systems may employ electromagnetic radiation; particle radiation or plasmas alone or in combination with chemicals. The operational and technical characteristics which follow are intended to accommodate both chemical and energetic approaches.

Table 4-3 Thorough Decontamination Large Capacity System - Requirements

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
1.1 Mobility (between theatres)	The system shall be readily transportable by road, rail, ship and air.	The size or weight of the system components shall not exceed the capacity of standard transport vehicles. The system must be capable of being loaded and unloaded from transport vehicles without the need for special equipment or extra personnel.	Specifications of cargo aircraft, trucks, ships (including loading and unloading equipment) shall be the determining criteria.
1.2 Mobility (within theatre)	The system must be capable of moving to a site suitable for establishment of a decontamination site.	The system must be capable of being moved by dedicated vehicles over public roads, paved and unpaved, as well as field/wood paths and dirt roads with consolidated surfaces. Applicable to the corresponding requirements of systems.	The design of the system shall be in accordance with national and agreed standards for the design and development of military equipment. (e.g. STANAG 4521, 4360/4447,)
2 Set-up Time/ Strike Time	There must be minimal delay between arrival at the decontamination site and commencement of operations as well as the time between completion of operations and readiness to leave the site.	System must be fully operational in as short a time as possible but not to exceed 40 minutes after arrival at the decontamination site. The system shall be ready to depart the site within 60 min after decontamination operations are concluded.	Field trials and exercises shall be used to establish set-up and strike times.
3.1 Capability (efficacy)	The system shall effectively decontaminate all known CBRN contamination. Effectiveness against TIM which are considered a threat is desirable.	The unit must reduce chemical contamination on robust surfaces to the standardized limit values. It must also be capable of removing/neutralizing biological agents and removing nuclear/radiological contamination.	Laboratory and chamber testing with selected threat chemicals on all appropriate target materials shall be used to verify that the levels specified in Vol. II can be attained.

3.2 Capability (system capacity)	The system shall have sufficient capacity to decontaminate an average of 6 platforms per hour (armoured platoon, vehicles or equivalent)	The system must be capable of decontaminating at a rate of approximately 600 m^2 or equivalent per hour; this capability shall not be reduced by the presence of mud, dust or dirt on the vehicles.	This capability shall be established using field trials with actual systems, target equipment and crews.
3.3 Capability (decontamination process)	The system- shall affect sufficient reduction in agent contamination to allow a removal/reduction in IPE.	The system must perform thorough decontamination by means of chemical neutralization, physical removal, encapsulation or any combination of these processes.	Establish in laboratory or chamber efficacy testing
3.4 Capability (surface area)	The system shall have sufficient capacity to decontaminate about 20 average military platforms or the equivalent.	The system shall be capable of decontaminating 2000 m^2 without re-supply of fuel or decontaminant(s); this capability shall not be reduced by the presence of mud, dust or dirt on the vehicles.	Establish in the decontamination efficacy studies to be performed during development.
3.5 Capability (target materials)	The system shall perform decontamination on the exterior surfaces of platforms, transport vehicles, trailers and other robust items of military equipment.	The system shall be able to decontaminate the various painted and bare metal surfaces, polymers, elastomers, canvas and other materials used in the construction of large items of military equipment.	Establish in the decontamination efficacy studies to be performed during development.
3.6 Capability (location)	The system shall be deployable in an uncontaminated area as near to the point of incident as is consistent with safe and expeditious conduct of the operation.	(See requirement 1.2). The system must be able to use available water sources.	

4 Reliability	The system must be of robust design to assure maximum operational reliability.	The system shall have a MTBF > 1000 hours of intermittent use. Operating crew should be able to repair 95% of all failures within 6 hours and 50% within 2 hours. The system shall be available for service at least 80% of its lifetime. The system shall be designed for straightforward maintenance with regular servicing sites located for simple and raid access.	The system shall be subjected to appropriate operational testing to verify the reliability.
5.1 Compatibility (other NATO formulations)	The decontamination system should be able to operate in concert with other NATO systems.	All liquid-based systems should be designed to dispense as wide a variety of decontaminants from other NATO countries as possible.	Countries should provide to other NATO countries, to the extent possible, formulation data to facilitate compliance with this technical characteristic.
5.2 Compatibility (interoperability)	The decontamination system should be able to operate in concert with other NATO systems.	Designers should endeavour to utilize common hose connections or to provide adapters. Electrical power requirements and interfaces should be standardized whenever possible.	Countries should provide to other NATO countries, to the extent possible, hardware data to facilitate compliance with this technical characteristic.
5.3 Compatibility (with other equipment/ systems)	The decontamination system should not interfere with essential operation of military equipment in the decontamination area.	The system shall not interfere with the operation of other NATO equipment including communications, fire control, CB detection/monitoring and similar battlefield items. System must not degrade the IPE worn by operators or other associated personnel.	The system shall be tested by operating it in proximity to these items and examining them for interference or performance degradation.

6.1 Survivability (decontamination system)	The system operation should not be compromised by CBRN contamination or any known decontaminants.	Decontaminability, compatibility with decontaminating solutions and CBRN hardening shall be incorporated into the basic system design. In systems using water, the substitution of seawater must not degrade performance.	All materials and components of the system shall be tested for compliance with STANAG 4521.
6.2 Survivability (target equipment)	The decontamination system should not degrade target equipment.	The system must not reduce the functionality (i.e., mobility, combat effectiveness, etc.) of target equipment. The system shall not cause degradation of camouflage and concealment properties of the equipment surfaces.	All material compatibility issues shall be addressed with appropriate testing during item development. (Reference STANAG 4521).
7.1 Support/ Logistics (personnel)	The system shall be operable by a specialized crew or, if necessary, ad hoc personnel with limited training.	The system must be capable of being deployed, operated and restocked by a crew of not more than six persons in IPE.	Personnel requirements shall be established in field trials.
7.2 Support/ Logistics (hardware and consumables)	The system shall be self- contained.	The system should be self-contained and should be operable either on a transport vehicle or should be removable from that vehicle by the crew. It should have all of the components, including lighting, maintenance kits/spare parts and a power supply to allow operation for its rated capacity without support from any other military units.	Field trials under realistic conditions shall be used to establish the support and logistic requirements of the system. The trials shall be used to determine the items for incorporation into maintenance and spare parts kits.
8 Environmental Concerns	In operation and storage, the system shall meet the environmental regulations of the hosting nation and the owner.	See Chapter 5.4 (Environmental considerations) of this AEP.	See Chapter 5 (Environmental considerations) of this AEP.

9 Documentation	Supporting documentation must be supplied for both operation and maintenance. Operating manuals should be in French or English as well as the national language of the owner.	Complete operator's manuals, schematics and parts list should accompany the system.	Adequacy of manuals shall be addressed with field trials.
10.1 Operational Parameters (climatic conditions)	System must function within all climates likely to be encountered.	System design shall include deployment and operational compatibility with climate zones A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation (reference AECTP 200 – Environmental Conditions or see Annex H).	Testing shall be conducted within stated ranges of temperatures and humidity outside or wherever possible (reference AECTP 200 – Environmental Conditions or see Annex H).
10.2 Operational Parameters (shelf life)	Shelf life should comply with national regulations.	The system should have a shelf life as determined by individual nations. The system should retain full effectiveness during storage.	Long term storage trials, followed by effectiveness testing to meet the criteria in Vol. II.
10.3 Operational Parameters (stability of decontaminant)	Decontamination capability of chemically based systems should not be degraded during deployment or application.	Formulations used in the system shall comply with the pertinent stability requirements given in Subchapter 0413, Requirement 10.3.	Controlled testing using the climatic conditions from requirement 10.1 and the effectiveness criteria in Vol. II.
11 Training	A crew specifically trained to use the equipment should perform this type of decontamination.	Equipment should utilize simple design and/or automation to reduce the need of complex decision-making by the operators. Each crewmember should be capable of operating all components of the system.	Simulants, if necessary, shall be provided for training purposes and should mimic, to the extent possible, the actual decontaminant materials.

0404. Thorough Decontamination Large Capacity System – Fixed Site

1. This large capacity system is required to perform thorough decontamination of large robust pieces of military equipment within the framework of a dedicated decontamination site or as a part of the decontamination systems to be used at large essential, fixed site

installations. Examples of fixed site installations are seaports, airfields, and equipment staging and resupply locations. This equipment may also fill the role of operational or thorough decontamination of sensitive equipment, aircraft, ship and maritime equipment, and personnel and casualties.

2. Further the equipment will be returned to combat for use by troops who are not necessarily outfitted in full individual protective equipment. Two basic types of systems may be considered for this purpose: liquid and energetic. Liquid systems are more traditional and utilize chemically reactive mixture(s) to dissolve and, optionally, neutralize the agents. Energetic systems are typified by those which employ forced hot air to evaporate chemical or biological agents from the surface or remove non-fixed radioactive contaminations. Future energetic systems may employ electromagnetic radiation; particle radiation or plasmas alone or in combination with chemicals. The operational and technical characteristics which follow are intended to accommodate both chemical and energetic approaches.

Table 4-4 Thorough Decontamination Large Capacity System – Fixed Site - Requirements

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
1.1 Mobility (between theatres)	The system shall be readily transportable by road, rail, ship and air.	The size or weight of the system components shall not exceed the capacity of standard transport vehicles. The system must be capable of being loaded and unloaded from transport vehicles without the need for special equipment or extra personnel.	Specifications of cargo aircraft, trucks, ships (including loading and unloading equipment) shall be the determining criteria.
1.2 Mobility (within theatre)	The system must be capable of moving to a site suitable for establishment of a decontamination site.	The system must be capable of being moved by dedicated vehicles over public roads, paved and unpaved, as well as field/wood paths and dirt roads with consolidated surfaces. Applicable to the corresponding requirements of systems.	The design of the system shall be in accordance with national and agreed standards for the design and development of military equipment. (e.g. STANAG 4521, 4360/4447; 2175, 2832, 2895)

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
2 Set-up Time/Strike Time	There must be minimal delay between arrival at the contamination site and commencement of operations as well as the time between completion of operations and readiness to leave the site.	System must be fully operational in as short a time as possible but not to exceed 6 hours after arrival at the decontamination site. The system shall be ready to depart the site within 8 hours after decontamination operations are concluded.	Field trials and exercises shall tie used to establish set-up and strike times.
3.1 Capability (efficacy)	The system shall effectively decontaminate all known CBRN contamination. Effectiveness against TIM which are considered a threat is desirable.	The unit must reduce chemical contamination on robust surfaces to the standardized limit values. It must also be capable of removing/neutralizing biological agents and removing nuclear/radiological contamination.	Laboratory and chamber testing with selected threat chemicals on all appropriate target materials shall be used to verify that the levels specified in Vol. II can be attained.
3.2 Capability (system capacity)	The system shall have sufficient capacity to decontaminate an average armoured platoon (6 vehicles) or equivalent per hour.	The system must be capable of decontaminating at a rate of approximately 600 m^2 or equivalent per hour; this capability shall not be reduced by the presence of mud, dust or dirt on the vehicles.	This capability shall be established using field trials with actual systems, target equipment and crews.
3.3 Capability (decontamination process)	The system- shall effect sufficient reduction in agent contamination to allow a removal/reduction in IPE.	The system must perform thorough decontamination by means of chemical neutralization, physical removal, encapsulation or any combination of these processes.	Establish in laboratory or chamber efficacy testing
3.4 Capability (surface area)	The system shall have sufficient capacity to decontaminate about 20 average military platforms or the equivalent.	The system shall be capable of decontaminating 2000 m^2 without re-supply of fuel or decontaminant(s); this capability shall not be reduced by the presence of mud, dust or dirt on the vehicles.	Establish in the decontamination efficacy studies to be performed during development.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
3.5 Capability (target materials)	The system shall perform decontamination on the exterior surfaces of platforms, transport vehicles, trailers and other robust items of military equipment.	The system shall be able to decontaminate the various painted and bare metal surfaces, polymers, elastomers, canvas and other materials used in the construction of large items of military equipment.	Establish in the decontamination efficacy studies to be performed during development.
3.6 Capability (location)	The system shall be deployable in an uncontaminated area as near to the point of incident as is consistent with safe and expeditious conduct of the operation.	(See requirement 1.2). The system must be able to use available water sources.	
4 Reliability	The system must be of robust design to assure maximum operational reliability.	The system shall have a MTBF > 1000 hours of intermittent use. Operating crew should be able to repair 95% of all failures within 6 hours and 50% within 2 hours. The system shall be available for service at least 80% of its lifetime. The system shall be designed for straightforward maintenance with regular servicing sites located for simple and raid access.	The system shall be subjected to appropriate operational testing to verify the reliability.
5.1 Compatibility (other NATO formulations)	The decontamination system should be able to operate in concert with other NATO systems.	All liquid-based systems should be designed to dispense as wide a variety of liquid decontaminants as possible.	Countries should provide to other NATO countries, to the extent possible, formulation data to facilitate compliance with this technical characteristic.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
5.2 Compatibility (interoperability)	The decontamination system should be able to operate in concert with other NATO systems.	Designers should endeavor to utilize common hose connections or to provide adapters. Electrical power requirements and interfaces should be standardized whenever possible.	Countries should provide to other NATO countries, to the extent possible, hardware data to facilitate compliance with this technical characteristic.
5.3 Compatibility (with other equipment/ systems)	The decontamination system should not interfere with essential operation of military equipment in the decontamination area.	The system shall not interfere with the operation of other NATO equipment including communications, fire control, CB detection/monitoring and similar battlefield items. System must not degrade the IPE worn by operators or other associated personnel.	The system shall be tested by operating it in proximity to these items and examining them for interference or performance degradation.
6.1 Survivability (decontaminatio n system)	The system operation should not be compromised by CBRN contamination or any known decontaminants.	Decontaminability, compatibility with decontaminating solutions and CBRN hardening shall be incorporated into the basic system design. In systems using water, the substitution of seawater must not degrade performance.	All materials and components of the system shall be tested for compliance with STANAG 4521.
6.2 Survivability (target equipment)	The decontamination system should not degrade target equipment.	The system must not reduce the functionality (i.e., mobility, combat effectiveness, etc.) of target equipment. The system shall not cause degradation of camouflage and concealment properties of the equipment surfaces.	All material compatibility issues shall be addressed with appropriate testing during item development. (Reference STANAG 4521).

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
7.1 Support/ Logistics (personnel)	The system shall be operable by a specialized crew or, if necessary, ad hoc personnel with limited training.	The system shall be capable of being set up, operated and restocked and decontamination being prepared by six person decontamination teams wearing full CBRN protective clothing or by any number of personnel with limited onsite training	Personnel requirements shall be established in field trials.
7.2 Support/ Logistics (hardware and consumables)	The system shall be self-contained.	The system should be self contained and should be operable either on a transport vehicle or should be removable from that vehicle by the crew. It should have all of the components, including lighting, maintenance kits/spare parts and a power supply to allow operation for its rated capacity without support from any other military units.	Field trials under realistic conditions shall be used to establish the support and logistic requirements of the system. The trials shall be used to determine the items for incorporation into maintenance and spare parts kits.
8 Environmental Concerns	In operation and storage, the system shall meet the environmental regulations of the hosting nation and the owner.	See Chapter 5.4 (Environmental considerations) of this AEP.	See Chapter 5 (Environmental considerations) of this AEP.
9 Documentation	Supporting documentation must be supplied for both operation and maintenance. Operating manuals should be in French or English as well as the national language of the owner.	Complete operator's manuals, schematics and parts list should accompany the system.	Adequacy of manuals shall be addressed with field trials.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
10.1 Operational Parameters (climatic conditions)	System must function within all climates likely to be encountered.	System design shall include deployment and operational compatibility with climate zones A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation (reference AECTP 200 – Environmental Conditions or see Annex H).	Testing shall be conducted within stated ranges of temperatures and humidity outside or wherever possible (reference AECTP 200 – Environmental Conditions or see Annex H).
10.2 Operational Parameters (shelf life)	Shelf life should comply with national regulations.	The system should have a shelf life as determined by individual nations. The system should retain full effectiveness during storage.	Long term storage trials, followed by effectiveness testing to meet the criteria in Vol. II.
10.3 Operational Parameters (stability of decontaminant)	Decontamination capability of chemically based systems should not be degraded during deployment or application.	Formulations used in the system shall comply with the pertinent stability requirements given in Subchapter 0413, Requirement 10.3.	Controlled testing using the climatic conditions from requirement 10.1 and the effectiveness criteria in Vol. II.
11 Training	A crew specifically trained to use the equipment should perform this type of decontamination.	Equipment should utilize simple design and/or automation to reduce the need of complex decision making by the operators. Each crewmember should be capable of operating all components of the system.	Simulants, if necessary, shall be provided for training purposes and should mimic, to the extent possible, the actual decontaminant materials.

0405. Thorough Decontamination Small Scale Capacity System

1. The mobile small capacity vehicle/equipment thorough decontamination system comprises devices, decontaminants and procedures and facilitates thorough decontamination of small robust items and small numbers of large robust items for the purposes of limiting the spread of contamination and reducing or eliminating the hazard. The equipment and any associated decontaminants shall address decontamination of items, which require thorough decontamination, but, because of numbers or location, would not warrant use of large-scale decontamination equipment.

2. It will reduce required protection for personnel operating and handling equipment and supplies. It will address decontamination to safe residual levels on items such as robust personal equipment, ammunition, food racks, supplies, platforms, equipment requiring maintenance, etc., in areas forward of or not readily accessible to larger decontamination stations. This will be accomplished by heat, physical removal/encapsulation, and CB agent detoxification and may involve solid/liquid decontaminants, which are rinsed off or left in place.

Table 4-5 Thorough Decontamination Small Scale Capacity System - Requirements

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
1.1 Mobility (between theatres)	The system shall be readily transportable by road, rail, ship air, and/or, if part of a larger system, shall be readily detachable.	The size or weight of the system and components shall be compatible with standard transport vehicles.	Transportation platform specification in design criteria and user trials to confirm portability.
1.2 Mobility (within theatre)	The system shall be highly mobile and compact in size and be sufficiently manoeuvrable for location near or among pieces of contaminated equipment and/or supplies.	The system must be capable of being moved by dedicated vehicles over public roads, paved and unpaved, as well as field/wood paths and dirt roads with consolidated surfaces. Applicable to the corresponding requirements of systems. Sub-assemblies shall be equipped with load-bearing handles and/or hoist points to facilitate loading/unloading and preferably, be capable of being lifted by personnel and mobile lifting equipment.	The design of the system shall be in accordance with national and agreed standards for the design and development of military equipment. (e.g. STANAG 4521, 4360/4447)

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
2 Set-up Time/ Strike Time	There must be minimal delay between arrival at the decontamination site and commencement of operations as well as the time between completion of operations and readiness to leave the site.	System must be fully operational including preparation of decontaminant in as short a time as possible but not to exceed 20 minutes after arrival at the decontamination site. The system shall be ready to depart the site within 20 min after decontamination operations are concluded.	Field trials and exercises shall be used to determine capability and establish set-up and strike time.
3.1 Capability (efficacy)	The system shall effectively decontaminate all known CBRN contamination. Effectiveness against TIM, which are considered a threat, is desirable.	The system must reduce chemical contamination on robust surfaces to the standardized limit values. It must also be capable or removing/neutralizing biological agents and removing radiological and nuclear contamination.	Laboratory and chamber testing with selected threat chemicals on all appropriate target materials shall be used to verify that the levels specified in Vol. II can be attained.
3.2 Capability (system capacity)	The system shall address the need for thorough decontamination on small size/numbers of equipment items and supplies equivalent to three (3) platforms/hr.	It shall perform thorough decontamination on equipment or supplies of comparable surface area for up to 300 m^2/hr; this capability shall not be reduced by the presence of mud, dust or dirt.	Capabilities shall be tested in field trials.
3.3 Capability (decontamination process)	The system shall be capable of performing Thorough Decontamination procedures on equipment and supplies and/or applying and rinsing off decontaminants to permit removal/reduction in protective posture.	The system must perform thorough decontamination by means of chemical neutralization, physical removal, encapsulation or any combination of these processes.	Confirm by decontamination effectiveness studies performed on selected target materials. See Vol. II and annexes for methodology and criteria.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
3.4 Capability (surface area)	The system shall carry sufficient initial supplies to perform decontamination on at least the equivalent area of six platforms.	The system shall be capable of performing decontamination on at least 600 m^2 of contaminated area without replenishment of fuel or decontaminant components.	Assess concurrently with requirement 3.1.
3.5 Capability (target materials)	The system shall perform decontamination on the coated or bare robust surface exterior of platforms, trailers and other robust items of military equipment in forward and rear areas of the theatre.	The system shall be able to decontaminate the various painted and bare metal robust surfaces of platforms, polymers, elastomers, canvas, stocks of supplies, food, and ammunition and other materials used in military equipment and accessing all potentially contaminated surfaces in locations remote from large Thorough Decontamination systems.	Assess concurrently with requirement 3.1.
3.6 Capability (location)	The system shall be deployable in an uncontaminated area as near to the point of incident as is consistent with safe and expeditious conduct of the operation.	(See requirement 1.2). The system must be able to use available water sources.	

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
4 Reliability	The mechanical components on the system shall be robustly designed to provide maximum reliability under all normal operating conditions.	The system shall have a MTBF > 1000 hours of intermittent use. Operating crew should be able to repair 95% of all failures within 6 hours and 50% within 2 hours. The system shall be available for service at least 80% of its lifetime. The system shall be designed for straightforward maintenance with regular servicing sites located for simple and raid access.	The system shall be subjected to appropriate operational testing to verify reliability.
5.1 Compatibility (other NATO formulations)	The decontamination system should be able to operate in concert with other NATO systems and mechanical components of the system shall be compatible with other NATO decontaminants where possible.	A liquid-based system should be designed to dispense as wide a variety of decontaminants from other NATO countries as possible.	Countries should provide to other NATO countries, to the extent possible, formulation data to facilitate compliance with this technical characteristic.
5.2 Compatibility (inter-operability)	The decontamination system should be able to operate in concert with other NATO systems.	Designers should endeavour to utilize common hose connections or to provide adapters to interface with those from other NATO countries. Electrical power requirements and interfaces should be standardized whenever possible.	Countries should provide to other NATO countries, to the extent possible, hardware data to facilitate compliance with this technical characteristic.
5.3 Compatibility (with other equipment/ systems)	Operation of the decontamination system should not interfere with essential operation of military equipment in the decontamination area.	Operation of the system shall not interfere with the operation of other NATO equipment including communications, fire control, CB detection and monitoring and similar battlefield items.	The system shall be tested by operating it in proximity to these items and examining them for interference or performance degradation.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
6.1 Survivability (decontamination system)	The system operation should not be compromised by CBRN contamination or any known decontaminants.	The system must comply with STANAG 4521 as well as national standards. The system shall be capable of self-decontamination or decontamination by another similar system. The use of sea water shall not degrade the function of the system.	Decontaminability, hardness, and compatibility aspects shall be incorporated into the system at the design and fabrication stages. Survivability characteristics shall be assessed in user trials for compliance with criteria of STANAG 4521.
6.2 Survivability (target equipment)	Decontamination processes and decontaminants shall not cause unacceptable degradation to target equipment or supplies.	The system must not reduce the functionality (i.e., mobility, combat effectiveness, etc.) of target equipment. The system shall not cause degradation of camouflage and concealment properties of the equipment surfaces.	All material compatibility issuers shall be addressed with appropriate testing during item development. (Reference STANAG 4521)
7.1 Support/ logistics (personnel)	The equipment shall be operable by a specialized crew augmented by personnel with limited training and experience.	The system shall be capable of being set up, operated and restocked and decontaminants being prepared by two-man decontamination teams wearing full CBRN protective clothing or any personnel with limited on-site training without reduction in protective capacity of the equipment.	To be evaluated through users field trials.
	The system shall be capable of being loaded on/unloaded from a prime mover with a minimum of external support or auxiliary equipment.	The system shall be capable of being loaded on/unloaded from a prime mover by not more than four personnel in protective gear.	Field trials and user exercises to determine compatibility capability.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
7.2 Support logistics (hardware/ consumables)	The equipment shall be self-contained.	The system should be self-contained and should be operable either on its transport vehicle or trailer or be removable from the transport by the crew. It should have all of the components, including initial supplies of consumables, spare parts and a power supply to allow operation for its rated capacity including auxiliary requirements such as lighting and mixing without support from any other military units.	Capabilities to be assessed during training exercises.
	The system shall be capable of preparing decontaminant, if used, and dispensing it with full capability of decontaminating platforms, equipment, and supplies without additional equipment.	If used to apply liquid/solid decontaminant, the system shall incorporate an adjustable delivery device capable of covering surfaces with a uniform coating of decontaminant. If decontaminant is used, the system shall be capable of dispensing and rinsing off of expended decontaminants.	Capabilities shall be tested in field trials with fully operational systems, target equipment and crews.
8 Environmental Concerns	In operation and storage, the system shall meet the environmental regulations of the hosting nation and the owner.	See Chapter 5 (Environmental considerations) of this AEP	See Chapter 5.4 (Environmental considerations) of this AEP

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
9 Documentation	The system shall be provided with detailed supporting documentation for operation and field maintenance. Operating manuals should be in French or English as well as the national language of the owner.	Complete operator's manuals, schematics and parts list should accompany the system. Maintenance manuals shall contain sufficient detail to permit field repair of common problems by decontamination personnel and diagnosis and repair of major malfunctions by second-line maintenance facilities. For multinational operations, translations of operating manuals are desirable.	Adequacy of manuals and instructional material will be assessed during training sessions, using, if necessary, simulants for agents and decontaminants.
10.1 Operational Parameters (climatic conditions)	System must function within all climates likely to be encountered.	System design shall include deployment and operational compatibility with climate zones A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation (reference AECTP 200 – Environmental Conditions or see Annex H).	Testing shall be conducted within stated ranges of temperatures and humidity outside or wherever possible (reference AECTP 200 – Environmental Conditions or see Annex H).
10.2 Operational Parameters (shelf life)	Shelf life should comply with national regulations.	The system should have a shelf life as determined by individual nations. The system should retain full effectiveness during storage. Mechanical equipment forming part of the system shall meet the performance criteria applicable to new equipment throughout the specified shelf life.	Long term storage trials, followed by effectiveness testing.
10.3 Operational Parameters (stability of decontaminant)	Decontamination capability of chemically based systems should not be degraded during deployment or application.	Formulations used in the system shall comply with the pertinent stability requirements given in Subchapter 0413, Requirement 10.3.	Controlled testing using the climatic conditions from requirement 10.1 and the effectiveness criteria in Vol. II.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
11 Training	A crew specifically trained to use the equipment should perform this type of decontamination.	Equipment should utilize simple design and/or automation to reduce the need of complex decision-making by the operators. Each crewmember should be capable of operating all components of the system.	Simulants, if necessary, shall be provided for training purposes and should mimic, to the extent possible, the actual decontaminant materials.

0406. Thorough Decontamination System for Sensitive or Non Hardened Equipment

1. The system shall provide for the thorough decontamination of sensitive equipment and/or interiors of platforms. It is designed for:

   a. Small individual equipment such as masks, guns, helmets or others;

   b. Sensitive equipment such as electronics, optics, optronics, computers or others; and

   c. The interior of equipment and inside platforms.

2. This complements the thorough decontamination system or unit for large equipment.

Table 4-6 Thorough Decontamination System for Sensitive or Non Hardened Equipment - Requirements

N°- requirement	Operational Characteristics	Technical specifications	Test procedures and evaluation criteria
1.1 Mobility (between theatre)	The system shall be readily transportable by road, rail, ship and air.	The system can be integrated in a 20 feet International Organization for Standardization (ISO) container or any other structure as a platform but may include several specialized decontamination units.	Transportation platform specification in design criteria and user trials to confirm portability.

N°- requirement	Operational Characteristics	Technical specifications	Test procedures and evaluation criteria
1.2 Mobility (within theatre)	The system must be capable of moving to a site suitable for establishment of a decontamination site.	The system must be capable of being moved by dedicated vehicles over public roads, paved and unpaved, as well as field/wood paths and dirt roads with consolidated surfaces. Applicable to the corresponding requirements of systems.	The design of the system shall be in accordance with national and agreed standards for the design and development of military equipment. (e.g. STANAG 4521, 4360/4447)
2 Set up time/ Strike time	There must be minimal delay between arrival at the decontamination site and commencement of operations as well as the time between completion of operations and readiness to leave the site.	System must be fully operational in as short a time as possible but not to exceed 30 minutes after arrival at the decontamination site. If necessary slope stabilization may be required.	Field trials exercises shall be used to determine capability and establish set up and strike times.
3.1 Capability (efficacy)	The system shall effectively decontaminate all known CBRN contamination on sensitive or non- robust equipment and the interior of vehicles. Effectiveness against TIM, which are considered a threat is desirable.	The unit must reduce chemical contamination on non robust surfaces to the standardized limit values. It must also be capable of removing/neutralizing biological agents and removing radiological and nuclear contamination.	Laboratory and chamber testing with selected threat chemicals on all appropriate target materials shall be used to verify that the levels specified in Vol II can be attained.

N°- requirement	Operational Characteristics	Technical specifications	Test procedures and evaluation criteria
3.2 Capability (system capacity)	The system shall address the need for thorough decontamination of sensitive or non robust equipment of two (2) infantry or tank platoons (each with 3 or 4 vehicles or platforms) in less than one hour.	The system, alone or in multiples, shall perform decontamination within 1 hour of: 54 individual equipment such as guns, helmets and masks, 3 or 4 interiors of platforms (not mandatory), sensitive equipment removed from platforms or belonging to platoons. The rate of decontamination of vehicle, facility and aircraft interiors and unique sensitive items will be determined by national standards.	Capabilities shall be tested in field trials with a fully operational system, target equipment and crews.
3.3 Capability (decontamination process)	The system shall effect sufficient reduction in agent contamination to allow a removal/reduction in IPE.	The system must perform thorough decontamination by means of chemical neutralization, physical removal, encapsulation or any combination of these processes.	Confirm by decontamination effectiveness studies performed on selected target materials. See Vol II and annexes for methodology and criteria.
3.4 Capability (surface area)	The surface area to be treated shall correspond with the surface area of the average sensitive equipment of 54 personnel.	The system shall be capable of performing decontamination for at least three (3) hours without replenishment of consumables.	Field trials to determine efficacy shall confirm capability.
3.5 Capability (target materials)	The system shall decontaminate: small individual equipment (masks, guns, helmets), sensitive equipment (electronics, optics, optronics, computers), interior of equipment or platforms.	The system shall be able to decontaminate the various surfaces, polymers, elastomers, canvas and others sensitive materials used in the construction of military equipment.	See Vol II and annexes. Laboratory an chamber trials to determine efficacy shall confirm capability.
3.6 Capability (location)	The system shall be deployable in an uncontaminated area as near to the point of attack is consistent with safe and expeditious conduct of operations.	See requirement 1.2. If necessary the system may be able to use available water sources.	

N°- requirement	Operational Characteristics	Technical specifications	Test procedures and evaluation criteria
4 Reliability	The mechanical components of the system shall be robustly designed to provide maximum reliability under normal operating conditions.	The system shall have a MTBF > 1000 hours of intermittent use. Operating crew should be able to repair 95% of all failures within 6 hours and 50% within 2 hours. The system shall be available for service at least 80% of its lifetime. The system shall be designed for straightforward maintenance with regular servicing sites located for simple and rapid access. Spare parts and appropriate tools should be included to allow basic field repair.	The system shall be subjected to appropriate operational testing to verily the reliability.
5.1 Compatibility (other NATO decontaminants)	The decontamination system should be able to operate in concert with other NATO systems.	A liquid-based system should be designed to dispense as wide a variety of decontaminants from other NATO countries as possible.	Countries should provide to other NATO countries, to extent possible, formulation data of-in service decontaminants to facilitate compliance with this technical characteristic.
5.2 Compatibility (inter-operability)	The decontamination system should be able to operate in concert with other NATO systems.	Designers should endeavour to utilize common hose connections or to provide adapters to interface with those from other NATO countries. Electrical power requirements and interfaces should be standardized whenever possible.	Countries should provide to other NATO countries, to the extent possible, hardware data to facilitate compliance with this technical characteristic.

N°- requirement	Operational Characteristics	Technical specifications	Test procedures and evaluation criteria
5.3 Compatibility (with others equipment systems)	The decontamination system should not interfere with essential operation of military equipment in the decontamination area.	The system shall not interfere with the operation of other NATO equipment including communications, fire control, CB detection/monitoring and similar battlefield items. System must not degrade the IPE worn by operators or other associated personnel.	The system shall be tested by operating it in proximity to these items and examining them for interference or performance degradation.
6.1 Survivability (decontamination system)	The system operation should not be compromised by CBRN contamination or any known decontaminants.	Decontaminability, compatibility with decontaminating solutions and CBRN hardening shall be incorporated into the basic system design. In systems using water, the substitution of seawater must not degrade performance.	All materials and components of the system shall be tested for compliance with STANAG 4521.
6.2 Survivability (target equipment)	The decontamination system should not degrade target equipment.	The system must not reduce the functionality (i.e., mobility, combat effectiveness, etc.) or target equipment. The system shall not cause degradation of camouflage and concealment properties of the equipment surfaces.	All material compatibility issues shall be addressed with appropriate testing during item development (Reference STANAG 4521).
7.1 Support and logistics (personnel)	The decontamination system shall be operated by a specialized crew augmented by personnel with limited experience.	The system shall be capable of being set up, operated and restocked and decontamination being prepared by three-man decontamination teams wearing full CBRN protective clothing or by any number of personnel with limited on-site training.	Personnel requirements shall be established in field trials.

N°- requirement	Operational Characteristics	Technical specifications	Test procedures and evaluation criteria
7.2 Support and logistics (hardware / consumables)	This system shall be self-contained.	This system should be self- contained and should be operable either on its transport vehicle or trailer or be removable from the transport by the crew. It should have all of the components, including initial supplies of consumables, spare parts and a power supply to allow operation for its rated capacity including auxiliary requirements such as lighting and mixing without support from any other military units.	Field trials under realistic conditions shall be used to establish the support and logistic requirements of the system. The trials shall be used to determine the items for incorporation into maintenance and spare parts kits.
8 Environmental Concerns	In operation and storage, the system shall meet the environmental regulations of the hosting nation and the owner.	See Chapter 5 (Environmental considerations) of this AEP.	See Chapter 5 (Environmental considerations) of this AEP.
9 Documentation	Supporting documentation must be supplied for both operation and maintenance. Operating manuals should be in French or English as well as the national language of the owner.	Complete operator's manuals, schematics and parts list should accompany the system.	Adequacy of manuals shall be addressed with field trials.
10.1 Operational Parameters (climatic conditions)	System must function within all climates likely to be encountered.	System design shall include deployment and operational compatibility with climate zones A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation (reference AECTP 200 – Environmental Conditions or see annex H).	Testing shall be conducted within stated ranges of temperatures and humidity outside or wherever possible (reference AECTP 200 – Environmental Conditions or see annex H).

N°- requirement	Operational Characteristics	Technical specifications	Test procedures and evaluation criteria
10.2 Operational parameters (storage shelf life)	Shelf life should comply with national regulations.	The system should have a shelf life as determined by individual nations. The system should retain full effectiveness during storage.	Long term storage trials, followed by effectiveness testing to meet the criteria in Vol. II.
10.3 Operational Parameters (stability of formulations)	Decontamination capability of chemically based systems should not be degraded during deployment or application.	Formulations used in the system shall comply with the pertinent stability requirements given in Subchapter 0413, Requirement 10.3.	Controlled testing using the climatic conditions from requirement 10A and the effectiveness criteria in Vol. II.
11 Training	A crew specifically trained to use the equipment should perform this type of decontamination.	Equipment should utilize simple design and/or automation to reduce the need of complex decision-making by the operators. Each crewmember should be capable of operating all components of the system.	Simulants, if necessary, shall be provided for training purposes and should mimic, to the extent possible, the actual decontaminant materials.

0407. Thorough Decontamination System for Aircraft

1. The system is intended to be used for thorough decontamination for aircraft (fixed wings, UAV or helicopter). The aim is to limit or avoid contamination transfer and to protect aircraft and weapon systems.

2. The system should achieve thorough decontamination that could be completed for all exterior, inside and hidden parts. It should allow for the reduction of the CBRN protective posture for the crew or aircraft technicians.

Table 4-7 Thorough Decontamination System for Aircraft - Requirements

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
1.1 Mobility (between theatre)	The system shall be readily transportable by road, rail, ship and air.	The size or weight of the system components shall be compatible with standard transport vehicles.	Transportation platform specification in design criteria and user trials to confirm portability.
1.2 Mobility (within theatre)	The system shall be highly mobile and compact in size and be sufficiently manoeuvrable for location near or among aircraft (cargo and fighter).	The system must be capable of being moved by dedicated vehicles over public roads, paved and unpaved, as well as field/wood paths and dirt roads with consolidated surfaces. Applicable to the corresponding requirements of systems.	The design of the system shall be in accordance with national and agreed standards for the design and development of military equipment. (e.g. STANAG 4521, 4360/4447)
2 Set up time/ Strike time	There must be minimal delay between arrival at the decontamination site and commencement of operations as well as the time between completion of operations and readiness to leave the site.	System must be fully operational including preparation of decontaminant in as short a time as possible but not to exceed 20 minutes after arrival at the decontamination site. The system shall be ready to depart the site within 20 min after decontamination operations are concluded.	Field trials and exercises shall be used to determine capability and establish set-up and strike time.
3.1 Capability (efficacy)	The system shall effectively decontaminate all known CBRN contamination. Effectiveness against TIM, which are considered a threat, is desirable.	The unit must reduce chemical contamination on surfaces (horizontal, upper and lower surfaces, vertical) to the standardized limit values. It must also be capable of removing / neutralizing biological agents and removing radiological and nuclear contamination	Laboratory and chamber testing with selected threat chemicals on all appropriate target materials shall be used to verify that the levels specified in Vol II can be attained.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
3.2 Capability (system capacity)	The system shall address the need for thorough decontamination of aircraft in time depending on the type of aircraft and type of decontamination (e.g. 3 maneuver force helicopters per hour).	It shall perform thorough decontamination on equipment or supplies of comparable surface area for up to 600 m^2/hr; this capability shall not be reduced by the presence of mud, dust or dirt.	The capabilities shall be tested in field trials.
3.3 Capability (decontamination process)	The system shall be capable of performing thorough decontamination procedures on equipment and supplies and/or applying and rinsing off decontaminants to permit removal /reduction in protective posture.	The system must perform thorough decontamination by means of chemical neutralization, physical removal, encapsulation or any combination of these processes.	Confirm by decontamination effectiveness studies performed on selected target materials. See Vol. II and annexes for methodology and criteria.
3.4 Capability (surface area)	The system shall have sufficient initial supplies to perform decontamination on at least the equivalent area of 3 fighters.	The system shall be capable of performing decontamination on at least 600 m^2 of contaminated area without replenishment of fuel or decontaminant components.	Field trials to determine efficacy shall confirm capability.
3.5 Capability (target materials)	The system shall be able to treat every kind of surface on all type of aircraft.	Every aircraft coating system (including polyurethane, stealth or infrared painting or coating, transparent materials) and all others non protected parts shall be treated by the system.	Establish in the decontamination efficacy studies to be performed during development (specific; criteria shall be defined for each aircraft).
3.6 Capability (location)	The system shall be operated in and around airbases, maritime air platform and helicopter landing area.	(See requirement 1.2). The system must be able to use available water sources.	

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
4 Reliability/ maintenance	The system must be of robust design to assure maximum operational reliability.	The system shall have a MTBF > 1000 hours of intermittent use. Operating crew should be able to repair 95% of all failures within 6 hours and 50% within 2 hours. The system shall be available for service at least 80% of its lifetime. The system shall be designed for straightforward maintenance with regular servicing sites located for simple and raid access.	The system shall be subjected to appropriate operational testing to verify the reliability.
5.1 Compatibility (other NATO formulations)	The decontamination system should be able to operate in concert with other NATO systems.	All liquid-based systems should be designed to dispense as wide a variety of decontaminants from other NATO countries as possible.	Countries should provide to other NATO countries, to the extent possible, formulation data to facilitate compliance with this technical characteristic.
5.2 Compatibility (interoperability)	The decontamination system should be able to operate in concert with other NATO systems	Designers should endeavour to utilize common hose connections or to provide adapters to interface with those from other NATO countries. Electrical power requirements and interfaces should be standardized whenever possible.	Countries should provide to other NATO countries, to the extent possible, hardware data to facilitate compliance with this technical characteristic.
5.3 Compatibility (with other equipment systems)	The decontamination system should not interfere with essential operation of military equipment in the decontamination area.	The system shall not interfere with the operation of other NATO equipment including communications, fire control, CB detection/monitoring and similar battlefield items. System must not degrade the IPE worn by operators or other associated personnel.	The system shall be tested by operating it in proximity to these items and examining them for interference or performance degradation.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
6.1 Survivability (decontamination system)	The system operation should not be compromised by CBRN contamination or any known decontaminants.	Decontaminability, compatibility with decontaminating solutions and CBRN hardening shall be incorporated into the basic system design. In systems using water, the substitution of seawater must not degrade performance.	All materials and components of the system shall be tested for compliance with STANAG 4521.
6.2 Survivability (target equipment)	The decontamination system should not degrade target equipment.	The system must not reduce the functionality (i.e., mobility, combat effectiveness, etc.) of target equipment. The system shall not cause degradation of camouflage and concealment properties of the equipment surfaces.	All material compatibility issues shall be addressed with appropriate testing during item development. (Reference STANAG 4521).
7.1 Support and logistic (personnel)	The system shall be capable of being used by reduced CBRN air base team, augmented by personnel with limited training and experience.	The system shall be capable of being set up, operated, restocked and decontaminants being prepared by a specially trained decontamination team wearing full CBRN protective clothing. This team may be supplemented by personnel with limited on-site training. Operation of the system shall be to the extent possible be automated with simple pictogram control.	Personnel requirements shall be established in field trials.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
7.2 Support and logistic (hardware/ consumables)	The system shall be self-contained.	The system should be self-contained on its own transport vehicle(s) and should be operable either on that transport vehicle or should be removable from that vehicle by the crew. It should have all of the components, including lighting, maintenance kits/spare parts and a power supply to allow operation for its rated capacity without support from any other military units.	Field trials under realistic conditions shall be used to establish the support and logistic requirements of the system. The trials shall be used to determine the items for incorporation into maintenance and spare parts kits.
8 Environmental concerns	In operation and storage, the system shall meet the environmental regulations of the hosting nation and the owner.	See Chapter 5 (Environmental considerations) of this AEP.	See Chapter 5 (Environmental considerations) of this AEP.
9 Documentation	Supporting documentation must be supplied for both operation and maintenance. Operating manuals should be in French or English as well as the national language of the owner.	Complete operator's manuals, schematics and parts list should accompany the system.	Adequacy of manuals shall be addressed with field trials.
10.1 Operational parameters (climatic conditions)	System must function within all climates likely to be encountered.	System design shall include deployment and operational compatibility with climate zones A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation (reference AECTP 200 – Environmental Conditions or see annex H).	Testing shall be conducted within stated ranges of temperatures and humidity outside or wherever possible (reference AECTP 200 – Environmental Conditions or see annex H).
10.2 Operational parameters (shelf life)	Shelf life should comply with national regulations.	The system should have a shelf life as determined by individual nations. The system should retain full effectiveness during storage.	Long term storage trials, followed by effectiveness testing to meet the criteria in Vol. II.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
10.3 Operational parameters (stability of decontaminant)	Decontamination capability of chemically based systems should not be degraded during deployment or application.	Formulations used in the system shall comply with the pertinent stability requirements given in Subchapter 0413, Requirement 10.3.	Controlled testing using the climatic conditions from requirement 10.1 and the effectiveness criteria in Vol. II.
11 Training	A crew specifically trained to use the equipment should perform this type of decontamination.	Equipment should utilize simple design and/or automation to reduce the need of complex decision-making by the operators. Each crewmember should be capable of operating all components of the system.	Simulants, if necessary, shall be provided for training purposes and should mimic, to the extent possible, the actual decontaminant materials.

0408. Thorough Decontamination System for Ship and Maritime Equipment

1. The system should consist of equipment, decontaminants and procedures for the decontamination of non sensitive items on maritime platforms in the battlespace.

2. The system will reduce the levels of contamination to acceptable threshold levels, which will then enable the wearing of IPE by personnel to be relaxed, so easing the physiological burden to personnel.

Table 4-8 Thorough Decontamination System for Ship and Maritime Equipment - Requirements

N°- requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
1.1 Mobility (between theatres)	The system must be capable of being transported in and/or on any in Service transportation platform designated for strategic deployment.	The size and weight of the system shall not exceed the load capacity of NATO ships, land vehicles and transport aircraft that are in service and designated for use in strategic deployment.	Transportation platform specification in design criteria and user trials to confirm portability.
1.2 Mobility (within theatre)	The system must be capable of being transported in and/or on any in Service transportation platform for tactical deployment.	The size and weight of the system shall not exceed that which will permit it being moved within the confines of its perceived area of operation.	The design of the system shall be in accordance with national and agreed standards for the design and development of military equipment. (e.g. STANAG 4521, 4360/4447)

N°- requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
2 Set-up/Strike time	The time from arrival at site requiring decontamination until the operation commences and that from the order to move the equipment and its redeployment shall be minimized. The system start-up procedures must be short and simple.	Time to prepare the system and bring to an operational state should not be greater than 30 minutes. The time to strike the system shall not exceed the set-up time. The system shall be capable of being initiated by unskilled personnel with a minimum degree of training.	User trials to confirm that the characteristics are fulfilled.
3.1 Capability (efficacy)	The system will be capable of providing thorough decontamination of all known CBRN agents to agreed levels including as many toxic industrial materials as possible.	The system must reduce chemical contamination on robust surfaces to standardized limits. It must remove or neutralize biological agents and remove radiological and nuclear contamination (see Vol. II).	Laboratory and chamber testing with selected threat chemicals on all appropriate target materials shall be used to verify that the levels specified in Vol II can be attained.
3.2 Capability (system capacity)	The system will be capable of undertaking thorough decontamination of a predetermined area of a single maritime platform with a single charge. It must also be capable of undertaking thorough decontamination of a total pre determined area of a single platform following replenishment. The system must be capable of being easily recharged.	The system shall decontaminate a pre-determined area in 15 minutes without replenishment. The system must be capable of being recharged whilst in IPE.	Field and maritime platform trials to confirm efficacy should also confirm capability.

N°- requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
3.3 Capability (decontamination process)	The system shall be capable of performing thorough decontamination of equipment and supplies, and applying and rinsing off decontaminants to permit removal/reduction in protective posture.	The system must perform thorough decontamination by any means compatible with the other requirements of this specification.	Laboratory, field and maritime platform tests on materials from which equipment will be manufactured (see Vol. II).
3.4 Capability (surface area)	The system will be capable of decontaminating an agreed surface area within an acceptable timescale.	Thorough decontamination of 50m^2 must be achieved within 15 minutes for individual classes of maritime platform.	Field and maritime platform trials to confirm efficacy should also confirm capability.
3.5 Capability (target materials)	The system shall perform Thorough decontamination on the coated or non coated surfaces of non sensitive target areas on or in the platform.	The system must achieve removal of any known hazard to standardized limit values without detrimental effect on the surfaces to be decontaminated. In particular it should not degrade coatings nor the concealment, camouflage properties or original functionality of the target platform.	See Vol II. User trials to confirm efficacy should also confirm capability.
3.6 Capability (location)	The system will be capable of achieving thorough decontamination at all locations on or in the platform, including accessible confined spaces. It must also be capable of decontaminating areas in order to prevent migration of the contaminant into the interior of the platform.	The system must be able to be used inside compartments of the platform.	Field and maritime platform trials to confirm efficacy should also confirm capability.

N°- requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
4 Reliability	The mechanical components on the system shall be robustly designed to provide maximum reliability under all normal operating conditions.	The equipment shall have a MTBF > 1000 hours of intermittent use. The system shall be designed for straightforward maintenance with regular servicing sites located for simple and rapid access. Operating crew should be able to repair 95% of all failures within 6 hours and 50% within 2 hours. The system shall be available for use at least 80% of its lifetime.	The system shall be subjected to appropriate operational testing to verify reliability.
5.1 Compatibility (other NATO formulations)	The decontamination system should be able to operate in concert with other NATO systems.	All liquid-based systems should be designed to dispense as wide a variety of decontaminants from other NATO countries as possible.	Countries should provide to other NATO countries, to the extent possible, formulation data to facilitate compliance with this technical characteristic.
5.2 Compatibility (inter-operability)	The decontamination system should be able to operate in concert with other NATO systems.	Designers should endeavour to utilize common hose connections or to provide adapters. Electrical power requirements and interfaces should be standardized whenever possible.	Countries should provide to other NATO countries, to the extent possible, hardware data to facilitate compliance with this technical characteristic.
5.3 Compatibility (with other equipment systems)	The system must not cause any degradation to the mission essential functionality of equipment on or in the platform being decontaminated.	In operation the system shall not adversely effect any other systems or activities likely to be concurrently used in the battlespace, such as electronic detection or communication systems. The system must not initiate false detector alarms.	The system must not case target equipment to fail AEP-7 hardness criteria.

N°- requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
6.1 Survivability (decontamination system)	The system must not be degraded by CBRN agents or any current in service decontaminants to such an extent that it fails during use. It must be resistant to degradation from the in service environment.	The system must have the appropriate degree of mechanical and chemical hardening. (STANAG 4521).	Material compatibility issues to be addressed with appropriate testing during development.
6.2 Survivability (target equipment)	The system shall not cause unacceptable degradation to the mission essential functionality of the system being decontaminated. A separate option may be required if the system is to decontaminate sensitive items.	The method of decontamination or decontaminant used must not interfere with target component materials such as rubber seals, jointing and paint. It must not adversely affect the imaging or signature of the equipment being decontaminated. The method of decontamination or decontaminant used on sensitive equipment must not interfere with materials such as glass (optics) and other electronic components.	Must not make target equipment fail AEP-7 hardness criteria. Assessment by user trials.
7.1 Support/ Logistics (personnel)	The system must be capable of being operated and relocated on the target platform by 2 men with limited training wearing full IPE.	During operation the system shall be capable of being used by one man with one in support. The physical load required to operate the system must be limited to ensure that 2 teams of operators can alternate rest and decontamination activities for 2 hours. These will be non-skilled personnel in full IPE.	Assessment by field and maritime platform trials.

N°- requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
7.2 Support/ Logistics (hardware & consumables)	The system should be self contained and capable of preparing decontaminant, if used, and dispensing it with full capability to decontaminate platforms, equipment and supplies without additional equipment. Sufficient amounts of equipment spares and consumables shall be available to meet the operational demand.	The system should be self-contained and should be operable either on its target platform or be removable from the platform by the crew. It should have all of the components, including initial supplies of consumables, spare parts and a power supply to allow operation for its rated capacity including auxiliary requirements such as lighting and mixing without support from any other military units. If used to apply decontaminant, the system shall incorporate an adjustable delivery device capable of covering surfaces with a uniform coating of decontaminant. If applicable, the system shall be capable of dispensing and rinsing off expended decontaminants. A selection of regularly required spare parts and maintenance kits shall be identified and stocked.	Capabilities shall be tested in field trials with fully operational systems, target equipment and crews, and during training exercises based on recurring maintenance and need for replacement.
8 Environmental concerns	In operation and storage, the system shall meet the environmental regulations of the hosting nation and the owner.	See Chapter 5 (Environmental considerations) of this AEP.	See Chapter 5 (Environmental considerations) of this AEP.

N°- requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
9 Documentation	Supporting documentation must be supplied for both operation and maintenance. Operating manuals should be in French or English as well as the national language of the owner.	Complete operator's manuals, schematics and parts list should accompany the system.	Adequacy of manuals shall be addressed with field trials.
10.1 Operational Parameters (climatic conditions)	System must function within all climates likely to be encountered.	System design shall include deployment and operational compatibility with climate zones A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation (reference AECTP 200 – Environmental Conditions or see annex H).	Testing shall be conducted within stated ranges of temperatures and humidity outside or wherever possible (reference AECTP 200 – Environmental Conditions or see annex H).
10.2 Operational Parameters (Shelf life)	Shelf life should comply with national regulations.	The system should have a shelf life as determined by individual nations. The system should retain full effectiveness during storage.	Long term storage trials, followed by effectiveness testing to meet the criteria in Vol. II.
10.3 Operational parameters (stability of decontaminants)	Decontamination capability of chemically based systems should not be degraded during deployment or application.	Formulations used in the system shall comply with the pertinent stability requirements given in Subchapter 0413, Requirement 10.3.	Controlled testing using the climatic conditions from requirement 10.1 and the effectiveness criteria in Vol II.

N°- requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
11 Training	A crew specifically trained to use the equipment should perform this type of decontamination. The system shall be capable of being frequently operated for purposes of training. Decontaminants or suitable simulants capable of being frequently dispensed for purposes of training shall be supplied.	Equipment should utilize simple design and/or automation to reduce the need for complex decision-making by the operators. Each crewmember should be capable of operating all components of the system. The system shall be capable of functioning with simulants for training purposes where decontaminants are normally used.	Simulants, if necessary, shall be provided for training purposes and should mimic, to the extent possible, the actual decontaminant materials. To be assessed in field and maritime platform trials.

0409. Thorough Decontamination System for Personnel

1. The thorough decontamination system for personnel comprises devices, decontaminants and procedures for the thorough decontamination of personnel. The system shall establish safe dressing and undressing areas.

2. The system must be a multi-purpose system which shall be effective against –chemical and biological agents, radiological material and nuclear fallout. Efficiency against TIM which are considered a threat to the soldier is desirable.

Table 4-9 Thorough Decontamination System for Personnel - Requirements

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
1.1 Mobility (between theatres)	The system shall be self propelled or readily deployable by dedicated trailer, mobile trailer, air and ship.	The system may be equipped with wheels or be transportable by separate trailer suitable for air-, land-, or ship transport. The international limit values for public road access, train or ship loading must be observed.	Transportation platform specification in design criteria and user trials to confirm portability.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
1.2 Mobility (within theatre) establishment of decontamination	The system must be capable of moving to a site suitable for over public roads, paved and site.	The system must be capable of being moved by dedicated vehicles standards for the design and unpaved, as well as field/wood paths and dirt roads with consolidated surfaces. Applicable to the corresponding requirements of systems.	The design of the system shall be in accordance with national and agreed development of military equipment. (e.g. STANAG 4521, 4360/4447)
2 Set up and strike time	Set up for and commencement of operation as well as disassembly for relocation shall be quick and achieved easily by personnel wearing IPE.	Set up by trained personnel wearing IPE must be possible on 15 min notice. Starting the system shall be achieved electrically or with a minimum physical effort. Reloading for transport after decontamination operations are concluded within 30 minutes.	Field trials on set up and strike time will determine capability.
3.1 Capability (efficacy)	The system shall effectively decontaminate all known CBRN contamination. Effectiveness against TIM which are considered a threat is desirable.	The unit must reduce chemical contamination on unclothed personnel to the standardized limit values. It must also be capable of removing/neutralizing biological agents and removing radiological and nuclear contamination. A continuous flow of clean air through the unit has to be ensured.	Laboratory and chamber testing with selected threat chemicals on appropriate human skin simulant and/or animals shall be used to verify that the levels specified in Vol II can be attained. Field trials will determine capability.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
3.2 Capability (system capacity)	The system shall address the need for through decontamination of 54 persons per hour. If applicable, a procedure to deal with non-ambulatory personnel should be taken into consideration.	The system shall address the need for thorough decontamination on personnel for a number of 54 personnel per hour. The needed decontaminants and the amount of water stored in internal tanks shall enable the system to operate 3h without additional supply. The capacity of the system shall match the capacity of the respective decontamination unit for personal equipment.	This capability shall be established using field trials with actual systems, target equipment and crews.
3.3Capability (decontamination process)	Not applicable		
3.4 Capability surface area	Not applicable		
3.5 Capability (target materials)	Not applicable (N/A)		
3.6 Capability (location)	The system shall be deployable in an uncontaminated area as near to the point of attack as is consistent with safe and expeditious conduct of the operation.	The exact location would depend upon the time IPE may be worn according to doctrine; see requirement 1.2.	Field trials will determine capability.
4 Reliability	The system must be of robust design to assure maximum operational reliability.	The system shall have a MTBF > 1000 hours of intermittent use. Operating crew should be able to repair 95% of all failures within 6 hours and 50% within 2 hours. The system shall be available for service at least 80% of its lifetime. The system shall be designed for straightforward maintenance with regular servicing sites located for simple le and raid access.	The system shall be subjected to appropriate operational testing to verify the reliability.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
5.1 Compatibility (other NATO formulations)	N/A		
5.2 Compatibility (inter-operability)	The decontamination system should be able to operate in concert utilizing common hose connections or with other NATO systems.	Designers should endeavour to NATO countries, to the extent to provide adapters. Electrical power requirements and interfaces should be standardized whenever possible.	Countries should provide to other possible, hardware data to facilitate compliance with this technical characteristic.
5.3 Compatibility (with other equipment/ systems)	The decontamination system should not interfere with essential operation of military equipment in the decontamination area.	The system shall not interfere with the operation of other NATO equipment including communications, fire control, CB detection/monitoring and similar battlefield items. System must not degrade the IPE worn by operators or other associated personnel	The system shall be tested by operating it in proximity to these items and examining them for interference or performance degradation.
6.1 Survivability (decontamination system)	The system operation should not be compromised by CBRN contamination or any known decontaminants.	Decontaminability, compatibility with decontaminating solutions and CBRN hardening shall be incorporated into the basic system design.	All materials and components of the system shall be tested for compliance with STANAG 4521.
6.2 Survivability (target equipment)	The use of the system on bare skin shall not cause any injury or irritation; it shall not have any toxic effect nor increase the permeability of skin to potential agents.	The substance(s) used as decontaminant(s), their components, reaction and degradation products shall not be irritant, toxic or carcinogenic.	Material Safety Data Sheet for every substance / component. Skin irritation testing, medical approval.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
7.1 Support/ Logistics (personnel)	The system shall be capable of being loaded on/unloaded from a prime mover without the need of external support or auxiliary equipment.	The system shall be capable of being set up, operated, restocked by a specially trained decontamination team wearing full CBRN protective clothing. This team may be supplemented by personnel with limited on-site training.	To be assessed during troop trials, tactical part.
7.2 Support/ Logistics (hardware /consumables)	The system shall be self-contained.	The system should be self-contained on its own transport vehicles) and should be operable either on that transport vehicle or should be removable from that vehicle by the crew. It should have all of the components, including lighting, maintenance kits/spare parts and a power supply to allow operation for its rated capacity without support from any other military units.	Field trials under realistic conditions shall be used to establish the support and logistic requirements of the system. The trials shall be used to determine the items for incorporation into maintenance and spare parts kits.
8 Environmental Concerns	In operation and storage, the system shall meet the environmental regulations of the hosting nation and the owner.	See Chapter 5 (Environmental considerations) of this AEP.	See Chapter 5 (Environmental considerations) of this AEP.
9 Documentation	Supporting documentation must be supplied for both operation and maintenance. Operating manuals should be in French or English as well as the national language of the owner.	Complete operator's manuals, schematics and parts list should accompany the system.	Adequacy of manuals shall be addressed with field trials.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
10.1 Operational Parameters (climatic conditions)	System must function within all climates likely to be encountered.	System design shall include deployment and operational compatibility with climate zones A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation (reference AECTP 200 – Environmental Conditions or see annex H).	Testing shall be conducted within stated ranges of temperatures and humidity outside or wherever possible (reference AECTP 200 – Environmental Conditions or see annex H).
10.2 Operational Parameters (shelf life)	Shelf life should comply with national regulations.	The system should have a shelf life as determined by individual nations. The system should retain full effectiveness during storage.	Long term storage trials, followed by effectiveness testing to meet the criteria in Vol. II.
10.3 Operational parameters (stability of decontaminant)	Decontamination capability of chemically based systems should not be degraded during deployment or application.	Formulations used in the system shall comply with the pertinent stability requirements given in Subchapter 0413, Requirement 10.3.	Controlled testing using the climatic conditions from requirement 10.1 and the effectiveness criteria in Vol. II
11 Training	A crew specifically trained to use the equipment should perform this type of decontamination.	Equipment should utilize simple design and/or automation to reduce the need of complex decision-making by the operators. Each crewmember should be capable of operating all components of the system.	Simulants, if necessary, shall be provided for training purposes and should mimic, to the extent possible, the actual decontaminant materials.

0410. Thorough Decontamination System for Casualties

1. In a CBRN environment commanders need to consider what casualty evacuation assets (e.g., ground vehicles, aircraft, and personnel) are required in the hazard area. Cumbersome protective gear, climate, increased workloads, and fatigue, will greatly reduce the effectiveness of those involved with evacuation. Every effort will be made to limit contamination of evacuation assets. Casualties may need to be decontaminated before transport.

2. The mobile casualties decontamination system comprises devices, decontaminants and procedures and facilitates thorough decontamination of casualties for the purposes of limiting the spread of contamination and reducing or eliminating the hazard.

3. It will reduce required protection for wounded personnel as well as the involved Health Service Staff allowing the rapid evacuation to clean medical facilities. It will address decontamination to safe levels on personnel in uncontaminated areas.

Table 4-10 Thorough Decontamination System for Casualties – Requirements

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
1.1 Mobility (amongst theatres)	The system shall be readily transportable by road, rail, ship, air, and/or, if part of a larger system, shall be readily detachable.	The size or weight of the system and components shall be compatible with standard transport vehicles.	Transportation platform specification in design criteria and user trials to confirm portability.
1.2 Mobility (within theatre)	The system shall be highly mobile and compact in size and be sufficiently manoeuvrable.	The system must be capable of being moved by vehicles over public roads, paved and unpaved, as well as field/wood paths and dirt roads with consolidated surfaces. Applicable to the corresponding requirements of systems. Sub-assemblies shall be equipped with load-bearing handles and/or hoist points to facilitate loading/unloading and preferably, be capable of being lifted by personnel and mobile lifting equipment.	The design of the system shall be in accordance with national and agreed standards for the design and development of military equipment. (e.g. STANAG 4521 and 4360)
2 Set-up Time/ Strike Time	There must be minimal delay between arrival at the decontamination site and commencement of operations as well as the time between completion of operations and readiness to leave the site.	The system must be capable of deployment, set-up, operation (including preparation of decontaminant), clean-up, replenishment, teardown and in as short a time as possible but not to exceed 1 hour[8] after arrival at the decontamination site. The system shall be ready to	Field trials and exercises shall be used to determine capability and establish set-up and ready for operation.

[8, 8]With a full crew of minimum 8 people consisting of health services Pers supported by CBRN specialized Pers and/or non specialized Pers from the supported unit. Due to the limited number of health services Pers, it is highly unlikely that this Pers will contribute to the setup or teardown of the system.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
		depart (i.e., shut down, cleaned, disassembled, prepared for storage/transportation, stowed, replenished, and ready for movement) the site within 1 hour[8] after decontamination operations are concluded.	
3.1 Capability[9] (efficacy)	The system shall effectively decontaminate all known CBRN contamination on casualties. Effectiveness against TIM, that are considered a threat, is desirable.	The system must reduce chemical contamination on casualties, specifically on open wounds below IDLH standardized limit values. It must also be capable of removing/inactivating biological agents and removing radiological and nuclear contamination. A continuous flow of clean air through the unit has to be ensured.	Laboratory and chamber testing with selected CBRN threat levels on all appropriate skin simulant shall be used to verify that the levels specified can be attained.
3.2 Capability (system capacity)[10]	The system shall address the need for thorough decontamination on small numbers of non ambulatory casualties of 6 /hr and/or ambulatory casualties of 12/Hr		Capabilities shall be tested in field trials.
3.3 Capability (decontamination process)	The system shall be capable of performing Thorough Decontamination procedures on casualties to permit the safe evacuation to clean health facilities.	The system must perform thorough decontamination by means of chemical neutralization, physical removal, encapsulation or any combination of these processes.	Field-testing with selected CBRN threat levels on all appropriate target materials shall be performed to prove that the levels specified can be achieved.

[9] With regards to the mention of “all known CBRN contamination” and “below IDHL standardized limit values” the detectability needs to be taken into account.

[10] The described capability is for operating 1 line of non-ambulatory casualties and/or 1 line of ambulatory casualties.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
3.4 Capability (surface area)	The system shall carry sufficient initial supplies to perform decontamination for 8 hours without resupply.	The system shall be capable of performing decontamination on at least 48[11] contaminated non-ambulatory and/or 96 contaminated ambulatory casualties without replenishment of consumables less water.	Assess concurrently with requirement 3.1.
3.5 Capability (medical stretchers and transport system)	Due to limited resources available with regard to stretchers or other casualty transportation systems within the casualty decontamination facility, the used stretchers must be decontaminated by adequate means prior to repeated use	The stretchers as well as the casualty transportation system will have to be adequately designed to ensure rapid decontamination and, easy drainage of contaminated waste water. The stretchers shall facilitate loading and unloading of non ambulatory casualties (e.g. scissor-like opening).	Stretchers will be subjected to laboratory or chamber testing for decontaminability from threat chemical, biological, radiological, and TIC contaminants. Stretchers will be subjected to appropriate operational testing to determine ease of loading and unloading casualties.
3.6 Capability (location)	The system shall be deployable in an uncontaminated area as near to the point of incident as is consistent with safe and expeditious conduct of the operation.	Drinking water quality (minimum according to STANAG 2136) is required, i.e. use available potable water sources or external water supply. Waste water management must be considered an issue.	Operational testing of compliance of the system with the requirements of column “operational characteristics”
4 Reliability	The mechanical components on the system shall be robustly designed to provide maximum reliability under all normal operating conditions.	The system shall have a MTBF > 1000 hours of intermittent use. Operating crew should be able to repair 95% of all failures within 6 hours and 50% within 2 hours. The system shall be available for service at least 80% of its lifetime. The system shall be	The system shall be subjected to appropriate operational' testing to verify reliability.

[11] Hourly rate multiplied by eight hours (see 3.2)

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
		designed for straightforward maintenance with regular servicing sites located for simple and raid access.	
5.1 Compatibility (other NATO formulations)	The decontamination system should be able to operate in concert with other NATO systems and mechanical components of the system shall be compatible with other NATO decontaminants where possible.	A liquid-based system should be designed to dispense as wide a variety of liquid decontaminants from other NATO countries as possible. Since water can be a limited resource in theatre foam based decontamination systems should also be considered an alternative due to reduced water consumption.	Countries should provide to other NATO countries, to the extent possible, formulation data to facilitate compliance with this technical characteristic.
5.2 Compatibility (inter-operability)	The decontamination system should be able to operate in concert with other NATO systems.	Designers should strive to utilize common hose connections or to provide adapters to interface with those from other NATO countries. Electrical power requirements and interfaces should be standardized whenever possible.	Countries should provide to other NATO countries, to the extent possible, hardware data to facilitate compliance with this technical characteristic.
5.3 Compatibility (with other equipment/ systems)	Operation of the decontamination system should not interfere with essential operation of military equipment in the decontamination area.	Operation of the system shall not interfere with the operation of other NATO equipment including communication, fire control, CB detection and monitoring and similar battlefield items.	The system shall be tested by operating it in proximity to these items and examining them for interference or performance degradation.
6.1 Survivability (decontamination system)	The system operation should not be compromised by CBRN contamination or any known decontaminants.	The system must comply with STANAG 4521 as well as national standards. The system shall be capable of self-decontamination or decontamination by another similar system. The use of sea water shall	Decontaminability, hardness and compatibility aspects shall be incorporated into the system at the design and fabrication stages. Survivability characteristics shall be assessed in user trials for

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
		not degrade the function of the system	compliance with criteria of STANAG 4521.
6.2 Survivability (casualties)	Decontamination processes and decontaminants shall be such to minimize the possible aggravation of the casualties' medical condition. If needed medical specialists will contribute to the drafting of the procedures and the execution of the decontamination[12].	The system must provide a continuous flow of non contaminated air through the unit. The substance(s) used as decontaminant(s), their components, reaction and degradation products shall not be irritant, toxic or carcinogenic.	MSDS for every substance / component. Skin irritation testing, medical approval. Verify non-reduction in functionality of selected portions of IPE and personal equipment to be treated with the kit during immediate decontamination.
7.1 Support/ logistics (personnel)	The equipment shall be operable by a specialized and trained crew.	The system must be capable of deployment, set-up, operation (including preparation of decontaminant), clean-up, replenishment, teardown and ready to be transported by minimum eight-man decontamination team[13] wearing full CBRN protective clothing. Additional untrained personnel may be required from the supported unit to support the decontamination process.	To be evaluated through users field trials.
	The system shall be capable of being loaded on/unloaded from a prime mover with a minimum of external support or auxiliary	The system shall be capable of being loaded on/unloaded from a prime mover by four personnel.	Field trials and user exercises to determine compatibility capability.

[12] In accordance with national policy, responsibility for the execution of the casualties decontamination, can lie with the Medical Services with Sp of CBRN Specialists. Nevertheless Medical Pers will always perform life saving actions before the decontamination process will start.

[13]This crew will comprise health services Pers supported by CBRN specialized Pers and/or non specialized Pers from the supported unit. The crew of minimum six to eight is valid for ONE decontamination line only. Due to the limited number of Health services Pers, it is highly unlikely that this Pers will contribute to the setup or teardown of the system.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
	equipment.		
7.2 Support logistics (hardware/ consumables)	The equipment shall be self-contained.	The system should be self-contained and should be operable either on its transport vehicle or trailer or be removable from the transport by the crew. It should have all of the components, including initial supplies of consumables, spare parts and a power supply to allow operation for its rated capacity including auxiliary requirements such as lighting and mixing without support from any other military units.	Capabilities to be assessed during training exercises.
	The system shall be capable of preparing decontaminants, if used, and dispensing it with full capability of decontaminating casualties.	If used to apply liquid decontaminant, the system shall incorporate an adjustable delivery device capable of covering surfaces with a uniform coating of decontaminant. If decontaminant is used, the system shall be capable of dispensing and rinsing off of expended decontaminants.	Capabilities shall be tested in field trials with fully operational systems, target equipment and crews.
8 Environmental Concerns	In operation and storage, the system shall meet the environmental regulations of the hosting nation and the owner.	See Chapter 5 (Environmental considerations) of this AEP	See Chapter 5.4 (Environmental considerations) of this AEP
9 Documentation	The system shall be provided with detailed	Complete operator's manuals, schematics and	Adequacy of manuals and instructional

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
	supporting documentation for operation and field maintenance. Operating manuals should be in French or English as well as the national language of the owner.	parts list should accompany the system. Maintenance manuals shall contain sufficient detail to permit field repair of common problems by decontamination personnel and diagnosis and repair of major malfunctions by second-line maintenance facilities. For multinational operations, translations of operating manuals are desirable.	material will be assessed during training sessions, using, if necessary, simulants for agents and decontaminants.
10 Operational Parameters (Day/night conditions, and personnel comfort)	System must function within all lighting conditions.	The system must be under cover with appropriate white and blackout lighting, from the start of IPE removal until completion of dressing, protected from the weather, and kept at a comfortable ambient temperature under all specified outside cold temperature conditions.	
10.1 Operational Parameters (climatic conditions)	System must function within all climates likely to be encountered.	System design shall include deployment and operational compatibility with climate zones A1, A2, A3, B1, B2, B3, and C0. In addition C1 for storage and transportation (reference AECTP 200 – Environmental Conditions or see Annex H).	Testing shall be conducted within stated ranges of temperatures and humidity outside or wherever possible (reference AECTP 200 – Environmental Conditions or see Annex H).
10.2 Operational Parameters (shelf life)	Shelf life should comply with national regulations.	The system should have a shelf life as determined by individual nations. The system should retain full effectiveness during storage. Mechanical equipment forming part	Long term storage trials, followed by effectiveness testing.

N° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
		of the system shall meet the performance criteria applicable to new equipment throughout the specified shelf life.	
10.3 Operational Parameters (stability of decontaminant)	Decontamination capability of chemically based systems should not be degraded during deployment or application.	Formulations used in the system shall comply with the pertinent stability requirements given in Subchapter 0413, Requirement 10.3.	Controlled testing using the climatic conditions from requirement 10.1 and the effectiveness criteria.
11 Training	A crew specifically trained to use the equipment should perform this type of decontamination.	Equipment should utilize simple design and/or automation to reduce the need of complex decision- making by the operators. Each crewmember should be capable of operating all components of the system.	Simulants, if necessary, shall be provided for training purposes and should mimic, to the extent possible, the actual decontaminant materials.

0411. Thorough Decontamination System for Entering Collective Protective Shelter

The ATP-70 (STANAG 2515) and AEP-54 (STANAG 4634) take into account the procedures and technical requirement for decontamination to entry and exit in CBRN collective protection facilities (CCA-Control Contamination Area).

CCAs provide a controlled environment in which it is safe to remove contaminated protective clothing. CCAs can be part of a COLPRO or they can be sited outside in the open air. In either case, they are the entrance to the COLPRO, as entry into the TFA (toxic free area) may not occur without processing through the CCA. These procedures are required to maintain the integrity of the TFA when personnel are transiting in/out of the facility whilst under CBRN conditions outside.

SECTION II - DECONTAMINANTS

0412. General

1. CBRN threat agents and TIM are diverse in their characteristics, mechanism of action and stability. Decontaminant formulations (decontaminants) shall be designed to address this diversity for each level of decontamination (immediate, operational, thorough and clearance decontamination) and, where possible, shall have a multi-purpose capability for more than one and, preferably, all levels. The decontaminants shall have a broad-spectrum application and the capability of being used with the applicable decontamination system described in this paper.

2. They shall be designed for the purpose of limiting the spread of contamination, detoxifying, eliminating or aiding in the removal of the contaminant. They shall be either pre-packaged or capable of being prepared on site, applied by a minimum number of trained and/or untrained protected personnel and be friendly to the environment. The decontaminants will enable the decontamination of personnel, small and large equipment, hardened and sensitive equipment and limited areas of terrain.

0413. Decontaminant Criteria

The decontaminants shall be designed to meet the following criteria, which address all operational and thorough applications for CBRN agents. Where necessary, characteristics specific to single applications are noted separately.

Table 4-11 Decontaminant Requirements

N-° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
1.1 Mobility (Between theatres)	The decontaminants shall be transportable by air, land and sea vehicles. Containers shall incorporate all necessary components for preparation of decontaminant formulation.	Decontaminant containers shall be packaged for easy storage and transport and be capable of ready loading onto/unloading from prime movers by readily available equipment. No additional materials shall be required (other than water or medium) for preparation of the decontaminant solution. Decontaminant components and packaging shall conform to applicable international transportation regulations by air, land (road and train) and sea (e.g. International Air Transport Association (IATA).	Loading/unloading and transport of containers can be achieved without the need for specialized equipment. Packaging shall conform to appropriate safety standards.
1.2 Mobility (within theatre)	Containers of decontaminant shall be sized for easy transport, handling and storage in the field.	Decontaminant components shall be packaged for easy transport on existing field transport equipment and stackable for easy storage at the decontamination site. Packaging will enable the transfer of decontamination formulation components by a single person wearing protective gear. Loading/unloading and transport of containers shall be accomplished without the need for specialized equipment.	Individual components shall be readily lifted and handled by a single person in IPE without causing undue degradation to the operator.

N-° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
2 Set-up Time	Decontaminant components shall be ready for immediate use on arrival at the decontamination site. Preparation of the decontaminant, from component to active product, shall be within the set-up time of the application equipment. Preparation of decontaminant shall be achievable with a minimum of disruption or interference to the setup of the parent system.	The decontaminant components shall require minimal unpacking on arrival at the decontamination site. The decontaminant shall be prepared rapidly by personnel in IPE without need for specialized auxiliary equipment. Preparation of the decontamination solution is to be carried out by non-skilled personnel (max 2), in IPE.	To be assessed during training exercises with various decontamination systems.
3.1 Capability (efficacy)	The decontaminant formulation shall be broad spectrum, multipurpose and capable of achieving effective decontamination of the target agents listed at Chapter 2.	The decontaminant shall neutralize, detoxify, and/or remove a wide range of CBRN and toxic industrial chemical (TIC) hazards from contaminated items and must not be toxic to human.	The decontaminant capabilities shall be evaluated against selected chemical agents, appropriate biological simulants , radiological agents or simulants and selected representative TIC.

N-° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
		The decontaminant shall fulfil all decontamination roles. Must require little or no formulation adjustment during operations. For continuous process systems which require mixing just prior to application, the decontaminant must achieve maximum decontamination activity within 5 minutes of application. Nuclear: Must be capable of removing radiological particulate of spectrum expected in CBRN scenarios from target materials.	Residual agent/simulant hazard levels must be less than those specified in the criteria (Vol II). Field trials to confirm.
3.5 Capability (Target materials)	The decontaminant shall effectively decontaminate as wide a variety of target materials as possible.	Decontamination shall be achieved without degrading the target materials. It is desirable that a single decontaminant be applicable to as many materials as possible The decontaminant must be effective on surfaces in any orientation, flat, vertical or underside.	Confirmation by materials interaction testing on target materials. (STANAG 4521)
4 Reliability	The decontaminant shall be reliable under all normal operating conditions	Decontaminant formulation shall be 100% effective in achieving the required criteria levels for decontamination.	Trials to confirm 100% reliability.

N-° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
5.1 Compatibility (other NATO formulations)	Decontaminant formulations should be capable of being used in concert with other NATO equipment and formulations.	Decontaminant formulations should be capable of operation and application by other NATO equipment. Efforts should be made to avoid adverse chemical interactions with other formulations. Where unavoidable, these interactions should be identified in the documentation.	Laboratory testing should be used to assess chemical compatibility. Equipment compatibility should be assessed in field trial.
5.2 Compatibility (inter- operability)	N/A "This is a hardware requirement; the formulation requirement is 5.1."	N/A	N/A
5.3 Compatibility (with other equipment/ systems)	The decontaminant formulation should not interfere with other military equipment not involved in the decontamination operation.	The presence of the decontaminant shall not interfere with the operation of other NATO equipment including communication, fire control, CB detection/monitoring and similar battlefield items. IPE worn by operators and associated personnel shall not be degraded by contact with the decontaminant formulation.	The decontaminant formulations shall be prepared and dispensed in proximity to the types of equipment referenced. After exposures, equipment should be tested for any performance degradation. Tests should include equipment from all NATO countries. IPE should be tested by direct contact with the formulation.

N-° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
6.1 Survivability (decontamination system)	The decontaminant formulation and its packaging shall incorporate features to ensure its survivability in a fielded (land, sea or air) environment. The decontaminant shall not cause degradation of the disseminating equipment.	Packaging shall incorporate agent and decontaminant-resistant materials. Decontaminants shall not render their dissemination system incapable of functioning in its intended manner for the duration of the designed lifetime of that system. The decontaminant shall not affect the MTBF of the application system.	Trials on packaging. Materials interaction testing and field trials followed by inspection of the dissemination system.
6.2 Survivability (target equipment)	The decontaminant shall not degrade the operational capability of the target equipment.	The decontaminant shall not cause the failure of protective equipment such as masks, boots, canisters, suits or of a protective decontamination overgarment (if used). Decontaminants and the products of decontamination shall not interfere with the use and operation of detection and monitoring equipment used for verification of decontamination effectiveness.	Materials interaction testing to ensure protective equipment does not degrade by more than 5% over a period of four hours. Materials interaction testing to ensure that the decontaminant does not cause unacceptable discoloration, de lamination, softening, or transitory or permanent changes as determined) by standard tests applied to new surfaces.

N-° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
		The decontaminant shall not cause transitory or permanent damage to sensitive surfaces and critical components such as optical devices or polymeric materials. Decontamination shall not cause subsequent malfunction in the operation of platforms or equipment or lead to structural weaknesses in platforms, equipment or composite components. (i.e. wings, rotors, antennae, radar domes, etc)	The testing norm will be at least 5 consecutive decontamination applications.
7.2 Support/ Logistics (hardware/ consumables	N/A - System specific		
8 Environmental Concerns	In operation and storage the decontaminant shall meet the environmental regulations of the hosting nation and the owner.	Effluent from self-contained decontamination systems shall be strictly controlled, treated and disposed of in accordance with national law and host country regulations. In non-self-contained systems the formulation and the resulting effluent shall meet all national and host country environmental regulations. In operations where decontaminants are employed which do not meet the above criteria full containment and treatment/disposal (in accordance with national/host regulations) of the effluent will be necessary	Evaluation of the decontaminant and effluent to confirm that national and host country environmental regulations are respected.

N-° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
9 Documentation	Detailed instructions for preparation of the decontaminant shall be provided. Operating manuals should be in French or English as well as the national language of the owner.	Operating instructions shall be clear and concise and shall enable untrained personnel to prepare the decontaminant without other sources of information. It is recommended that these instructions be provided on the packaging material. Full safety and hazard warnings are to be prominently displayed on the packaging. If applicable decontaminant waste management instructions are also to be included.	Instructions shall be assessed during training sessions.
10.1 Operational Parameters (Climatic)	Decontaminant should function within all climates likely to be encountered by NATO equipment. Aqueous based decontaminants should be provided with a climate-controlled environment for the operation. Decontaminants should be subject to the same storage climatic conditions as other comparable NATO equipment.	Decontaminant should be compatible with climate zones A1, A2, A3, B1, B2, B3 and C0. In addition C1 for storage and transportation without permanent deterioration of operational capabilities.	Testing shall be conducted within stated ranges of temperature and humidity outside or wherever possible (reference AECTP 200 – Environmental Conditions or see Annex H). The system should continue to function and meet original specifications after being previously stored at the extremes of low and high temperature and low and high humidity.

N-° requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
10.2 Operational Parameters (Shelf life)	Decontaminants (or their components) shall be stable and maintain an acceptable level of decontamination effectiveness after storage under normal NATO environmental conditions.	Decontaminants and their components shall remain fully capable of preparing a decontaminant solution which meets the full performance criteria for a period defined by the individual nations.	Trials to confirm the viability of the decontaminant components over the time period.
10.3 Operational Parameters (Stability)	Once prepared or removed from its packaging the decontaminant shall active components shall maintain full decontaminant capability for as long as possible.	Deployed Storage: Decontaminant full capability for a period of greater than 90 days after issue, from depot, until seals are broken. Stability Unsealed: Minimum period of stability from the breaking of seals until activation of decontaminant should be: Operational Decontaminants: Greater than 3 days. Thorough Decontaminants: Greater than 6 hours. Stability Activated: Period from final preparation until loss of effectiveness of unused decontaminant must be greater than 1 hour in batch processes for thorough decontamination and 24 hours operational decontamination.	Trials to confirm the viability of the decontaminant components over the time period.
11.1 Training	Simulants will be made available for training purposes.	Simulants shall be provided for training purposes and should mimic, to the extent possible, the actual decontaminants and their effects on materials.	

CHAPTER 5 - OTHER CONSIDERATIONS

0501. Decontamination Guidance for Large Essential Installations

1. There has been increased concern in recent years regarding the threat of a CBRN attack on fixed installations such as airfields and seaports. The complex nature of the operations at these sites, the wide variety of materials and equipment which could become contaminated and the uncertainty of the extent of the threat cannot be found in a separate document and are therefore considered in this chapter.

2. The growing availability of short and medium range ballistic rockets with chemical and biological capability make an attack on fixed installations feasible but the effect of these weapons would not be as great as that of a CB attack on forward deployed forces. Consequently, the density of agent contamination on such sites is not expected to be as great as the 10 g/m^2 used in considering decontamination in forward areas. Likewise, since the intent would be to disrupt operations for an extended period, it would be reasonable to expect that the attack would employ persistent agents such as HD and VX rather than the G-agents.

3. For ionizing radiation, the main threat from radiation dispersal devices (RDD) is as an area (land) denial weapon, since health effects from ionizing radiation may only be long term (depending on dose). Additionally, the equipment or personnel going into the contaminated area would get contaminated which would restrict its use and further movement of the equipment and personnel.

4. Before one can design equipment to perform decontamination in the large areas, it is necessary to consider the objectives of these decontamination operations. The objective may not be the same for different installations or circumstances. The chain of command will have to decide what level of decontamination effort is most appropriate in each situation. It is generally agreed that thorough decontamination of an entire facility to a level where no IPE would be required is not feasible with current or foreseeable technology. The critical issue is that the decontamination must improve the overall efficiency and safety of the operations at the installation to a degree that justifies the diversion of time and manpower for decontamination. At a fighter base, for example, the objective is to continue to launch sorties. If this can be done at a satisfactory rate by placing personnel in protective clothing, no decontamination operation may be warranted until the combat activities are complete. Alternatively, it may be desirable to decontaminate small areas of the facility for specialized activities.

5. For bases in which the transfer of cargo is the primary activity, a different set of priorities might apply. In these cases, it is essential that the cargo be protected and/or decontaminated so that it can be passed on to its destination without transferring a CB hazard. Another primary consideration is the need to prevent and/or remedy the interior contamination of cargo carrying vessels (ships and aircraft).

6. Thus, the decontamination operations at large fixed facilities may be operational or thorough as circumstances dictate. In those cases where thorough decontamination is to be

performed, criteria to be employed will be those delineated in Vol. II. No specific criteria are necessary for operational decontamination since this level does not allow reduction in IPE.

7. The principal technical obstacles in the decontamination of large installations are:

a. large amount of contaminated surface;

b. wide variety of contaminated surfaces;

c. large percentage of adsorbing and otherwise non-hardened surfaces;

d. non-availability of specifically trained decontamination personnel; and

e. reduced option of moving operations to uncontaminated areas.

8. In contrast, there are also a number of advantages in conducting decontamination at fixed installations:

a. more decontamination equipment and expendables may be available;

b. different decontamination formulations may be used depending on the agent involved;

c. more electrical power and fuel will be available - more personnel may be available;

d. existing installation equipment could be put to "dual use" (construction equipment, fire fighting equipment, de-icing equipment, etc.); and

e. seaports would have an unlimited supply of seawater.

9. Initially, most countries will use a combination of multiple quantities of existing or modified field decontamination systems for large installation decontamination while requirements for dedicated systems are developed. New systems may seek to integrate decontamination approaches with existing equipment as mentioned above. Systems capable of rapid coverage of large areas may find favour. These would include foams, plasma torch, and liquid spray. There is also the option of generating reactive chemical mixtures on site and on demand. The ability to preposition decontamination equipment reduces the need for mobility required of field decontamination systems.

10. If large installations are to remain operational after a chemical attack, a carefully considered and integrated defence including deterrence, interception, detection, protection and decontamination is essential (reference STANAG 2352). Only early warning coupled with effective protection of cargo and essential equipment can reduce the decontamination burden to a realistic level.

0502. Clearance Decontamination

1. On the cessation of hostilities in which CBRN weapons have been employed or a contamination has been caused by TIM, NATO countries will be faced with the task of decontaminating equipment to a level which will allow it to be returned to the home country

without hazard. It is also conceivable that such clearance decontamination must occur during a period of continued hostility. As a rule, it will be necessary to clean the equipment to a degree well in excess of that used in thorough field decontamination. The objective in field decontamination is to make the equipment usable without full IPE. After clearance decontamination, one must be certain that the equipment can be disassembled, refitted and stored (often by civilian contract workers) with no adverse health effects (immediate or long term). The respective national regulations must be taken into account. Therefore it will be the responsibility of each nation to establish the decontamination criteria which will be used to allow the return of equipment to that country. Often, however, it is necessary to move equipment overland or through the airspace of another country in order to return it to the country of origin. Each country should be aware of other NATO countries' clearance decontamination criteria if such transit is anticipated. Standards should be provided during operations.

2. One of the purposes of this AEP is to specify the technical and operational performance objectives for decontamination equipment. At present, there are no systems fielded or planned for exclusive application to clearance decontamination. Rather, it is anticipated that various field decontamination systems and probably non-military industrial equipment will be used with modified procedures to attain these decontamination objectives. Among other things, partial disassembly of the equipment prior to decontamination would be considered. Depending on the circumstances, natural or accelerated weathering could be employed in clearance decontamination.

3. Unlike field operations, clearance decontamination is not severely constrained by the many operational requirements imposed on thorough decontamination equipment employed in combat situations. The equipment used has only to be sufficiently mobile to get it into the host country and set up at an appropriate location. It is not essential that the process be universal (all agents) since it would be possible to identify the contaminants and use optimized procedures or formulations. Moreover; the number and type of personnel are more flexible. Large crews of both military and civilian personnel could be employed. Such crews may include highly trained technical personnel and the equipment itself could be custom built and would not have to be ruggedized for military use. The need for accurate verification of clearance decontamination cannot be overemphasized. It will be necessary to utilize the best instrumentation and techniques possible for this purpose.

4. Hazard Management Sub-group (HMSG) has published "CBRN Clearance Decontamination – Guidance Information Based On Open Source Data" (AC/225 (JCGCBRN-HMSG)D(2009)0001) . This document delivers further information, especially with regard to toxicity values.

0503. Verification in the Field

Methods are required to enable verification in the field that the decontamination criteria for thorough decontamination have been met. The methods need to be able to look at residual CBRN contamination. Currently, verification is limited to a nation's current in-service detection and monitoring equipment. The limits of sensitivity of this equipment may be insufficient to verify the thorough decontamination efficiency criteria. There is no definition for specific equipment for verifying decontamination efficiency within D/100 and D/104 the

NATO Triptych for Combined Operational Characteristics, Technical Specification and Evaluation Criteria for CB and RN detection equipment.

0504. Environmental Considerations

1. Defence materiel is generally developed to serve a single nation's needs and therefore complies in general with this nations laws, regulations and so on. Interoperability, to whatever level, is an additional, strictly mission-oriented requirement initially caused by NATO's system of common defence and today emphasized by the necessity of multinational missions, be it in the form of Combined Joint Task Forces under Article V of the North Atlantic Charter or in the context of European Union/Western European Union (EU/WEU)-led (Petersberg missions) or other peace-enforcing, peace-keeping or humanitarian operations, the global location of which is unpredictable.

2. For these reasons, as well as for financial reasons, it can hardly be expected by a nation that its materiel comply with all applicable regulations worldwide in the area of occupational safety; industrial hygiene and environmental protection. A modus operandi must be found to assure that the requirements of host nations be met while, on the other hand, no unacceptable burden is placed on the sending nation.

3. It is therefore decided that for decontamination materiel, compliance with the building or procuring nation's environmental legislation is mandatory; if the respective nation is a member of the EU, compliance with applicable EU regulations is mandatory. If the system is to be used on the territory of a third-party nation, these criteria mentioned above will be met. Should the environmental regulations of the host nation be more restrictive than those of the contributing nation, it is put to the host nation to decide whether to receive and use the respective system(s) on an "as-is" basis, to refuse the entry and the use of the system to the receiving nation's territory or to obtain compliance with these national regulations.

4. In case the receiving nation decides to choose the latter, the means to achieve this additional compliance, however, are strictly within the responsibility of the host nation.

0505. Water Purification System

Water contamination typically may be either C, B, or R/N. Since in armed conflicts CBRN contamination of water may happen. The availability of drinking water, be it for human consumption, medical purposes or personnel decontamination, is essential for sustainability of operations as well as the survivability of personnel. Hence, the capability to appropriately purify water may be required

Table 5-1 Water Purification System - Requirements

N°- requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
1.1 Mobility (between theatre)	The system shall be deployable by train, ship or cargo aircraft.	Size, form and weight of the system shall allow for these kinds of transportation.	The international limit values for public road access, train or ship loading shall be observed.
1.2 Mobility (within theatre)	The system shall be readily movable either self-propelled by road or by other standard means of transportation.	The system must be capable of being moved by dedicated vehicles over public roads, paved and unpaved, as well as field/wood paths and dirt roads with consolidated surfaces. Applicable to the corresponding requirements of systems.	The design of the system shall be in accordance with national and agreed standards for the design and development of military equipment. (e.g. STANAG 4521, 4360/4447)
2 Set-up/Strike time	The system shall be operational within a minimum time after arrival at the operating site.	The system should be operable within one hour of arrival at the operating site.	Field trials and exercises shall be used to establish and verify set-up and strike times.
3.1 Capability (efficacy)	The system shall be equally effective against all known CBRN agents. Efficiency against TIM which are considered a threat to the soldier is desirable.	Efficiency according to standardized limit values shall be achieved. National regulations have to be applied if they are far beyond NATO standards.	Limit values according to WHO- standards and to the standards of STANAG 2136, if existing to additional national regulations.
3.2 Capability (System capacity)	The system shall be able to supply 300 personnel with an adequate drinking / showering water supply.	The system shall be able to purify 5 m^3 of water per hour and a minimum of 45 m^3 per day. STANAG 2885: 150 litres/individual/ day for temporary or semi-permanent camps included drinking, cooking laundries and domestic water	Field trials and exercises shall be used to verify the capacity.

N°- requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
3.3 Capability (type of decontamination	The system shall allow purification of contaminated water.	The system may employ any combination of separation, filtration or chemical detoxification.	Laoratory and field trials
3.4 Capability (total capacity)	The system should be capable of producing an adequate amount of purified water before resupply.	The system should be capable of operating one month and detoxifying at least 1400 m^3 of water before resupply is required. (45 m^3/d, 31 days)	Laboratory and field trials and exercises shall be used to verify the total capacity.
3.5 Capability (Target materials)	The system shall be able to process any surface water.	This includes raw water with a high content of salt(s) s.a. sea water as well as water with high turbidity and/or high contents of suspended articles or sand.	Laboratory and field trials and exercises shall be used to verify this capability.
3.6 Capability (location)	The system shall be capable of being operated in any environment likely to be encountered due to the mission characteristics.	The system will be set up in rear combat areas or fixed sites.	
4 Reliability	The system must be of robust design to assure maximum operational reliability.	The system shall have a MTBF of >1000 hrs.; 50 % of all defects should be repaired within 2 hours, 95 % of all defects within 6 hours by the operating personnel.	Field trials shall be used to verify the required reliability.
5.1 Compatibility (other NATO-formulations	N/A	N/A	N/A

N°- requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
5.2 Compatibility (interoperability)	The system should be able to operate in concert with other NATO systems.	Designers should endeavour to utilize common hose connections or to provide adapters. Electrical power requirements and interfaces should be standardized whenever possible.	Countries should provide to other NATO countries, to the extent possible, hardware data to facilitate compliance with this technical characteristic.
Compatibility (with other equipment/ systems) 5.3	The system should not interfere with other military equipment not involved in the decontamination operation.	The system shall not interfere with the operation of other NATO equipment including communications, fire control, CB detection/monitoring and similar battlefield items.	Appropriate field tests shall be conducted to ensure compliance.
6.1 Survivability (of system)	The system shall comply to the standard CBRN hardening criteria.	See AEP-7	See AEP-7
6.2 Survivability (of target equipment)	N/A	N/A	N/A
7.1 Support/ Logistics (personnel)	The system shall be operated by a specialized crew.	The system should be designed to be operated by not more than 2 trained personnel. Additional untrained personnel may be required from the supported unit	Appropriate field tests shall be conducted to ensure compliance.

N°- requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
7.2 Support /logistics (hardware/ consumables)	The equipment shall be self- contained.	The system shall be self-contained and should be operable either on a transport vehicle or should be removable from that vehicle by the crew. It should have all of the components, including maintenance kits/spare parts and a power supply to allow operation for its rated capacity without support from other military units.	Appropriate field tests shall be conducted to ensure compliance.
8 Environmental concerns	The system shall meet the actual environmental regulations of the hosting nation and the owner M[14]	See chapter 5. 050, Environmental Considerations, of this AEP.	See chapter 5.4, Environmental Considerations, of this AEP.
9 Documentation	The system shall be equipped with a manual covering all steps of operation and field maintenance. Operating manuals should be in French or English as well as the national language of the owner.	Complete operator's manuals, schematics and parts list should accompany the system.	Adequacy of manuals shall be addressed with field trials.

[14] EU-nations have to fully transform EU-regulations into national laws within 3 years after EIF

N°- requirement	Operational characteristics	Technical specifications	Test procedures and evaluation criteria
10.1 Operational parameters (climatic conditions)	The system shall be used without performance degradation under all climatic conditions likely to be encountered. This includes operations with salt water and long-term exposure to sea air.	To be accounted for should be climate zones A1, A2, A3, B1, B2, B3, C0, C1 and C2 (reference AECTP 200 – Environmental Conditions or see Annex H).	Testing shall be conducted within stated ranges of temperatures and humidity outside or wherever possible (reference AECTP 200 – Environmental Conditions or see Annex H).
10.2 Operational parameters (storage shelf life)	Shelf life should comply with national regulations.	The system should have a shelf life as determined by individual nations. The system should retain full effectiveness during storage.	Long term storage trials, followed by effectiveness testing to meet tile performance criteria.
10.3 Operational parameters (stability of decontaminant)	Decontamination capability of chemically based systems should not be degraded during deployment or application.	Formulations used in the system shall comply with the pertinent stability requirements given in Subchapter 0411, Requirement 10.3.	Controlled testing using the climatic conditions from requirement 10. 1 and the effectiveness criteria in Volume 2.
11 Training	The system shall be operated by personnel after being adequately trained.	A full-time training period of one week should enable the operating personnel to adequately operate the unit.	Appropriate field tests shall be conducted to ensure compliance.

ANNEX A
DECONTAMINATION METHODS AND PROCESSES (CHART)

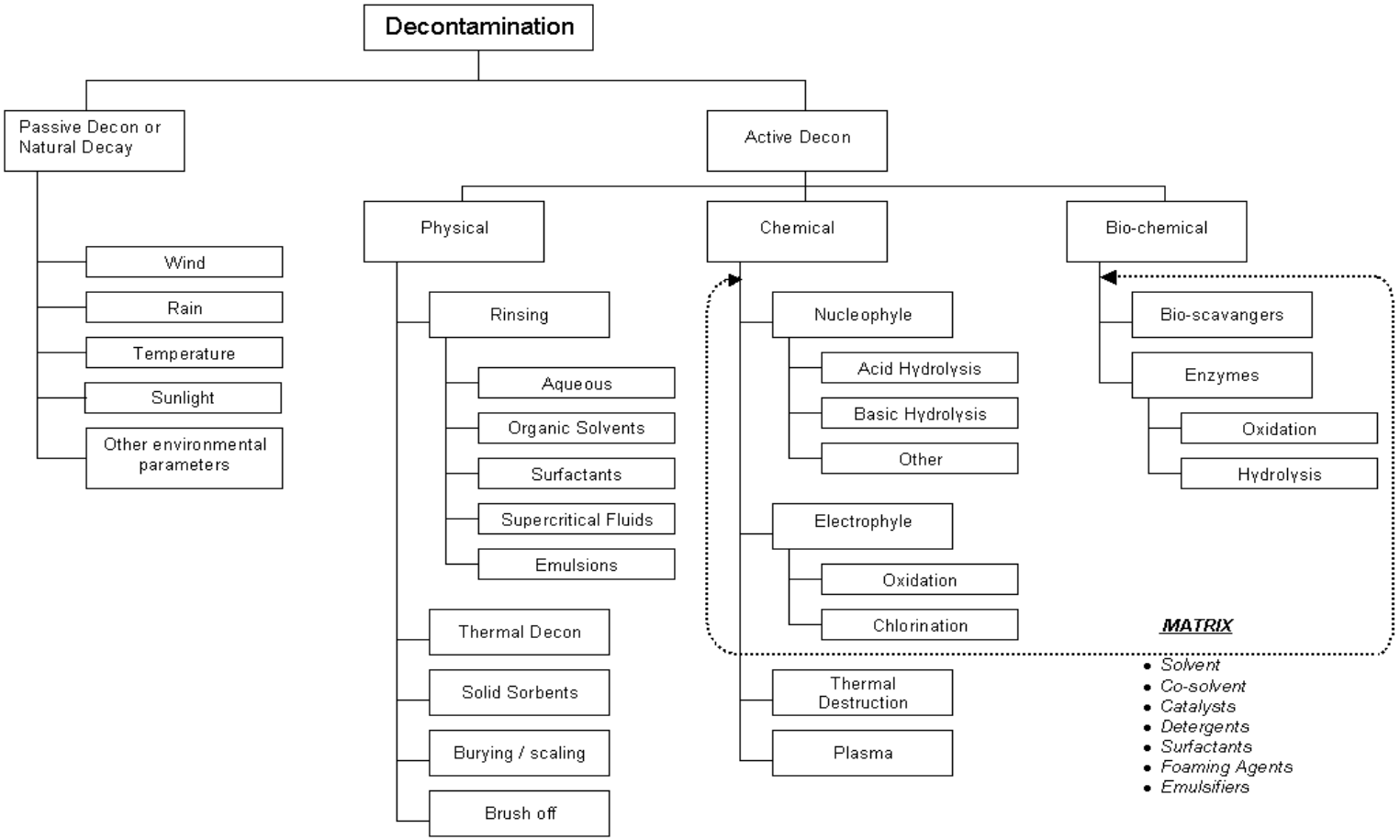

Figure A-1 Decontamination Methods and Procedures Chart

ANNEX B
CHEMICAL EFFICIENCY DECONTAMINATION EVALUATION THEORETICAL AND PRACTICAL CONSIDERATIONS

SECTION I - GENERAL

B01. Objectives

1. To evaluate chemical decontamination efficiency is to determine the residual hazard (inhalation and percutaneous) associated with the use of equipment that has been contaminated and decontaminated using active or passive (e.g. weathering) decontamination procedures.

2. This AEP attempts to identify the measurements relevant to the evaluation of chemical decontamination efficiency and to identify appropriate criteria to be used in evaluation procedures.

3. To recognize the uncertainty in available physiological data, the emphasis is on defining what measurements are to be used in evaluation procedures and how these measurements can be compared to available toxicological data, whatever actual value they may have. For this reason symbols rather than actual values are used in developing the evaluation procedures.

B02. Hypothesis

1. Any evaluation procedure to be performed in laboratory will be performed on sample substrates rather than on full size equipment. This implies the assumption that the measurements obtained from samples can be used to calculate values applicable to the complete item(s) of interest. The only restriction on sample-size selection is that the sample pieces need to be sufficiently large as to be able to ignore edge effects.

2. To study decontamination, a standard contamination density must be assumed. The standard contamination density is $d_b\left[\frac{g}{m^2}\right]$ and has a suggested value of 10 g/m^2.

3. For any contamination and subsequent decontamination two types of residual hazard can be identified:

   a. Desorption of the toxic substance posing an inhalation or percutaneous risk (including eye effects); and

   b. Absorption of the toxic substance through physical contact posing a contact risk (percutaneous risk).

4. Three distinct parameters can be identified to characterize these residual hazards:

   a. The residual contamination;

b. The desorption characteristic; and

c. The contact characteristic.

SECTION II - PRACTICAL LAB EVALUATIONS

B03. Introduction

1. From paragraph B02 it is clear that in general three measurements must be performed in order to obtain a full evaluation of any contaminated and decontaminated sample. These measurements are: residual contamination, desorption and contact characteristics. Several methods to perform these measurements are possible:

Table B-1 Measurement Methods

Measurement	Method	Result
Residual contamination	Extraction + GC-analysis; Extraction + enzyme-analysis (VX only)	grams/m^2
Desorption characteristic	Desorption cell + GC-analysis Contact sampler + extraction + GC- analysis[15]	grams/m^2 =f(t) grams/m^2=f(t)
Contact characteristic	Contact sampler + extraction + GC- analysis	grams/m^2=f(t)

B04. Detailed Procedures

1. The first step in a decontamination analysis will be the contamination of substrates to be tested. As indicated above, a standard contamination density must be achieved if actual pass/fail criteria are to be used. This may be realized by calculating the number of discrete 1 µl drops required to obtain that density and applying them evenly over the test sample.

2. To obtain results within the specified threat level, the number of droplets is always taken to give at least the required density:

$$V_{agens}\left[\mu l\right] = INTEGER\left(10^6.\frac{d_b.S}{P_{agens}}\right)+1$$

where:

$d_b\left[\frac{g}{m^2}\right]$ = required contamination density

$S\left[m^2\right]$ = sample surface

[15] French-German protocol

$P_{agens}\left[\frac{g}{l}\right]$ = density chemical agent

Some parameters like temperatures, humidity, closed or open space and time have an influence on the tests results.

3. The next stage will be a wait period (to be specified) during which the agent can absorb into the substrate (contamination period *Tc* [s]), after which the test samples are decontaminated using a specified system. The samples are then used to determine either the residual contamination, desorption or contact characteristics, if requested, at different temperatures.

B05. Residual Contamination

Measurement of residual contamination is performed by placing the samples in a suitable extraction solvent, after which the amount of agent is quantitatively determined by GC or an enzyme technique (VX only). The parameters are the type and amount of extraction solvent, and extraction period with possibly the execution of successive extractions to ensure full extraction of residual contamination (as described in AEP-7).

B06. Desorption Characteristic

1. The amount of agent desorbed over time from the sample plates can be measured as the amount of agent present in a controlled gas-flow over the samples. An alternative method consisting of measuring weight-loss over time is possible if no actual decontaminant is used in the decontamination procedure (but the gravimetric method can be used for weathering or heat desorption studies).

2. The flow-rate of gas used to trap desorbing agent is an important parameter in this procedure, since it can actively participate in the desorption process if the flow-rate is too high (convection rather than diffusion). The parameters are the type and flow-rate of gas, the time-intervals at which the amount of agent has desorbed, and the temperature of the sample.

3. A second method is provided by a French-German protocol, where desorption is measured by contact-sampling. The parameters in this procedure are the same as those for the determination of the contact characteristic (see below). It is clear that this procedure simulates the diffusive process of desorption without the possibility of convective transport measurements.

B07. Contact Characteristic

1. The amount of agent absorbed over time by physical skin contact can be measured as the amount of agent absorbed by a suitable contact-sampler pressed against the samples. The amount of agent absorbed within the contact sampler over a period of time can then be measured as a residual contamination (extraction and analysis: see above).

2. The parameters are clearly the type of contact sampler, the pressure used to simulate physical contact, the time interval at which the amount of agent absorbed is determined, and the parameters for the determination of residual agent within the contact sampler.

B08. Lab Analysis Report

1. To allow for future re-interpretation of results and comparison, a decontamination evaluation report shall include the residual contamination measurements (including details on the extraction and analysis procedure) and the complete desorption and contact-curves for a time-period of at least twice the required operational time-window (including details on measurement procedures).

2. To facilitate qualitative interpretation and allow direct comparison (even across labs) it is also suggested to add, to each evaluation report, the results of a standard decontamination procedure using a reference decontamination method on a reference substrate.

SECTION III - EXPLOITATION OF LABORATORY RESULTS

B09. Introduction

To obtain values for complete items of interest, the three measurements obtained from sample plates need to be converted to the full-scale objects. Two corrections are to be considered: first, the measurements must be recalculated and adjusted for surface area of either exterior or interior exposure, then a shape factor is introduced to account for the complex shapes of full-scale objects in relation to the flat test-samples.

B010. Residual Contamination

For this absolute measurement, there is no requirement to make the distinction between exterior and interior exposure scenarios. The values for full-scale items can simply be calculated by multiplying amounts of agent found on test-samples with surface ratios for each substrate found on a full scale item (tested surface versus actual surface) and adding for the different types of substrates that make up the item.

B011. Exterior Exposure, Desorption Characteristic of Full-scale Objects

1. **Method**. The desorption characteristic gives the amount of agent desorbed per unit surface in time. To obtain an exposure concentration, a corresponding volume needs to be identified. The easiest method is to consider a unitary exposure volume $V_{\exp}^{ext}\left[m^3\right]$, so that the measured values per square meter substrate surface are also the concentrations above the substrate. It is further assumed that for exterior exposure, atmospheric diffusion and convection will result in reducing agent concentration away from the contaminated substrate. The value of interest therefore, is the concentration just above the surface of the substrate, assuming a continuous removal of desorbed agent corresponding to the definition of the desorption characteristic.

2. Considering a full scale-object such as a tank or truck, two different approaches can then be used. The full-scale concentrations can either be calculated as the weighted average of the individual sample-substrates, with weighing coefficients determined from surface ratios or they can be taken as the highest concentrations measured from individual sample substrates.

3. **Example.** A truck is considered to consist mostly of surface types A (80% exterior surface) and B (20% exterior surface). Testing of individual samples results in two desorption characteristics: one for type A and one for type B. The desorption characteristic for the complete truck can then be taken as the weighted average of measured concentrations with coefficients 0.8 and 0.2 at every moment in time; or as the greatest concentration measured at any moment in time.

B012. Interior Exposure, Desorption Characteristic of Full-scale Objects

$$\frac{dC}{dt} = q.\frac{S}{V_{\text{exp}}^{\text{int}}} - k.C = \frac{dD}{dt}.\frac{S}{V_{\text{exp}}^{\text{int}}} - k.C$$

Where:

$q\left[\frac{g}{m^2.s}\right]$ = desorption flux per unit surface per unit time

$D\left[\frac{g}{m^2}\right]$ = amount desorbed per unit surface (= desorption characteristic)

$S[m^2]$ = contaminated surface within the enclosure

$V_{\text{exp}}^{\text{int}}\left[m^3\right]$ = volume within the enclosure

$k\left[\frac{1}{s}\right]$ = loss factor (agent disappearing from the enclosure due to inhalation or air refreshment)

Considering a worst case scenario, the loss factor can be taken as zero, and the differential equation can be discretized for sample points corresponding to the measured points of the desorption characteristic

$$\frac{C(t+\Delta t) - C(t)}{\Delta t} = \frac{\Delta D}{\Delta t}.\frac{S}{V_{\text{exp}}^{\text{int}}}$$

$$\Leftrightarrow C(t+\Delta t) = \Delta D.\frac{S}{V_{\text{exp}}^{\text{int}}} + C(t)$$

with $\Delta D\left[\frac{g}{m^2}\right]$ = amount desorbed per unit surface over a period Δt.

By this last equation the exposure concentration profile for the enclosure over time can be determined directly from the experimentally measured desorption characteristic. As can be seen from the above equations, the right hand side is always positive (and approaches a constant value as desorption approaches zero) so that the exposure concentration always increases in time and ultimately reaches a maximum value.

B013. Remark

1. As for the exterior exposure scenario, a combination of substrates could be considered where the flux becomes the summation over different contributions, each adjusted for their surface, but calculated over the same volume. The total flux is, therefore, the average flux calculated with weighing factors determined from surface ratios.

2. To standardize testing, a reference enclosure should be defined, and a loss factor might be introduced accounting for personnel inhalation and/or air refreshment.

B014. Contact Characteristic of Full-scale Objects

The evaluation of contact hazards for full-scale objects does not depend upon the object itself but on the effective contact surface between an individual and the object. The amount of agent absorbed by physical contact on sample plates can, therefore, be multiplied by a suitable ratio of sample surface and actual expected contact surface. $S_{con}\left[m^2\right]$.

B015. Shape Factors

1. Measured values on sample plates can be recalculated using the above methods to obtain values representative for whole items for both interior and exterior exposure. It is very likely, however, that actual measurements on whole items would not correspond to these calculated values.

2. The main reason for these differences lies in the complex shape of the full-scale items resulting in different sorption, decontamination and desorption behaviour. It is also very likely that, during contamination, not all of the object will be contaminated and certainly not with the same initial contamination density so that the actual surfaces used in the above methods must be carefully considered.

3. An evaluation of these correction factors is only possible by actually performing measurements on whole items and comparing them to calculated values from sample testing. This type of study would allow estimates acquired from the above models to be brought closer to actual values and the determination of shape factors to be used as actual scale-up factors in decontamination studies.

SECTION IV - EVALUATION CRITERIA

B016. Introduction

In this section the relationship between the measured and/or calculated values discussed above and typical toxicity information is described, allowing for the definition of appropriate decontamination criteria.

B017. Toxicity Information

1. **Three factors influence toxicity**:

   a. The amount of agent to which an individual is exposed;

   b. The time period of exposure; and

   c. The route of entry.

2. Quantitative toxicology uses values that describe either short-term high dose (acute) or long-term low dose (chronic) exposures. Amount of agent is expressed as vapour concentration to which an organism is exposed or as a total amount of agent taken up by an individual. Routes of entry to be considered in the context of this AEP are:

   a. Inhalation of vapour;

   b. Eye contact by vapour; and

   c. Uptake by the skin (transdermal) through physical contact[16] with contaminated materials.

3. Toxicity values are generally reported in accordance with the previous outline as acute doses or as exposure concentrations resulting in the effect being tested:

   a. $ED_{X\%}$: the administered dose (grams per kilogram bodyweight) resulting in x percent of the exposed population to exhibit the indicated effect.

   b. $ECt_{X\%}$: the exposure concentration (grams multiplied by time per volume air or water) to which a population is exposed during a period t and resulting in x percent of the exposed population to exhibit the indicated effect.

4. It is clear from these definitions that the first value is valid only for direct and immediate uptake of a total amount of the toxic substance, whereas the second value allows exposure time to be considered. There is evidence, however, that the Ct value is a function of exposure time, so that different values need to be considered for different exposure periods. For this reason and in order to overcome this time dependency, the concept of toxic load may be introduced:

   $ETL_{X\%}$: the toxic load calculated as the integration over time of the exposure concentration raised to a certain power, property of the toxic substance. The toxic load for

[16] Uptake by the skin of vapour is also a possible route, but it is assumed that the risks associated with this route will always be inferior to the risks of intake by inhalation. Intake through ingestion or through direct intake in open wounds is also not considered in this AEP.

a given effect can then be calculated from a range of available Ct-values valid for different exposure periods.

B018. Using Toxicity Values as Decontamination Criteria

1. The rationale behind any criterion for decontamination should be an allowable effect to an acceptable percentage of exposed personnel. This corresponds completely with the definitions and data available through toxicological studies of hazardous materials (as explained above).

2. Considering the risks of interest (inhalation, eye and contact) the question then remains whether or not the corresponding toxicity indexes are available. The idea here is to formulate a sound base without fixing the values themselves, since these values are still highly uncertain and may change in the future. A second reason to avoid statement of numbers only is that other agents might be considered and then studied using the same general procedure. The same applies to the different parameters in the exposure models.

3. **Desorption criteria**. To evaluate the desorption characteristic, recalculated as an exposure concentration in time (see earlier models), several methods can be used : given an operational time window, an average exposure concentration (for either interior or exterior exposure) may be calculated and compared to a selected ECt-value valid for the same time-window. If toxic load data is available, the experimental toxic load may be calculated by integrating over the time-window and casualties may be estimated through probit-analysis and compared directly to casualty-criteria. Alternatives include criteria on maximum concentration within the time-window.

4. **Contact criteria**. Given an operational time-window the total amount of agent absorbed by the skin is calculated from the contact surface and compared to available ED values. This criterion ignores time effects, but allows a worst case analysis, since the same amount of uptake spread over a certain period will most likely have a lower toxicity index than when the uptake is instantaneous.

5. The reason for this approach is that available ED-values are from studies where the dose was injected rather than applied on the skin. Alternative testing is of course feasible, whereby more accurate doses in accordance with certain exposure periods may then be used as criteria for decontamination. It would therefore be advisable that future data on toxicity always mention the exposure method and - if appropriate - the exposure period.

B019. Conclusions

Chemical decontamination efficiency is defined through residual hazard measurements. These measurements are the desorption and contact characteristics. Criteria should ideally be defined independent of exposure-time since exposure time is a decision of the operational commander and may differ from situation to situation (hence the idea to define the criterion rather than stating it's value). For this reason a set of Ct-values (corresponding to casualty criteria) need to be identified allowing for a full hazard analysis using toxic load functions rather than one single Ct-value.

ANNEX C
PROTOCOL FOR CHEMICAL DECONTAMINATION TESTING

SECTION I - OBJECTIVES AND PROCEDURAL ASPECTS

C01. General

1. This annex provides the frame conditions for a testing methodology and the affiliated evaluation criteria. A detailed compilation of the experimental parameters is indispensable for the comparison of the decontamination efficiencies achieved with respect to comparable systems. Likewise a common basis for residual hazard determination is necessary.

2. The following architecture of test methods and evaluation criteria enables CBRN research and development (R & D) agencies of nations to channel their decontamination results on a way of common understanding. Thus, it is possible to follow further the developmental pathways for new decontaminants and decontamination systems with the inclusion of comparability whenever wanted.

3. Moreover the agreed experimental measures and the respective residual hazard evaluation represent the appropriate testing procedure for the determination of material decontaminability as one of the major characteristics to be improved at chemical hardening. Just on the same experimental basis material selection can be carried out, as far as the ability of materials to be decontaminated is related.

SECTION II - TEST MATERIALS

C02. Test Materials

1. As a basis for comparative evaluation of decontamination results, the following materials commonly used as surface of military equipment, which may be subjected to the influences of chemical agents, should be taken into consideration.

2. **Painted test panels**. Square-shaped test panels (10 cm by 10 cm or 5 cm by 5 cm) coated with polyurethane or alkyd resin paint or any other paint of interest. Preparation of paint samples including pre-treatment of metal and application of the primer are carried out by drying within the ambient air or by baking in accordance with the processing instructions and (also consideration of ISO-standard 1513).

3. **Elastomers, Transparent Materials, Coated Fabrics**. Any materials of interest like elastomers, transparent materials, temporary strippable coatings or coated fabrics can be tested by that test method.

   a. Plates consisting of chloroprene (tire material) and/or butyl rubber (CBRN protective suits, boots, gloves, masks);

   b. Rubber cushions from the tracks of tanks;

c. Sealant materials (e.g. nitrile-butadiene-rubber)

d. Plexiglass (surface treated) and polycarbonates used in aircraft construction; and

e. Transparent materials used as cover materials on the basis of polymethacrylates.

f. Coated fabrics (protective covers). Material samples coated with polyurethane or polyvinyl chloride (PVC).

SECTION III - SAMPLE PREPARATION

C03. Test Samples

1. Test samples generally are to be prepared in accordance with industry manufacturing process instructions, particularly with respect to the surface conditions.

2. Special arrangements are required to establish standardized methods of accelerated ageing to approximate the environmental conditions that military equipment may experience , including but not limited to sun irradiation, rain, relative humidity, wind and temperature. Surface layer alterations are to be expected and are a matter of common experience in the case of paint surfaces.

SECTION IV - METHOD OF CONTAMINATION

C04. Comparative Decontamination Tests

1. The following parameters for the contamination of test samples have been defined and are binding for comparative decontamination tests:

a. Contamination density: 10 g/m^2 HD (purity > 90 %); 10 g/m^2 VX (essential); 10g/m^2 Soman

b. Distribution: Test plates 10 by 10 cm to be contaminated with approximately 85 droplets of mustard (1 µL each) or approx. 100 droplets of GD or VX (1µL each) . Test plates 5 by 5 cm to be contaminated with respective amount of agent are also applicable.

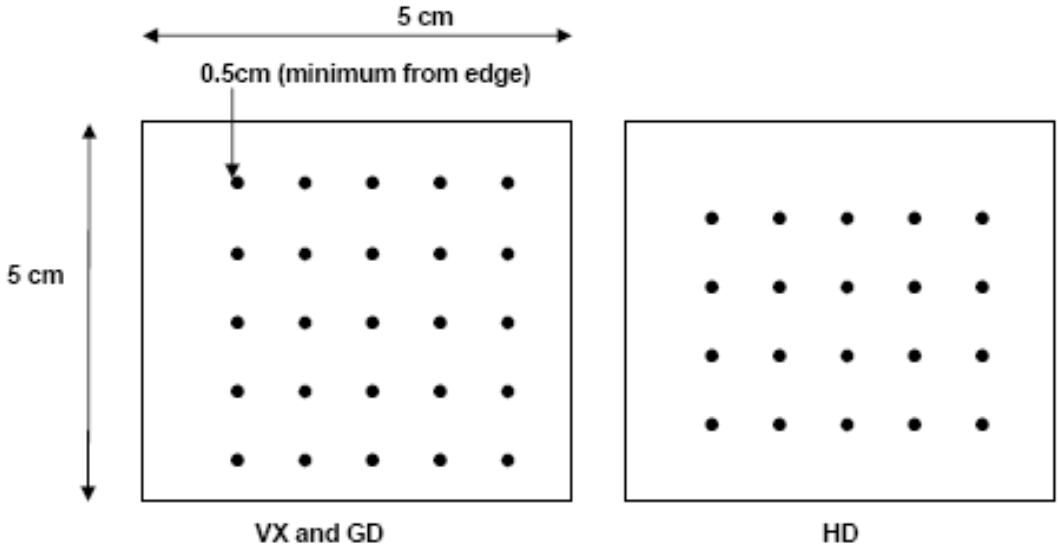

Figure C-1 Configuration of Contamination Drops on Test Panels

c. Thickened chemical agents: thickened with 10 % Parlon S300, or 1 % K125 (Rohm & Haas), 10 g/m^2 likewise in approximately < 100 droplets of 2 - 5 mm in diameter;

d. Duration of contamination: 3 hrs maximum in a closed box (can also be used as transporting container for contaminated samples); and

e. Temperature: 30° ± 2° C.

2. As a concept of combat operations in CBRN contaminated environments, a thorough (complete) decontamination is not achievable in less than 3 hrs after the attack, whereas operational (emergency or hasty) decontamination can be completed after 1 hr.

3. Non-resistant materials like alkyd paints, widely used for logistic vehicles, tend to absorb considerably more chemical agents over a 3 hrs period as opposed to 1 hr after contamination exposure. Accordingly, the required decontamination efforts are different in each case. The 3 hrs duration of contamination exposure represents a worst case scenario because it allows for more agent absorption.

4. To elucidate the time relations for both types of decontamination it is recommended to test samples after 1 hour of contamination followed by decontamination.

5. STANAG 4521 (AEP-7) and STANAG 4360 provide more details on decontamination tests.

SECTION V - METHODS OF DECONTAMINATION

C05. General

1. The decontamination of contaminated test samples will be carried out using standardized national decontamination methods. On this basis primarily the choice of materials for CBRN protective purposes is managed by following the goals of chemical hardening.

SECTION VI - METHOD FOR THE DETERMINATION OF DESORPTION RATES

C06. General

1. After military equipment decontamination, the decontamination quality must be verified by further hazard evaluation. Due to the potential incompleteness of some decontamination methods, hazards arise from residual and absorbed chemical agents left on the surface or in the surface layer of material. Particular consideration must be given to scaling laboratory–scale samples and test results to the potential residual contact and/or inhalation hazards with respect to the scale of large items such as combat vehicles.

2. An unique, passive sampling method has been established for the determination of chemical agent desorption rates based on previous comparison test program work between nations' CBRN protections centres. The method involves using a standard weight to press silica-gel paper disks in direct contact with the surface for a fixed period of time. After removal, solvent extraction is used to remove the absorbed chemical agent, which is analyzed using gas chromatography to derive quantity and desorption rates.

3. It can be demonstrated that the amount of chemical agent (particularly HD) transferred from the surface to the silica gel is proportional to vapour desorption from the uncovered surface into the ambient atmosphere. This passive sampling method thereby eliminates the need for a separate determination method to collect desorbed vapours from air-flow passed over the surface to be evaluated

4. Correlation of the agent transfer rates by contact and by direct vaporization is more complicated in the case of persistent chemical agents like VX. Desorption of VX from wet surfaces is higher than from dry ones.

5. The inhalation hazard with respect to volatile chemical agents may be calculated through the definition of an exposure model by the use of desorption data received by contact sampling.

C07. Desorption Rates Parameters

1. The following parameters are provided to determine desorption rates:

a.	Contact sampler:	silica gel paper Aluminium sheet covered with silica
b.	Temperature:	30° ± 2 °C;
c.	Pressure	20g/cm² (2 kPa)
d.	Desorption time:	15 min after decontamination, if necessary repeated after 45 - 60 min ;
e.	Solvent for extraction:	heptane / acetone (9 + 1 by volume) as solvent for thickened agents

f. Analytical method: gas chromatography.

2. The quantities of the two 15 min desorption periods are correlated to the absorbing areas of the applied contact samplers.

SECTION VII - DETERMINATION OF THE RESIDUAL HAZARD AFTER DECONTAMINATION

C08. Toxicological Threshold Levels

1. The criteria for decontamination quality are measured desorption rates in correlation with toxicological threshold levels. NATO paper AC/225 (Panel VII) N/175 provides negligible risk values for inhalation and skin contact of chemical agents.

2. The requirement to determine residual hazard shall not exceed the following dosage values or amounts of liquid chemical agent levels in Table C-1:

Table C-1 Maximum dosage values of liquid chemical agents (Ref: AEP-7)

CHEMICAL CONTAMINANT	VAPOUR/AEROSOL (mg . min/m^3)	LIQUID [b] (mg/70-kg man)
VX	0.25 (0.02 for visual Acuity) [a]	1.4
GD	2.5 (0.5 for visual acuity) [a]	30
HD	50	180 (0.01 m /cm^2)[c]

[a]. Applies to pilots
[b]. Applies to skin dose, not absorption through the eyes
[c]. For localized effects

C09. Evaluation of HD Desorption Data

1. From the measured desorption rates, chemical agent vapour doses which affect the skin or the respiratory tract of a person can be calculated by the application of standardized exposure models.

2. The resulting dosages are to be measured and compared with the toxicological threshold levels reported in paragraph B08.

3. A simplified model for the determination of the residual inhalation hazard coming from the decontaminated surface can be characterized as follows:

a. Desorbing area: 1 m x 1 m

b. Exposed air volume: 1 m x 1 m x 1 m above the desorbing area

c. Air flow: 1 m/s parallel to the desorbing surface

d. Air volume containing chemical agent vapours: 900m^3/15 min desorption time

4. Proceeding from the amount of desorbed agent (mg) for a surface of 1 m^2 within a desorption time of 15 min an inhalator dosage expressed in mg x min/m^3 may be ascertained. Assuming a constant desorption rate the inhalation risk can be figured out for a one hour exposure time.

5. Decontaminations end up with a positive result unless the toxicological threshold levels are exceeded.

6. In case of residual contamination of HD the skin contact risk is of initial concern before the inhalation risk. When contact sampling results in the dose value which causes negligible skin effects, the threshold level of inhalation risk has not nearly been attained.

7. Therefore the residual hazard after decontamination of HD will be evaluated exclusively with respect to the criterion of contact risk, namely < 10 µg / cm^2 HD in 15 minutes, determined immediately after the end of decontamination and again 45 minutes later.

C010. Evaluation of VX Desorption Data

1. The contact and inhalation hazards for residual VX exist over long periods of time because of VX's high persistency. The VX desorption rate via skin contact depends on the area and duration of contact to the decontaminated surfaces

2. A contact sampling dose of < 1 µg/cm^2 VX in 15 minutes is considered as the thresold criterion for a safe skin contact with two hands.

3. The conditions of VX desorption seem to be rather complicated with respect to the vapour hazard. For a 15 -minute exposure the calculated threshold levels of desorption are 0.12 µg/cm^2 for myosis and 1.4 µg/cm^2 for inhalation. More experimental and analytical work has to be carried out to confirm the applicability of such data. So far only the contact risk criterion should be employed for the evaluation of the residual hazard after decontamination.

SECTION VIII - EVALUATION CRITERIA FOR DECONTAMINATION EQUIPMENT

C011. General

1. Besides the common basis for the evaluation of the decontamination efficiency, differences may exist with respect to the sequence of priorities regarding the other equipment features.

2. In general a well-balanced relation between the characteristics of technical performance, military acceptability and expenses for production and in operation will be required.

3. The following characteristics or regimes of consideration are the criteria for the overall evaluation of decontamination systems:

a. Costs of development and fabrication;

b. Costs of operation;

c. Efficiency and dimension of use;

d. Logistics;

e. Personnel requirements;

f. Time requirements;

g. Feasibility and robustness;

h. Non aggressive to decontaminated material;

i. Function of item after decontamination ;

j. Suitability for militarization; and

k. Acceptability to the environment.

ANNEX D
CELLS METHOD METHODOLOGY AND EQUIPMENT FOR ASSESSMENT OF RESISTANCE TO PENETRATION OF CHEMICAL AGENTS BY PROTECTIVE COATINGS AND OF EFFECTIVENESS OF DECONTAMINATION MATERIALS AND METHODS BASED ON ANALYSES OF DESORBED VAPOUR.

SECTION I - INTRODUCTION

D01. General

This annex describes the methodology and instrumentation for the assessment of effectiveness of decontamination equipment, procedures, and formulations and resistance of materials to absorption of chemical agents based on subsequent desorption of vapour. The vapour test cell and associated methodology described below can also be used in modified form as a means for determination of desorption characteristics of chemicals absorbed into materials, soil or sand.

D02. Philosophy for Standardized Methodology and Equipment

1. **Standard Test Materials**. Although member nations may have common philosophical approaches and standardized characterization methods for the topics described herein, some differences in methodology and equipment will continue. In order that duplication of effort can be reduced to a minimum and overall efficiency be increased, it is essential that results generated in one country be readily comprehended and related to results in other countries. To achieve this objective, normalization of results through the use of standard materials and agents/simulants is desirable. The approach would be to have one or more "standard" materials whose decontaminability or agent resistance can be characterized in each of the test arrangements in which all pertinent test conditions (e.g., temperature, agent/simulant challenge or contamination density, sweep gas flow rates, contamination/decontamination duration, drop size and contact surface area) are reproduced. In that way, normalization of results from equipment to equipment with their associated methodologies can be accomplished. As well, one or more samples of the standard material could be included in each series of assessments so that results from each study can be compared in an overall normalized set of results.

2. **Simulants**. Simulants are often used in place of chemical agents in testing since they are easier to obtain and are much safer to use. However, the selection of an appropriate simulant must be carried out based mainly on the chemical and physical properties similar to the agent that it simulates. For chemical agents, a number of different compounds have been employed, the selection depending on the property being examined.

3. These include methyl salicylate, dimethyl methylphosphonate, triethyl phosphate, dipropylene glycol monomethyl ether, and 2-chloroethyl alkylsulfides, to name only a few. The critical properties in desorption studies include solubilities, adsorptivities, vapour pressures, wetting abilities, and surface tensions as well as chemical reactivities. The use of any simulant to characterize the decontaminability or absorption of a given material will require comparative studies on coupons of the material to correlate results from the simulant with results from the chemical agent. Once a database correlating the agent and the simulant

is generated, then use of that simulant on larger items fabricated of similar material can be undertaken with reasonable confidence. In the absence of such a correlation, the simulant may still be used to rank materials in relative order of desorption properties provided that critical physical properties such as vapour pressure and solubility approximate those of the chemical agent.

4. **Vapour Desorption from Coupons of Material**. In many cases, examination of a complete or whole item may not be feasible. For these cases, laboratory examination of coupons or small samples of the material can be a useful and economical approach. The physical parameter of interest for characterizing decontamination effectiveness or agent resistance is the rate of desorption per unit area of challenged material. In the case of vapour desorption, the general procedure is to contaminate a coupon of material, such as a painted panel or swatch of polymer, with a given quantity of chemical agent/stimulant. Allow the contaminated coupon to rest for a period of time so absorption can occur, decontaminate the coupon using the specific procedure appropriate to the decontaminant under investigation if assessment of decontamination effectiveness is being performed, rinse the coupon with water or an alcohol, e.g. ethanol, mount the coupon in a desorption cell and monitor the subsequent evolution of chemical agent/simulant vapour. The cumulative challenge vapour desorbing over a specified period of time at a given temperature can then be used as a means of assessing relative/absolute decontamination effectiveness or agent resistance. Where possible, monitoring of the profile of concentration during desorption over the duration of the test is highly desirable since this information can be used to identify periods of high desorption rates and permits further examination of the results using empirical or first-principles models.

5. **Desorption from Systems and Subsystems**. Whereas assessment of decontamination effectiveness or agent resistance of a specific material can be accomplished with the coupon approach, complete characterization may best be accomplished by evaluating the entire item as a unit. In this way, the combination of materials used in its construction and the composition of these materials, i.e., the relative amounts of each, as well as the construction design are directly addressed and accounted for in the determination of challenge compound desorbing from the overall item. Whether such determinations can be carried out will depend on the physical resources available. Whereas the fabrication of an enclosure with associated plumbing and analytical capability for small items such as masks, boots, gloves, rifles, etc. can be relatively straightforward, similar facilities for examination of large items such as trucks, tanks, etc. may not always be available or feasible. In summary, measurement of desorption from whole items is highly desirable but characterization of very large items may have to be accomplished by reliance on coupon or sub-component testing.

6. The general philosophy for characterization of desorption of chemical agent/simulant from whole pieces of equipment is essentially the same as for coupons. The item is contaminated with a given contamination density of challenge compound, allowed to rest for a period of time, decontaminated using the specific procedure appropriate to the decontaminant under investigation if assessment of decontamination effectiveness is being performed, rinsed off, positioned in a desorption chamber or enclosure, and monitored for the amounts of chemical agent/simulant vapour desorbing. Some modifications of this general procedure are necessary when whole items are being investigated. For example, application of agent/simulant must be carried out in a realistic manner, such as more attention to those areas which will be more exposed, thus receiving more agent/simulant, as compared to shielded areas, which might receive proportionately less liquid contamination. If

decontamination effectiveness is being evaluated, the decontamination procedure will be dictated by the nature of the item under investigation and may vary from item to item. For exterior surfaces, the flow patterns for effluent gas around the item should be realistic so that they represent the isolated item desorbing agent/simulant into a gentle breeze. In examinations of interiors of vehicles and equipment, normal air circulation patterns and flows must be established and the build-up/decay of agent/simulant vapour in the interior monitored or sampled over the test duration. The approaches to analysis of the vapour desorbing from the item may be similar to those employed in characterization of coupons, except that small samples of the effluent stream may be examined as compared to total collection or entrainment of the effluent gas in the case of coupon examination.

D03. Test Methodology and Equipment to Measure Desorption of Chemical Agent/Simulant Vapour

1. General features of the test equipment and associated methodology to measure desorption of chemical agent/simulant vapours are presented below:

2. Regardless of the particular design and associated methodology for assessment of vapour desorption, a number of primary requirements apply. Any enclosure used in such studies must be constructed from materials which are themselves resistant to absorption, penetration, and degradation by agent/simulant vapour. As well, all associated plumbing and effluent lines should similarly be constructed from agent/simulant-resistant materials. Secondly, for coupons, the cell or enclosure must be of physical size to accommodate coupons of a reasonable size so that realistic challenge quantities of agent/simulant may be used and decontamination of the coupons can be carried out in a realistic manner.

3. Analyses of agent/simulant desorbing from the material or item can be achieved by a variety of means including real-time detection, repetitive vapour-phase gas chromatographic analyses, repetitive solid sorbent collection followed by gas chromatographic analyses, and vapour entrainment in non-volatile solvents followed by gas chromatographic analyses.

4. In real-time detection, devices such as long-path length infrared spectrophotometers may be used to record the instantaneous agent/simulant concentration in the effluent gas provided that the sensitivity of the device is adequate. The approach will provide a complete profile of the concentration of desorbing agent/simulant while integration of the concentration versus time curve will supply the required pass/fail data. Repetitive vapour-phase gas chromatographic analysis may involve the sampling of the effluent gas with a multiport sampling valve with gas sampling loops and subsequent injection. Summation of the integrated areas of the relevant agent/simulant peaks in the analyses over the duration of the test will supply the required pass/fail data. Repetitive solid sorbent analyses are conducted in a manner similar to the vapour phase analyses except that all of the effluent, or a significant portion of it, is trapped on a solid absorbent leading to higher sensitivities and lower detectability limits. Injection is achieved by thermally desorbing the agent/simulant from the sorbent onto the column of the gas chromatograph with detection by an appropriate detector.

5. Vapour entrainment is the most economical and oldest of the methods employed for agent/simulant collection. A bubbler, which contains a non-volatile solvent such as diethyl phthalate or diethyl succinate, is positioned after the desorption cell so that all or a portion of the effluent gas is bubbled through the entrainment solvent. Profiles of agent/simulant

concentration over the duration of the desorption determination can be achieved by replacement of the bubblers from time to time. Quantification of the agent/simulant in the solvent is usually affected by gas chromatographic analysis although wet chemical analysis methods can be employed. While the bubbler method is economical, it does not provide as much information on the desorption profile as the other approaches because of the need for collection of many samples to achieve a smooth concentration profile while at the same time being constrained by modest detectability limits due to large volumes of entrainment solvent. In some cases in which characterization of the profile of the desorption could be important, such as those materials in which the desorption is quite rapid and is complete in a very short time, knowledge of this early behaviour could permit the material to be used in applications in which a period of weathering would always occur before human exposure. In those cases or as a simple pass/fail test, the bubbler method may be quite adequate.

6. For assessment of decontamination effectiveness using the desorption method, the following conditions could serve as a basis for the experimental determination:

a. Contamination Density: $5gm^{-2}$;

b. Wind Velocity (Sweep Gas Flow Rate): $1ms^{-1}$;

c. Substrate Temperature: 30°C;

d. Exposure Duration (Pre-decontamination): 30 min; and

e. Post-Decontamination Delay Time: 15 min

D04. Conclusion

This has been an overview of methods and equipment to assess the resistance of protective coatings to penetration by chemical agents, the effectiveness of promising vehicle/equipment decontaminant formulations and procedures, and the absorption/desorption of chemical agents into/from porous materials. The methodology is based on determination of chemical agent/simulant vapour desorbing from a challenged or decontaminated surface as a measure of the chemical-agent penetration resistance or post-decontamination vapour hazard.

SECTION II - METHODOLOGY AND EQUIPMENT FOR DETERMINATION OF VAPOUR DESORPTION FROM REPRESENTATIVE SAMPLES

D05. General

1. The ranking of various candidate systems can only be achieved efficiently if standardized methodology is adopted. The major difficulty encountered in interpreting results from studies in different member countries is that each study employs its own unique apparatus, environmental parameters, sampling conditions, and substrates often necessitating duplication of examinations with the same decontaminant or contamination control system in each country. The standardized equipment and methodology described below would be applicable to assessment of decontamination effectiveness as well as determination of material resistance to agent penetration and absorption/desorption of agent into/from porous materials.

D06. Design of the Desorption Cell[17]

1. The cell[18] is fabricated from agent resistant material such as polytetrafluoroethylene or a low-percentage glass-filled polytetrafluoroethylene, to reduce reaction with, and absorption of chemical agents/simulants and decontaminants yet maintain rigidity for ease of machining. Briefly, it is of circular design (diameter - 150 mm) large enough to contain 75 mm-square test coupons and with an internal volume of 200 ml (Figure 1). Each petri dish-shaped cell segment is milled with a lip on the bottom exterior surface to fit into a corresponding groove in the top of another segment so that each upper segment forms the lid for a lower unit. Up to six cell segments can be so stacked to provide a multi-sample apparatus. Seals between the segments are achieved by use of agent-resistant "O" rings set in grooves cut in the top face of each segment close to the outside circumference. An aluminium clamping ring assembly using three threaded rods holds the individual cell segments and a top lid together to achieve gas-tight seals (Figures D-1 to D-4).

2. Clean dried or humidified entrainment air or sweep gas is brought in through one side of a cell segment to the centre of a slot machined in the vertical wall of the cell segment extending as a sector 60° around the circumference of that side of the sampling chamber. The sweep gas enters the sample chamber itself through four holes distributed at equal height on the inside of the sampling chamber along the length of the sector with the two at the ends of the sector being larger than those near the centre to compensate for lower pressures at the extremities of the slot. Thus, the flow entering the chamber is approximately even and laminar at the height of the holes. The test coupon is supported by a stainless steel wire mesh stand so that the upper surface of the coupon is level with the gas entry/exit holes (Figure D-1 to D-4).

3. The gas is exhausted from the cell segment through a similar arrangement of four holes in the opposite wall into an identical slot and out from the centre of the slot through the outer wall of the cell segment. The slots are open-topped to permit easy fabrication and cleaning. "O" ring surfaces are cut around each slot and deformed "O" rings make seals between the cell segment and the bottom of the cell segment above or, alternatively, the cell top. Gas is

[17] NATO countries were provided with details of this cell in discussions on updating NATO STANAG 4360 on paints; a description is provided here for those who may not have received that information.

[18] A major portion of the development and design of this cell was performed at the Aeronautical and Maritime Research Laboratory, Ship Structures and Materials Division, PO Box 4331, Melbourne, Victoria, 3001, Australia by D. Amos et al [1]

introduced into and extracted from the slot by suitable tubing spigots or socket joints as dictated by the sample collection accessories.

D07. Control of Temperature and Effluent Gas Flow

The flows of filtered dried/humidified entrainment air into the cell segments are controlled using either critical orifices preceding a vacuum pump located at the exit of the collection/analysis system or preceding the cell and pressurized by a source of gas or pressurized mass flow controllers located upstream of the cell segments. Temperature control to within ± 0.5 °C is achieved either by mounting the entire cell assembly in an air bath maintained at constant temperature or immersed in a temperature-controlled water or fluid bath. The effluent gas is collected/analyzed over a period of at least 24 hours so that a major proportion of the residual agent (if it is non- persistent) will have desorbed from the material.

D08. Sample Preparation and Contamination/Decontamination Procedure

1. Coupons of the test material(s) (75 x 75 mm) for examination are prepared, cured and/or aged as appropriate. The desorption cell(s) is/are set up and coupon(s) is/are mounted in the cell(s). Sweep gas is passed over the test coupon(s) until the temperature has stabilized and the coupon(s) is/are conditioned. Contamination of the test coupon(s) involve(s) the placement of one or more droplet(s) of neat agent or simulant on each coupon. The quantity of agent/simulant used and the manner in which it is applied is designed to provide the level of coverage desired. This may involve a single drop applied to the centre of the coupon and covered by a thin circular glass cover slip to simulate the area which might be covered by an impacted thickened agent droplet after spreading. In this case, the cover slip is laid over the droplet and gentle pressure applied to it so that the agent/simulant flows out to the edge of the cover slip thus defining a reproducible area of coverage. This approach may not always be possible, e.g., in situations in which; the spread of the agent is so great that it extends beyond the edges of the cover slip or, the agent penetrates into the test coupon before the cover slip can be applied and agent caused to flow out to the edge of the glass or, the surface of the test material is so rough and irregular that pressure on the cover slip cannot cause the agent to flow out to the edge of the glass. In these cases, other approaches could include photography/video to determine the area of the spread droplet or could involve application of a number of small discrete 1-µL droplets in a domino pattern on the coupon surface. In this case, it may be necessary to perform a preliminary experiment to determine the extent of spreading of the agent/simulant on the substrate. This known, the number of droplets to be applied is then easily defined. Another approach might be to immerse the sample coupon completely in the agent or simulant. The area of exposure would then be the total surface area of the coupon.

2. This method might be necessary for those materials (e.g., rubber) in which there is likely to be extensive swelling or for which there is a large spread factor after agent/simulant application such that neither of the above approaches could provide reproducible and definable coverage areas. In this case, the challenge will not be 10 gm $^{-2}$ but could be determined by weight uptake of the coupon. The coupon(s) is/are then allowed to stand in still air for a period of 30 minutes to permit the challenge material to absorb into the coupon(s); the temperature of the coupon(s) is maintained at 30°C throughout this phase to ensure reproducibility in absorption.

3. If determination of agent/simulant resistance of a material or desorption from a porous surface such as soil is the aim of the examination, the coupon(s) is/are then rinsed with equal quantities of an appropriate solvent, such as an alcohol, to remove any remaining surface liquid. The coupon(s) is/are allowed to stand for a further period of 15 minutes to allow the solvent on the surface to evaporate, then the coupon(s) is/are mounted in the desorption cell for examination. If measurement of mass balance is desired, the washing solvent can be collected and analyzed for agent/simulant concentration.

4. If, on the other hand, the assessment of decontamination effectiveness is the aim, the test coupon(s) is/are next decontaminated following appropriate methodology to simulate as closely as possible the field operation. To permit appropriate drainage, the coupon(s) may be inclined at a 45° angle in a toxic-level fume hood. Decontaminant at the temperature of the desorption phase (30°C) is applied and scrubbing, if appropriate, is carried out. If physical action such as scrubbing is involved, a standard procedure with respect to number of strokes with a specific device (e.g., a brush) would have to be instituted to provide direct comparison between test items or materials. The decontaminant is left in contact with the coupon(s) for a period of time appropriate to the specific decontamination procedure or decontaminant (recommended 30 minutes but, in any case, less than 75 minutes in total). The coupon(s) is/are then allowed to drain, if appropriate, and sit for an additional period of 15 minutes before being mounted in the desorption cell(s).

5. After mounting the coupon(s) in the cell(s), the cell(s) is/are promptly closed and sealed, and the sweep gas flow is established to carry out sample analyses over the next 24 hours.

D09. Sample Collection and Analysis

1. The following description sub-paragraph a. will focus on the use of entrainment bubblers while sub-paragraph b. will describe automated gas chromatographic methods for monitoring of the agent/simulant concentration in the sweep gas.

a. Entrainment Bubblers:

(1) In normal use, the entrainment bubbler system involves the use of sets of one, and sometimes two, glass bubblers connected in series with the outlet of each desorption cell, usually by way of standard glass/glass or glass/metal joints with clamps to maintain leak-free seals.

(2) Use of the second bubbler in series is optional and is employed to verify whether complete capture of all the challenge compound from the flowing gas has been achieved and, if necessary, to quantify and correct for the level of slippage of agent/simulant for the particular entrainment solvent. The requirements are that the solvent to be employed in entrainment bubblers has a very low vapour pressure, has a relatively high solubility for the challenge substance, and be compatible with the method of analysis, e.g., elution from a gas chromatograph in a reasonable period of time. Since solvents with these properties will often absorb water vapour from the effluent gas, it is desirable that the air supplied to the cell(s) be pre-dried in a drying tower or similar process to prevent dilution of the entrainment solvent.

(3) In practice, the bubbler sets are removed and replaced with others containing fresh entrainment solvent on a regular basis throughout the examination to obtain an approximation to a time-concentration profile. Bubbler exchanges up to a frequency of one every 30 minutes may be required for examination of substrates which desorbs the bulk of the challenge material over a relatively short initial period of time. Analysis of the contents of the bubbler(s) is achieved by gas chromatograph or by spectrophotometric/wet chemical means. In either case, periodic analysis of standard solutions must be performed to ensure accuracy in the results.

b. Automated Desorption Gas Chromatograph. In the automated gas chromatographic approach, the aim is to capture a given volume of effluent gas followed by introduction of the sample onto a gas chromatographic column for separation and analysis, or to strip the challenge compound from a given volume of effluent gas using a solid phase absorbent followed by its introduction onto the column by thermal desorption of the absorbent. The first method examines only 1 or 2 ml of gas out of the total volume of several hundred ml of effluent gas flowing through a sampling valve loop during the time frame of a single analysis. Thus, high concentrations of challenge compound can be analyzed, such as might be found during the early stages of a desorption study involving porous materials. In the second approach, because all of the challenge compound in the effluent gas is collected and analyzed, trace amounts as might be found for agent resistant surfaces or in assessment of decontamination effectiveness can be quantified. In practice, the gas chromatograph is interfaced to the cell(s) by agent-resistant tubing maintained at an elevated temperature to reduce absorption and subsequent desorption of agent or simulant. The effluent or sweep gas is either forced through the gas chromatograph inlet system by pressure at the sweep gas source or drawn through the inlet system by a vacuum pump located downstream of the inlet system. Repetitive sampling and analysis can be performed over an extended period providing a temporal profile of the challenge substance concentration in the effluent gas. Typical chromatographic equipment could include either capillary or packed columns for separation and one or more detectors such as Flame Ionization and Flame Photometric. Operating parameters are adjusted to provide the shortest possible retention time for challenge substance commensurate with clean separation from any other eluting component.

2. **Analysis of VX**. Although the gas chromatographic approach described above works well for non-persistent agents such as tabun (GA), sarin (GB), soman (GD), cyclosarin (GF), and sulphur mustard (HD), analysis of VX requires a modified approach to provide reliable results which reflect the real-time concentration of desorbed agent. Because of its low vapour pressure, conductance of VX through long lines of agent-resistant tubing, even though heated, can result in delays and/or reduction in transmission of the agent. One solution to this difficulty is to convert the persistent VX to a G-type analog, ethyl methylphosphonofluoridate, by the installation of a simple reactive conversion pad in the effluent gas lines at the exit of the desorption cell. This compound, a lower molecular weight homologue of GB and GD, is volatile and can be successfully conducted through long lengths of agent-resistant tubing in the same manner as GB or GD, especially if the tubing is externally heated. The conversion of VX to this compound is achieved through the use of impregnated conversion pads installed typically in a filter holder constructed of an agent-resistant material. Desorbed VX, which can be successfully carried in sweep gases for short

distances, reacts with chemicals in the pad and is transformed into the more volatile product which is then carried out of the pad material by the sweep gas and through the tubing to the gas chromatograph.

3. **Pad Preparation**. The pads, which are commercially available from several companies[19], can be prepared in the laboratory using a procedure which involves impregnation of non-woven polyester material with a filtered aqueous ethanolic solution of the chemicals, $AgN0_3$ (silver nitrate) and KF (potassium fluoride). After impregnation and drying, the material is punched into suitably-sized disks which can be fitted into a filter holder. The pad is often backed with an identical pad of unimpregnated material to serve as a filter for any dislodged particles. The reaction of VX with the impregnate is rapid even at room temperature and the conversion efficiency has been determined to be 80%. One pad will provide reliable VX conversion for up to eight hours for humid air flows and up to several days if dry air or nitrogen is employed. For calibration purposes, the most straightforward approach is to synthesize an authentic sample of the G analog and calibrate the GC detector on a weight basis. If synthesis is not feasible, alternative approaches for calibration of the GC include: determination of the cumulative quantity of the analog collected from the gas stream when a weighed quantity of VX is deposited directly on the conversion pad or evaporated from a nonabsorptive surface in the cell or; calibration of the GC using GB and calculation of the analog Flame Photometric response factor on the basis that the analog is a factor of 1.12 greater than that of GB on a weight per weight basis. Once calibrated by one of these methods, desorption and quantitation of VX can be treated in the same manner as the other more volatile agents.

D010. Model for Treatment of Repetitive GC Analysis Results

1. The data from repetitive GC analyses is a temporal listing of quantity of agent desorbed and analyzed. From these data, curves of either cumulative agent desorbed or agent desorption for each analysis interval over the span of the test can be obtained. In order to be able to calculate the amount of cumulative agent which has desorbed over a specified period of time (or from the beginning of the desorption), it is possible to fit a computer-generated curve to the results and, from the resulting parameters, obtain the required information. In decontamination examinations using this approach, it has been found that the results can often be fitted to a sum of two exponential decay terms of the form:

Cumulative agent per unit of contaminated area = $N_0\left(1-\gamma\exp^{-(k_1Ht)}\right)-\left(1-\gamma\exp^{-(k_2Ht)}\right)$
where:

N_o is the total mass of agent per unit area remaining in the surface following decontamination
k_1 is the desorption time constant for agent which is desorbed rapidly
k_2 is the desorption time constant for agent which is desorbed slowly
y is the fraction of agent per unit area in the surface which evolves with a rate constant K_1

[19] e.g. in the USA two companies which market sheets of conversion material include:

OI Analytical/CMS Field Products Group, 2148 Pelham Parkway, Building 400, Pelham, AL, 35124-1131, (205) 733-6900

Southern Research Institute, Chemical and Biological Defense Division, 2000 Ninth Avenue South, Birmingham, AL 35205, (205) 581-2854.

$(1-\gamma)$ is the fraction of agent per unit area in the surface which evolves with a rate constant k_2
t is the elapsed time in hours

Cast another way, this model could be given as the sum of two contributions:
Cumulative agent per unit of contaminated area = $\alpha\left(1-\exp^{-(k_1 Ht)}\right)+\beta\left(1-\exp^{-(k_2 Ht)}\right)$
where $\alpha = N_0\gamma$ and $\beta = N_0(1-\gamma)$

This model could be interpreted as representing two facets of the desorption process; one which results from a surface- or near surface source of agent such as that loosely bound to surface layers or trapped in cracks, and the other which results from agent tightly absorbed or dissolved in the coating. While the model is empirical in origin, it has been found that representation of the results in this manner appears to be consistent with the nature of the decontaminants being examined. That is, known effective decontaminants display higher values of k_1 than less effective candidates whereas k_2 tends to be more constant from candidate to candidate consistent with k_2 representing the rate of desorption from sub-layers or slow desorption which would not be as influenced by differences in detoxification rates between various candidates. When the model is fitted, the value of N_o is derived which would estimate the total amount of agent per unit area remaining in the surface even though the experimental determination was terminated before all of the residual agent desorbed. The statistical analysis also allows for the other parameters such as γ, k_1 and k_2 to be integrated out of the model if they are of no interest.

2. In any case, after the data have been fitted by this or other simple generic curve fitting program and the parameters determined with a high degree of statistical fit, it is an easy process to calculate cumulative amounts of agent desorbed over a period of time. Correlation of results obtained using this method with those measured by the Franco-German approach, in which quantities of agent desorbing from a substrate and absorbing onto silica contact pads for two 15-minute periods (0-15 and 45-60 minutes elapsed time) are determined, is readily achieved by substituting the specific times into the fitted equations. Furthermore, the value, N_o, can be correlated with the amount of residual agent as would be determined by extraction of the surface following decontamination. In addition to providing values at these important values, the general shape of the desorption curves can be obtained readily by plotting up the temporal results.

SECTION III - METHODOLOGY FOR DETERMINATION OF DESORPTION FROM LARGER SYSTEMS AND SUBSYSTEMS

D011. General

1. For purposes of determination of vapour desorbing from larger items, two general levels of physical size could be considered:

a. Small complete items or pieces of items such as protective gloves, helmets, masks, rifles, water bottles etc.; and

b. Large complete pieces of equipment such as vehicles, armoured equipment, collective protection tents, etc.

2. For smaller items or pieces of equipment, contamination and examination of the whole item is possible, with special attention being paid to those areas most likely to face heavy contamination. The desorption cell in this case could be a stainless steel, Teflon-lined stainless steel, or glass enclosure of sufficient size to accommodate the entire item and provide adequate space around the item for free flow of air. In practice, the item is contaminated with agent or simulant to the extent of 5 gm^{-2} using an appropriate spraying device, then allowed to sit for a period of 30 minutes to permit absorption to take place. Since the item can be contaminated over its entire surface, sampling cards could be placed next to the item and collected immediately following contamination to obtain information on density and drop size distribution of the contamination.

3. Although it is not as likely to be an aim as it was in the case of coupon(s), if determination of agent resistance is the objective, the item is then rinsed with an appropriate solvent, allowed to stand for a period of 15 minutes, and then placed in the desorption enclosure. If evaluation of decontamination effectiveness is the objective, the item is decontaminated using appropriate methodology to simulate as closely as possible the field operation. The decontaminant is applied and scrubbing, if appropriate, is carried out. The decontaminant is left in contact with the item for a period of time appropriate to the specific decontamination procedure or decontaminant (recommended 30 minutes but, in any case, less than 75 minutes in total). If physical action such as scrubbing is involved, a standard procedure of number of strokes with a specific device (e.g., a bristle brush) must be determined to provide direct comparison between test items or materials. After rinsing and sitting for a further period of 15 minutes at 30°C, the item is placed in the desorption enclosure.

4. The temperature of the sweep gas supplied to and within the enclosure is maintained as close to 30°C as possible to permit direct comparison with coupon studies. The item is allowed to equilibrate for 2 minutes, effluent airflow is established and sample collection/analysis is carried out over the next 24 hours in a manner similar to that employed with the coupons. The quantity of effluent air passed through the enclosure is adjusted to provide 1 ms^{-1} air speed over the surface of the item. Alternatively, if the enclosure is large and/or the item is bulky with an irregular shape, consideration could be given to positioning air stream baffles to direct the sweep gas over the item and/or installing a circulation device such as a simple fan to circulate the air around the enclosure and the contaminated item.

5. To achieve 1 ms^{-1} flow over the contaminated item, the total quantities of sweep gas which are moved in/out of the enclosure may differ depending on the size of the enclosure. In any case, an exchange of at least one total volume per minute is desirable in order that the effluent concentration reflect the real-time interior concentration with reasonable accuracy. For small enclosures, this volume may be small enough so that all effluent gas can be passed through the analytical sampling device or, on the other hand, for larger enclosures, the effluent gas stream may be split so that only a small fraction of the total sweep gas is passed through the analytical sampling device and appropriate correction is made to the results based on the split ratio of effluent to sampled gas. Analyses in both situations can be affected by the same methods as employed for characterizing sample coupons. In those cases of large flows of sweep gas containing certain simulants, there may be benefit in monitoring the simulant

concentration using a real-time monitor such as a long path infrared spectrophotometer, which can often accommodate significantly larger volumes of gas than the standard analytical procedures suited to examination of coupons.

6. For larger items of equipment, the same approach for analysis can be followed but the sampling enclosure would need to be large enough to encase the entire item, e.g., a large room or chamber constructed of agent-resistant material and, optionally, equipped with permanently-mounted sprayers for contamination, decontamination, and rinsing operations.

File AG30N°1

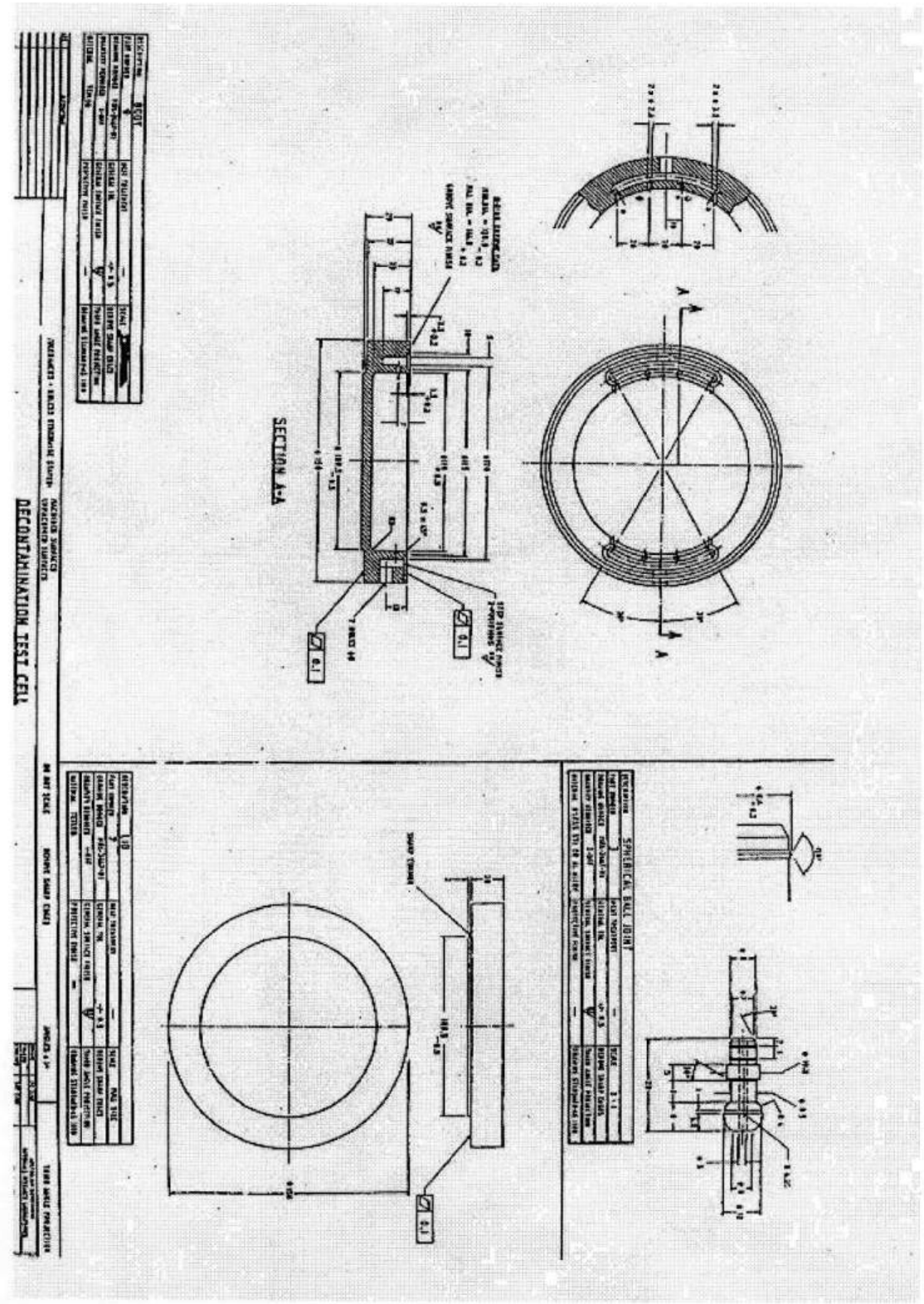

Figure D-1 Decontamination Test Cell (1 of 4)

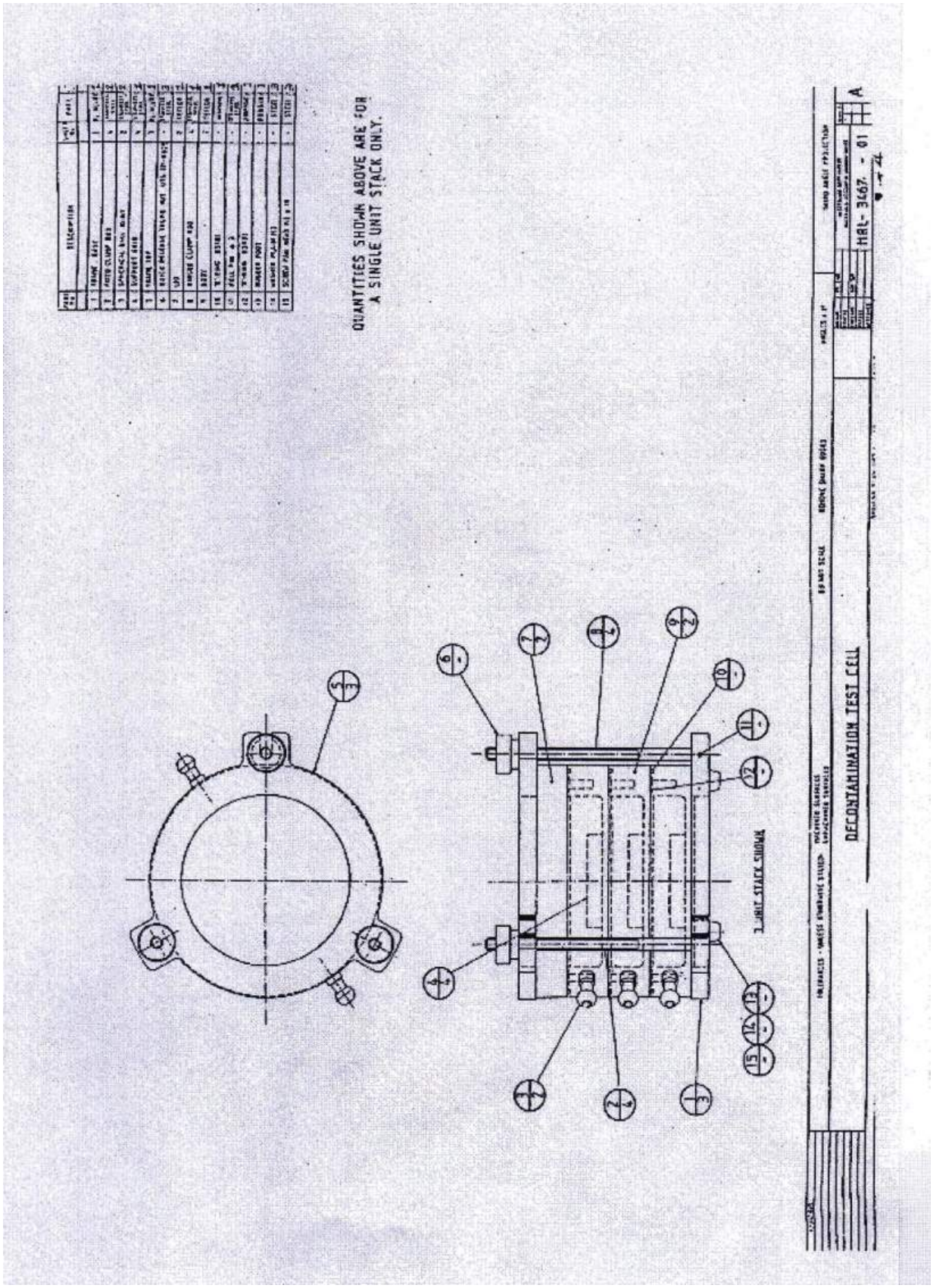

Figure D-2 Decontamination Test Cell (2 of 4)

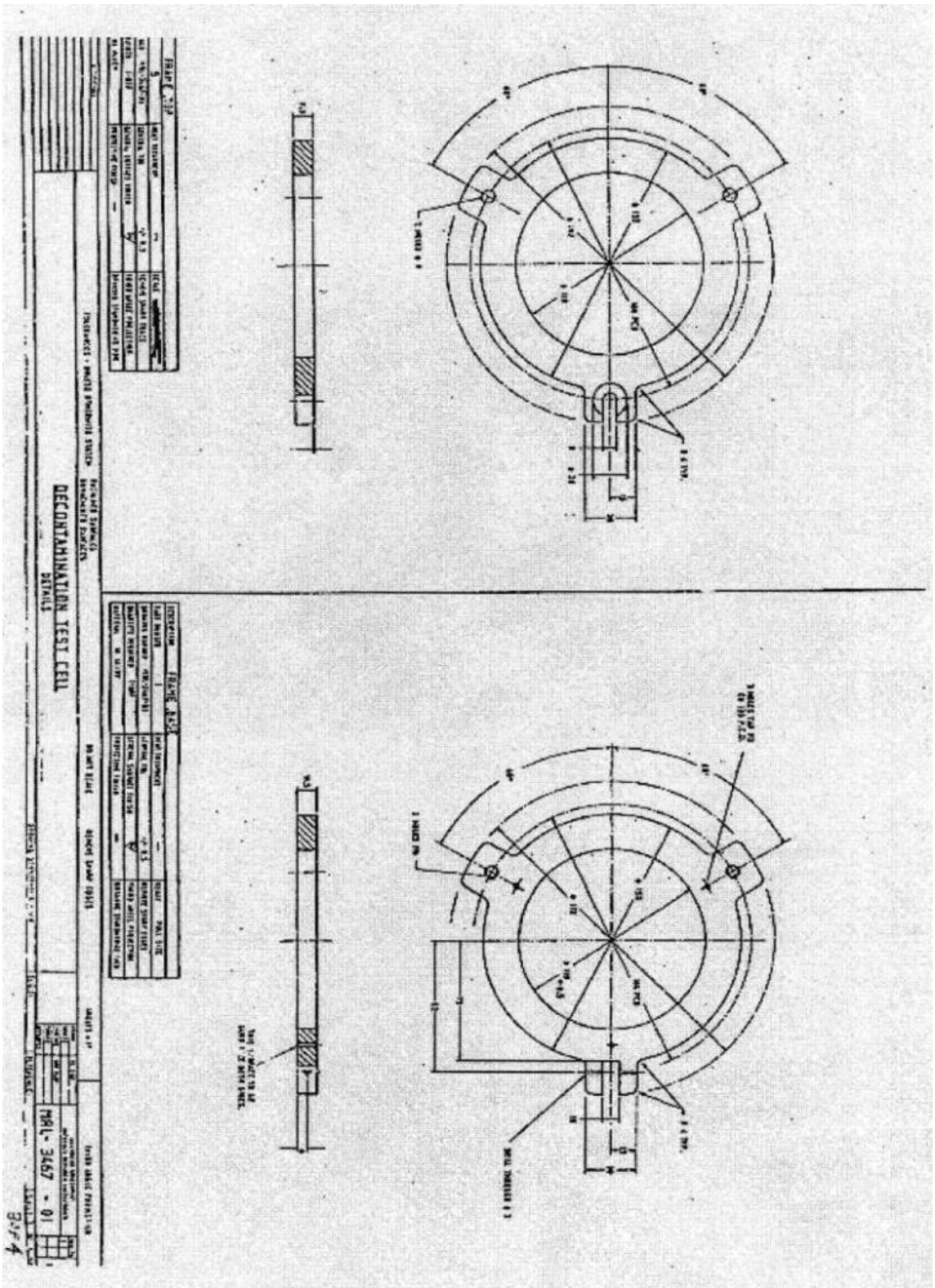

Figure D-3 Decontamination Test Cell (3 of 4)

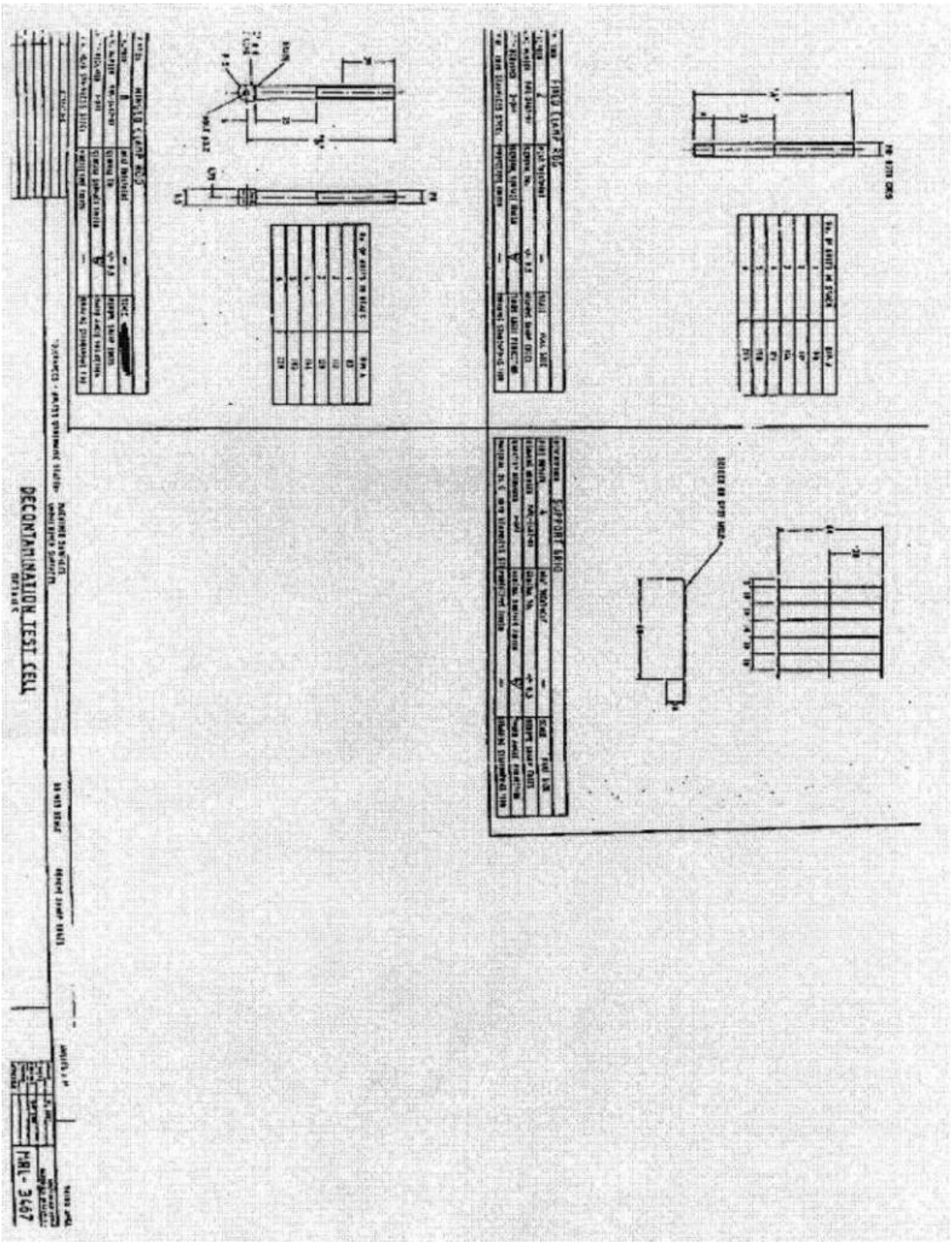

Figure D-4 Decontamination Test Cell (4 of 4)

ANNEX E
TOXIC INDUSTRIAL CHEMICALS (TIC)

E01. General

1. Not every chemical studied under International Task Force (ITF) 40[20], the source used for the information contained in this table, are listed in the following TIC Probability List Table. The focus is on chemicals identified as presenting an extreme risk/hazard of concern to commanders for the conduct of military operations.

2. The risk assessment process itself is very well documented in ATP-3.8.1 and does not need to be duplicated in this document.

3. Of these chemicals, those who are in a gaseous state do not pose any challenge to decontamination.

4. The following focuses only on TIC relevant for decontamination. For all other purposes, refer to ATP-3.8.1 VOL I.

E02. Selection of Relevant Chemicals

1. With respect to decontamination, only those chemicals which have low volatilities at ambient temperature or higher boiling points are relevant; namely, pure parathion, nitroglycerine, phenol solutions, alkali metal cyanides, phosphorous trichloride, phosphoryl trichloride, nitric acid, sulfuric and fuming sulfuric acids and acrylonitrile. Nitroglycerine, because of its instability, would be avoided if at all possible so avoidance rather than decontamination is likely to be the chosen option. For parathion, with a very low vapour pressure in pure form, releases of compressed gas mixtures could result in significant deposits of the chemical itself. Due to its similarity to organophosphorus nerve agents, it would be expected that effective decontaminants for chemical agents should also address parathion, and, because of its toxicity and low vapour pressure, parathion should be considered as a TIC requiring both Operational and Thorough decontamination. Phenol in solution has a low vapour pressure so could persist for significant duration and, because of its severe corrosivity and toxicity on contact with skin and eyes, would require decontamination. Alkali metal cyanides generate hydrogen cyanide on contact with water or acidic media so must be addressed if encountered. Phosphorus trichloride is highly irritating and corrosive to skin and mucous membranes, so Operational decontamination may be sufficient since it has a relatively high vapour pressure and would likely evaporate before Thorough decontamination could be undertaken. Phosphoryl trichloride reacts readily with water to produce phosphine, hydrochloric and phosphoric acids, reacts with acids and alkalis, alkali metals and alcohols and is corrosive and poisonous. With a vapour pressure lower than that of PCl_3, $POCl_3$ would require both Operational and Thorough decontamination.

2. Nitric and sulfuric acids are both highly corrosive liquids. In the case of fuming sulfuric acid, sulphur trioxide is listed as an “irritant and corrosive to mucous membranes” even at 1

[20] ITF 40 – Final report – Industrial Chemicals – Operational and Medical concerns – 15 April 2003

ppm. Sulphur trioxide exists in three forms, one of which has a vapour pressure of only 73mm Hg. Because of this, and the fact that liquid sulphur trioxide solidifies to this form, both Immediate and Thorough decontamination would be necessary to prevent vapour build-up or release. Concentrated sulfuric acid reacts very violently with water, contact must be avoided with water or aqueous solution. All three acids are very persistent so both Immediate and Thorough decontamination would have to be undertaken.

3. Acrylonitrile has been included in this group because it has a boiling point of 77ºC. Because it is explosive, flammable, irritant, toxic and carcinogenic and has a relatively high boiling point, Immediate decontamination should be undertaken to reduce the hazard to personnel. Since it is miscible in most organic solvents, there is a reasonable probability that it would penetrate into coated surfaces unless chemical agent resistant coating (CARC) were used. That, coupled with its high toxicity and boiling point, suggests, that Thorough decontamination would also have to be considered for cases of heavy contamination and exposure.

4. The remaining chemicals in the ITF-40 listing are intermediate in volatility and boiling point so the decision as to need for decontamination is not as easily addressed. Since most have significant vapour pressures, wearing of protective masks and equipment would be the first line of protection. Because of their vapour pressures, it would not appear that Thorough decontamination would be required for the same reason as the first grouping. As for the need for Immediate decontamination, each must be reviewed for its route of toxicity to determine if there is a need for Immediate decontamination.

5. For benzene, decontamination is not likely to be exercised unless to cover and/or absorb the chemical. Because of its flammability and toxicity, it is of concern but, because of its likely resistance to reaction with milder decontaminants, contact avoidance and respiratory/skin protection would be an adequate posture. Methylamine, Dimethylamine, and Trimethylamine can be treated as one family with similar characteristics, e.g., their inclusion in the ITF-40 listing is based primarily on flammability. Collectively, they are irritating to skin, eyes and mucous membranes but are not particularly toxic. Because of their relatively high volatility, Immediate and Thorough decontamination would be unlikely to be required since the chemicals would evaporate in a reasonably short period of time unless large quantities were encountered. However, Immediate decontamination might be required if access to the site were essential. Immediate decontamination would likely be required for the dimethylamine solutions which would be more persistent. For these solutions, Thorough decontamination could also be required. Hydrocyanic acid (a solution of hydrogen cyanide in water) with a boiling point of 26ºC and a vapour pressure of 620 mm Hg, would not be persistent enough to warrant Immediate or Thorough decontamination. Evaporation and dispersion by wind would reduce the hazard providing that protective masks capable of absorbing it are worn. Since it is a very weak acid, corrosivity and irritation problems would not be expected to occur.

6. Carbon disulfide is very flammable, poisonous, explosive and is readily absorbed by the skin. Given these properties, Immediate decontamination is indicated. Because it is toxic by inhalation, ingestion and by skin absorption and poses chronic health problems, Thorough decontamination, subject to the results from civilian monitors designed for its detection, would appear to be required.

7. Propylene oxide is highly irritating to eyes and mucous membranes. Thus, there would appear to be a need for Immediate decontamination efforts if the quantities warrant but not if there were only small amounts present. Thorough decontamination would be a requirement for propylene oxide due to its low vapour pressure and higher persistence. Buta-1,3-diene is highly flammable and reactive, can polymerise explosively on contact with air, sunlight, heat and is moderately toxic. Due to its relatively high vapour pressure, it would not appear that Thorough decontamination needs to be considered and only if larger quantities are encountered and access to the area cannot be avoided would Immediate decontamination be a priority.

8. Hydrochloric acid is very corrosive to skin and eyes and lethal in higher concentrations. Due to its lower vapour pressure (compared to the anhydrous form), Immediate decontamination would be necessary to prevent injury and to arrest corrosion of exposed equipment. Thorough decontamination would likely to be required unless the time delay from encounter was reasonably long since the vapour pressure is only 100 mm Hg. Hydrofluoric acid or hydrogen fluoride is corrosive and poisonous and absorbs into skin readily causing delayed sores as well as being a high vapour hazard. In addition, it attacks glass, stoneware and is a very strong acid. Immediate decontamination will be required to reduce the hazard to personnel and their protective equipment. Because of the high solubility of HF in organic solvents, it might be anticipated that it would also dissolve into plastic and polymer coatings. Subject to the results from civilian detection systems for this compound, there is a strong possibility that Thorough decontamination will also have to be implemented.

Table E-1 Listing of TIC with Relevance for Decontamination

CAS-#	UN-Nr	Chemical	Principal Hazard	Hazard Ranking	Physical State	Incident	Probability Ranking	Risk
55630	3343	nitroglycerin, desensitized	instability	catastrophic	solid	primary explosive	likely	extreme
55630	3064	nitroglycerin	instability	catastrophic	liquid	primary explosive	likely	extreme
56382	1967	parathion in compressed gas mixtures	toxicity	catastrophic	gas	release	likely	extreme
71432	1114	benzene	toxicity	catastrophic	liquid	release	likely	extreme
74908	1051	hydrogen cyanide	flammability, toxicity	catastrophic	liquid	CW	likely	extreme
75150	1131	carbon disulphide	flammability	catastrophic	liquid	release	likely	extreme
75569	1280	methyloxirane (propylene oxide)	flammability	catastrophic	liquid	release	likely	extreme
107131	1093	acrylonitrile	toxicity	catastrophic	liquid	release	likely	extreme
108952	2821	phenol, solutions	toxicity	catastrophic	liquid	release	likely	extreme
124403	1160	dimethylamine, solution	flammability	catastrophic	liquid	release	likely	extreme
143339	1689	sodium cyanide	toxicity	catastrophic	solid	ICW	likely	extreme

CAS-#	UN-Nr	Chemical	Principal Hazard	Hazard Ranking	Physical State	Incident	Probability Ranking	Risk
151508	3413	potassium cyanide	toxicity	catastrophic	solid	ICW	likely	extreme
7647010	1789	hydrochloric acid	toxicity chemical burns	catastrophic	liquid	ICW	frequent	extreme
7664939	1830	sulphuric acid	toxicity CAUSTICITY	catastrophic	liquid	ICW	frequent	extreme
7664939	2796	sulphuric acid, fuming (≥30% free SO_3)	toxicity CAUSTICITY	catastrophic	liquid	release	Likely	extreme
7697372	1796	nitric acid (>40%)	toxicity CAUSTICITY	critical	liquid	ICW	frequent	extreme
7719122	1809	phosphorus trichloride	toxicity CAUSTICITY	catastrophic	liquid	precursor	Likely	extreme
10025873	1810	phosphoryl trichloride	toxicity CAUSTICITY	catastrophic	liquid	precursor	Likely	extreme
1336216	2672	ammonia, aqueous solution	toxicity CAUSTICITY	catastrophic	liquid	release	occasional	high
7726956	1744	Bromine	toxicity	catastrophic	liquid	release	occasional	high
50000	1198	formaldehyde, solutions	toxicity	critical	liquid	release	likely	high

ANNEX F
BIOLOGICAL AGENT RESIDUAL CONTAMINATION

F01. Introduction

1. The aim of this annex is to highlight the potential long-term hazards that may arise following the dissemination of biological agents.

2. The problem arises because some biological species are capable of surviving for long periods after atmospheric dispersion, whilst retaining their infectious capacity. The survival of pathogenic species in the open environment is dependent on a number of factors, such as temperature, humidity, ultraviolet radiation and the physical and chemical characteristics of the support. However, within the confines of this AEP it is not possible to fully discuss the detailed effects of these conditions.

3. In summary, it is likely that some species can remain infectious whilst residing on inert supports, materials or soils for a sufficiently long time to present a secondary hazard. This hazard could be through either direct contact or inhalation (if the biological species becomes re-aerosolised). It should be noted that some species are only infectious by inhalation.

4. To minimize the operational risks presented by biological agents residual contamination, the secondary hazard requires active decontamination to allow personnel to remove individual protective equipment and restore operational effectiveness. However, as the symptoms of biological agents are not immediate, there could be great difficulty in identifying contaminated areas.

5. The remaining paragraphs discuss the long-term hazards presented by biological agents. It should be noted that there is still much to learn about the survival and infectious capacity of biological agents in the environment, as such the following text should only be used as a general guideline.

F02. Bacteria

Bacteria are autonomous species that exist under two forms, the living (or vegetative) element and the sporulated form:

a. Living (or vegetative) element. The first form is generally considered to be fragile and cannot survive long periods, although the survival times can be increased by a favourable dispersion medium or by encapsulation techniques.

   (1) Survival time: hours to days, some non sporulated forms might survive over longer period.

   (2) Decontamination methods: bactericidal products, heating, ultraviolet radiation, specific vapours such as formaldehyde, hydrogen peroxide.

b. Sporulated form. The sporulated form is significantly more robust than the vegetative element and can survive for very long periods. These forms are resistant to mild chemicals, heating and ultraviolet radiation. As such, these agents probably present the greatest long-term residual biological hazard. The main example of this form is anthrax spores.

(1) Survival time: decades of years.

(2) Decontamination medium: strong bactericidal products, strong heating, specific vapours such as formaldehyde, hydrogen peroxide

F03. Viruses

Viruses are non-autonomous species that require a living host. In general, viruses have a short lifetime outside of the host, as they are unable to reproduce and multiply. The survival time can be increased by either using a favourable dispersion medium, or by encapsulation methods, or when at low temperatures.

a. Survival time: hours to weeks, under favourable conditions some viruses (orthopox) stay active longer period.

b. Decontamination methods: virucidal products, heating, ultraviolet radiation.

F04. Toxins

1. Toxins are the natural products of living species such as vegetables, bacteria and fungi. Many of the toxins are composed of long chain amino-acid molecules with molecular weights ranging from 10 to 900 kilo Dalton (10^4 to $9x10^5$ g/mole). In general, the robustness of toxins on non-living supports can be variable and is dependent upon the environmental conditions and the dispersion medium.

a. Survival time: days to months (years).

b. Decontamination methods: bactericidal products, strong heating, oxidisers, acids, bleach….

2. Example: most varieties of botulinum toxin are destroyed after several minutes in boiling water (although the complex form is more robust to high temperatures).

F05. Conclusion

Further research is required to define practically and quantitatively the hazards presented by biological agents residual contamination. Moreover, greater consideration should be given to operational and environmental conditions that could increase these hazards in the theatre of operations. Even though criteria are difficult to implement at present, the best operational techniques for decontamination must be used in the field to minimize this hazard as far as possible. The acceptance of simple verification and recognition criteria should be the goal for experts of all NATO nations in the near future.

ANNEX F, APPENDIX 1
LIST OF POTENTIAL BIOLOGICAL AGENTS

A very large number of organisms and toxins have been identified at various times as offering a potential for employment as biological agents. A comprehensive list of potential biological agents is provided in AMedP-6 Volume II *NATO Handbook on the Medical Aspects of NBC Defensive Operations (Biological).* Specific agents that may be encountered in particular operations will be determined by Intelligence agencies at that time.

ANNEX F, APPENDIX 2
PROTOCOLS FOR THE DECONTAMINATION OF BIOLOGICAL AGENTS (SPORES, VEGETATIVE BACTERIA AND VIRUSES)

F-2-01. Introduction

1. In this appendix are described, for each type of agents, three protocols to test the biological decontamination capability of candidate decontaminants (sporicidal and/or bactericidal and/or virucidal activity).

2. The first protocol is used to test the sporicidal and/or bactericidal and/or virucidal activity of candidate decontaminants in solution (Liquid test protocol). The goal of this protocol is to enable a screening of candidate decontaminants, and to provide a quick method for determining the best conditions of use (temperature, contact time, concentration…) of the tested decontaminants.

3. The aim of the second protocol is to test the activity (sporicidal, bactericidal, virucidal) of candidate decontaminants in formulation for operational use (Lab/Field protocol). This test is carried out on painted metal coupons or other significant material panels (e.g. materials commonly found in military equipment or representative of these, etc.). The coupons used should have dimensions of 10 to 100 cm^2. The purpose of this protocol is to check the activity of candidate decontaminants on solid matrices. It can also be used to compare this activity against live agents and against simulants for the interpretation of the results of field trials (which are done with simulants only).

4. The goal of the third protocol is to propose a method for field trial (Field trial protocol) to assess the effectiveness of a decontamination process (decontamination solution and equipment). This test will be carried out against simulants of the live agents only.

F-2-02. Bacteria

1. Bacteria that are likely to be used as biological warfare agents are class 3 micro-organisms. They can be used for the Liquid test and Lab/Field protocols only, and tests with such agents must be carried out under appropriate safety conditions in a suitable laboratory. The following strains could be used for such trials:

a. *Bacillus anthracis* spores,

b. *Yersinia pestis*,

c. *Francisella tularensis*,

d. *Brucella* spp,

e. *Burkholderia mallei*.

2. As live agents handling requires heavy procedures, simulants could be used to make the tests easier to carry out.
For this purpose, the following strains could be used:

- Simulants for spores of *Bacillus anthracis*:
  - Spores of *Bacillus atrophaeus*,
  - Spores of *Bacillus cereus*,
  - Spores of *Bacillus subtilis*,
  - Spores of *Bacillus thuingiensis*.
- Simulants for Gram- vegetative bacteria (*Y. pestis*, *F. tularensis*, *Brucella spp*, *B. mallei*):
  - *Escherichia coli*,
  - *Yersinia enterocolitica*,
  - *Burkholderia cenocepacia*.

F-2-02-01. Preparation of the micro-organisms

1. Vegetative bacteria suspensions should be freshly prepared immediately prior to the tests, in an appropriate buffer (Phosphate Buffered Saline, distilled water…), and from overnight cultures.

2. Spores suspensions should be prepared by taking into consideration the following points:
   - Bacterial cultures to obtain spores should be at least 7 to 15 days old
   - Spores suspensions should be prepared in an appropriate buffer (Phosphate Buffered Saline, distilled water…).
   - If necessary, spores preparations can be treated to kill the remaining vegetative cells (for example by heat-shocking them for 1 hour at 60 °C).
   - If no treatment is performed, the sporulation rate of the preparations should be evaluated (by enumerating the bacteria before and after treating an aliquot of the suspension in order to kill the remaining vegetative cells). The sporulation rate should be at least 80 %.
   - Spores suspensions can be prepared ahead of the trials and stored at 4 °C.

F-2-02-02. Liquid test protocol

1. This protocol is designed to test in liquid medium the effectiveness of decontamination solutions in killing bacteria.

2. All procedures must be conducted using sterile techniques. Each candidate decontaminant should be tested at least in duplicate. It can be tested at different concentrations, for example: 0 % (control of the viability of micro-organisms), 20, 40, 80 and 100 %. For each replicate sample, the decontaminant solution will be placed into a sterile tube, and then distilled water and the suspension of micro-organisms will be added to it. Table F-1 summarizes the volumes needed to obtain different concentrations, for a final volume of 5 mL:

Table F-1 Volumes of decontaminant, distilled water and suspension of micro-organisms for Liquid test

Volume of decontaminant solution (mL)	Volume of the suspension of micro-organisms (mL)	Volume of distilled water (mL)	Concentration of the decontaminant solution (%)
0	1	4	0
1	1	3	20
2	1	2	40
4	1	0	80

Note: To test a decontaminant solution at a concentration of 100 % (undiluted), the initial suspension of micro-organisms should be centrifuged (10 min at 10 000 g and at 4 °C for example). Then the supernatant should be discarded and replaced by the decontaminant solution.

3. After that, each tube should be vortex-mixed for about 10 seconds.

4. The decontaminant solution can be tested at different exposure times, for example: 15, 30 and 60 min.

5. After the exposure, the remaining decontaminant should be neutralized by an appropriate product (e.g. sodium thiosulfate for oxidizers). The decontaminant's manufacturer should be able to indicate the most suitable product and the concentration necessary to properly neutralize the decontamination solution. Before the test, the effect of the neutralizing product on the viability of micro-organisms should be tested.

6. Next, the remaining number of bacteria (spores or vegetative cells) will be determined in each sample by enumeration on nutrient agar (or other medium suitable to organism) and incubation at an appropriate temperature for 5 days. The plates should be observed on day 1 and day 5, and the colony-forming units (CFU) obtained will be counted.

7. The number (N) of bacteria in the control tube and the number (N') of remaining bacteria in the test tubes will be compared, and the efficiency of the decontaminant will be evaluated by calculating the log (N/N') value.

8. Performance requirements for decontaminants may be found in AEP-58, VOL II.

F-2-02-03. Laboratory/Field protocol

1. In this protocol, the candidate decontaminants will be tested using their intended formulation for operational use (concentration, temperature, exposure time…). The purpose of this protocol is to check the activity of candidate decontaminants on solid matrices. It can also be used to compare this activity against live agents and against simulants for the interpretation of the results of field trials (which are done with simulants only).

2. These tests can be made on painted metal coupons or other significant material panels (e.g. materials commonly found in military equipment or representative of these, etc.). The coupons used should have dimensions ranging from 10 to 100 cm^2.

3. The trials should be made at least in triplicate. For example, to conduct one test against one micro-organism, 5 material coupons could be used: 2 as control panels, and 3 for the decontamination test.

4. Prior to the trials, the coupons can be cleaned (e.g. with alcohol) and/or autoclaved, provided these treatments do not alter them.

5. The panels will be contaminated by an appropriate method (spraying, deposit, painting, immersion…) to obtain a contamination rate of about 10^{xx} CFU/cm^2 (10^{xx} CFU/m^2). After contamination, the panels will be left to dry for at least 1 h.

6. Test panels will then be decontaminated following the instructions given by the manufacturer. Different exposure times can be tested (e.g. 15, 30 and 60 min).

7. After decontamination, a quenching step can be realized with an appropriate neutralizing product. Quenching can take place at different stages of the protocol (while rinsing the panels, when re-suspending the swab, etc.). In any event, it should be checked that the quenching method used is efficient enough, and has no effect on the viability of the tested micro-organisms.

8. After decontamination, the panels can be rinsed with sterile water, PBS (or another buffer) or a quenching solution. The rinsing liquid should be recovered together with the used decontamination solution, and placed in a sterile tube. If there is no rinsing step, the used decontamination solution should still be recovered. This tube could be named “waste”, for example.

9. Each coupon should be inspected for visible damage or degradation to its surface. Any damage shall be recorded.

10. Each panel will then be swabbed over its entire surface with a sterile sampling swab. This operation can be repeated if necessary. The swab will next be placed in a sterile tube containing 2 to 10 mL of an appropriate buffer (PBS, sterile water, culture medium…), and then be vortex-mixed to release the micro-organisms. This tube could be labelled “test”.

11. After swabbing, a contact agar plate can be used on each test panel to check if there are still remaining micro-organisms.

12. The remaining micro-organisms in “waste” and “test” will be enumerated by dilution, cultured on nutrient agar and incubated at an appropriate temperature for 5 days. (or longer depending on the microorganism in question) Contact agar plates will be cultured along with the media used for “waste” and “test”.

13. The plates should be observed regularly (or at least on days 1 and 5), and the CFU obtained will be counted. Remaining micro-organisms on control panels (number N) and on

test panels (number N') will be calculated, taking into account the micro-organisms observed in "waste", "test", and on contact agar plates. The efficacy of the decontaminant on material coupons will be evaluated by calculating the log (N/N') value.

14. Performance requirements for decontaminants may be found in AEP-58, VOL II.

F-2-02-04. Field trial protocol

1. In this protocol, the candidate process of decontamination (i.e. decontamination solution and system) will be tested under operational conditions (concentration, temperature, exposure time…). It could be tested for example on the frame of an armoured vehicle (or on an object simulating it) on which there are a set of painted metallic panels (or panels made of other significant materials, if pertinent). These panels should have quite large dimensions (at least 100 cm^2 if possible) to give significant results.

2. Such trials can only be carried out on non-pathogenic micro-organisms. Micro-organisms employed should also have no effect on the environment. All procedures must be conducted in accordance with local environmental and safety regulations.

3. Prior to the trials, the coupons can be cleaned (e.g. with alcohol) and/or autoclaved, provided these treatments do not alter them.

4. Panels will be contaminated by an appropriate method (spraying, deposit, painting, immersion…) to obtain a contamination rate of about 10^{xx} CFU/cm^2 (10^{xx} CFU/m^2). After contamination, the panels will be left to dry for at least 1 h.

5. At least 2 coupons should be used as control panels. These coupons will not be decontaminated.

6. After drying, the test panels will be set on the frame of the armoured vehicle (or on the object simulating it). These panels should be positioned all over the frame in 3 different ways: vertical, horizontal and sloping. The position of each coupon should be recorded.

7. The coupons will then be decontaminated with the process tested. Different exposure times of decontamination can be tried (for example 30 and 60 min).

8. After decontamination, a quenching step can be realized with an appropriate neutralizing product. Quenching can take place at different stages of the protocol (while rinsing the panels, when re-suspending the swab, etc.). In any event, it should be checked that the quenching method used is efficient enough, and has no effect on the viability of the tested micro-organisms.

9. Some of the used decontamination solution should be recovered if possible. If a rinsing step is included in the process, some of the rinsing waters should also be recovered. These liquids shall be placed in a tube or a container named "waste", for example.

10. Each panel will then be swabbed over its entire surface with a sterile sampling swab. This operation can be repeated if necessary. Each swab will next be placed in a sterile tube

containing 2 to 10 mL of an appropriate buffer (PBS, sterile water, culture medium…), and then be vortex-mixed to release the micro-organisms. This tube could be labelled “test”.

11. After swabbing, a contact agar plate can be used on each panel to check if there are still remaining micro-organisms on them.

12. The remaining micro-organisms in “waste” and “test” will be enumerated by dilution, culture on nutrient agar and incubation at an appropriate temperature during 5 days (or longer depending on the microorganism) Contact agars will be cultured along with the media used for “waste” and “test”.

13. The plates should be observed regularly (or at least on days 1 and 5), and the CFU obtained will be counted. Remaining micro-organisms on control panels (number N) and on test panels (number N’) will be calculated, taking into account the micro-organisms observed in “waste”, “test”, and on contact agars. The efficacy of the decontamination process will be evaluated by calculating the log (N/N’) value.

14. Performance requirements for decontaminants may be found in AEP-58, VOL II.

F-2-03. Viruses

1. Protocols to test the virucidal activity of a decontamination solution are very similar to those used for bacteria, except for the analytical procedure.

2. Pathogenic viruses can be used for these trials, but their handling requires heavy precautions. That is why it would be preferable to employ non-pathogenic virus strains, such as, for example:

a. Bacteriophages such as MS-2 or “Phi-6”: Although these bacteriophages are not closely related to virus biological warfare agents, they are commonly used in testing scenarios due to their ease of use and the level of knowledge on their characterization.
b. Viruses used in organic farming: baculoviruses, etc.
c. Simulants for DNA enveloped viruses (such as smallpox): fowlpox (particularly animal vaccinal strains), vaccinia virus…
d. Other viruses that could simulate biological warfare agents.

3. Virus suspensions can be prepared ahead of the trials and stored at -80 °C (long term) or -20 °C (short term). Viruses are best preserved in isotonic solutions containing high total protein loads (e.g. 3 % bovine serum albumin or ovalbumin, 10 % foetal calf serum, etc.). Repeated freezing and thawing should be avoided.

F-2-03-01. Liquid test protocol

1. This protocol is designed to test in liquid medium the effectiveness of decontamination solutions in killing viruses.

2. Each candidate decontaminant should be tested at least in duplicate. It can be tested at different concentrations, i.e. for example: 0 % (control of the viability of micro-organisms), 20, 40, and 80 %. For each replicate sample, the decontaminant solution will be placed into a sterile tube, and then distilled water and the suspension of micro-organisms will be added to it. Table F-2 summarizes the volumes needed to obtain different concentrations, for a final volume of 5 mL:

Table F-2 Volumes of decontaminant, distilled water and suspension of micro-organisms for Liquid test

Volume of decontaminant solution (mL)	Volume of the suspension of micro-organisms (mL)	Volume of distilled water (mL)	Concentration of the decontaminant solution (%)
0	1	4	0
1	1	3	20
2	1	2	40
4	1	0	80

3. After that, each tube should be vortex-mixed for about 10 seconds.

4. The decontaminant solution could be tested at different exposure times, for example: 15, 30 and 60 min.

5. After the exposure, the remaining decontaminant must be neutralized by an appropriate method, e.g. by using sodium thiosulfate for oxidizers, or by employing filtration processes to get rid of the decontaminant. Before the test, the effect of the neutralizing method on the viability of micro-organisms should be tested. The chosen method must also have no effect on the host cells on which the viruses are going to be cultured.

6. Next, the remaining number of viral particles will be determined in each sample by an appropriate analytical method (see F-2-03-04).

7. The number (N) of virions in the control tube and the number (N') of remaining virions in the test tubes will be compared, and the efficiency of the decontaminant will be evaluated by calculating the log (N/N') value.

8. Performance requirements should be approximately equivalent to those used for bacteria.

F-2-03-02. Laboratory/Field protocol

1. The candidate decontaminants will here be tested using their intended formulation for operational use and under operational conditions (concentration, temperature, exposure time…).

2. These tests can be made on painted metal coupons or other relevant material panels (e.g. materials commonly found in military equipment or representative of these, etc.). The coupons used should have dimensions ranging from 10 to 100 cm^2.

3. The trials should be made at least in triplicate. For example, to make one test against one micro-organism, 5 material coupons could be used: 2 as control panels, and 3 for the decontamination test.

4. Prior to the trials, the coupons can be cleaned (e.g. with alcohol) and/or autoclaved, provided these treatments do not alter them.

5. The panels will be contaminated by an appropriate method (spraying, deposit, painting, immersion…) to obtain a contamination rate of about 10^{xx} pfu/cm^2 (10^{xx} pfu/m^2). After contamination, the panels will be left to dry for at least 1 h.

6. Test panels will then be decontaminated following the instructions given by the manufacturer. Different exposure times can be tested (e.g. 15, 30 and 60 min).

7. After decontamination, a quenching step can be realized with an appropriate neutralizing method. Quenching can take place at different stages of the protocol (while rinsing the panels, when or after re-suspending the swab, etc.). In any event, it should be checked that the quenching method used is efficient enough, and has no effect on the viability of the tested micro-organisms or on the viability of its host cells.

8. After decontamination, the panels can be rinsed with sterile water, PBS (or another buffer), culture medium or a quenching solution. The rinsing liquid can be recovered together with the used decontamination solution, and placed in a sterile tube. If there is no rinsing step, the used decontamination solution can also be recovered. This tube could be named “waste”, for example. A neutralization step should be done on this tube before analyzing it.

9. Each coupon should be inspected for visible damage or degradation to its surface. Any damage shall be recorded.

10. Each panel will then be swabbed over its entire surface with a sterile sampling swab. This operation can be repeated if necessary. The swab will next be placed in a sterile tube containing 2 to 10 mL of an appropriate buffer or a culture medium, and then be vortex-mixed to release the micro-organisms. This tube could be labelled “test”.

11. The remaining micro-organisms in “waste” and “test” will be enumerated by an appropriate method (see F-2-03-04).

12. Remaining micro-organisms on control panels (number N) and on test panels (number N’) will be calculated, taking into account the micro-organisms observed in “test” and “waste” (if a “waste” tube has been sampled). The efficacy of the decontaminant on material coupons will be evaluated by calculating the log (N/N’) value.

13. Performance requirements for decontaminants should be approximately equivalent to those used for bacteria.

F-2-03-03. Field trial protocol

1. The candidate process of decontamination (i.e. decontamination solution and system) will here be tested in operational conditions (concentration, temperature, exposure time…). It could be tested for example on the frame of an armoured vehicle (or on an object simulating it) on which there are a set of painted metallic panels (or panels made of other significant materials, if pertinent). These panels should have quite large dimensions (at least 100 cm^2 if possible) to give significant enough results.

2. Such trials can only be carried out on non-pathogenic micro-organisms. Micro-organisms employed should also have no effect on the environment. Only Risk Group 1 microorganisms (i.e., those requiring a containment or biosafety level 1) can be used for these trials.

3. Prior to the trials, the coupons can be cleaned (e.g. with alcohol) and/or autoclaved, provided these treatments do not alter them.

4. Panels will be contaminated by an appropriate method (spraying, deposit, painting, immersion…) to obtain a contamination rate of about $10^?$ pfu/cm^2 (10^9 pfu/m^2). After contamination, the panels will be left to dry for at least 1 h.

5. At least 2 coupons should be used as control panels. These coupons will not be decontaminated.

6. After drying, the test panels will be set on the frame of the armoured vehicle (or on the object simulating it). These panels should be positioned all over the frame in 3 different ways: vertical, horizontal and sloping. The position of each coupon should be recorded.

7. The coupons will then be decontaminated with the process tested. Different exposure times of decontamination can be tried (for example 30 and 60 min).

8. After decontamination, a quenching step can be realized with an appropriate neutralizing product. Quenching can take place at different stages of the protocol (while rinsing the panels, when or after re-suspending the swab, etc.). In any event, it should be checked that the quenching method used is efficient enough, and has no effect on the viability of the tested micro-organisms or the viability of its host cells.

9. Some of the used decontamination solution can be recovered. If a rinsing step is included in the process, some of the rinsing waters should also be recovered. These liquids shall be placed in a tube or a container named “waste”, for example. A neutralization step must be done on this tube before analyzing it.

10. Each panel will then be swabbed over its entire surface with a sterile sampling swab, with additional swabs used if the test area exceeds 100cm2. This operation can be repeated if necessary. Each swab will next be placed in a sterile tube containing 2 to 10 mL of an appropriate buffer or a culture medium, and then be vortex-mixed to release the micro-organisms. This tube could be labelled “test”.

11. The remaining micro-organisms in “waste” and “test” will be enumerated by an appropriate method (see F-2-03-04).

12. Remaining micro-organisms on control panels (number N) and on test panels (number N') will be calculated, taking into account the micro-organisms observed in "test" and "waste" (if a "waste" tube has been sampled). The efficacy of the decontamination process will be evaluated by calculating the log (N/N') value.

13. Performance requirements should be approximately equivalent to those used for bacteria.

F-2-03-04. Examples of analytical methods for viruses

1. Here are described analytical methods that can be used to determine the number of remaining viral particles in each of the samples obtained after decontamination (or in control samples).

2. To enumerate virions, a medium containing host cells is required. Viral particles must be able to infect these cells in order to grow. The presence of the virus will be checked by observing the integrity (or the destruction) of the host cells.

3. Residual amounts of decontaminant solution in the samples must be low enough to avoid any possible effect on the remaining virions or on their host cells. If necessary, a quenching step must be done on the samples before analyzing them.

4. For the titration of MS-2 or "Phi-6" bacteriophages, serial dilutions of the samples will be cultured on nutrient agar along with the host cells. Cultures should be maintained for 5 days at an appropriate temperature. After that, the formed plaques will be counted and the number of remaining viral particles in the samples will be calculated (in pfu/mL).

5. For the titration of mammalian viral strains, serial dilutions of the samples will be made in a liquid culture medium containing host cells of the virus; then they will be cultured for 5 days at an appropriate temperature. Dilutions can be made in a 96-well microtitre plate. Then, after 5 days of culture, the integrity of the cells will be checked by observation with a light microscope, and the number of remaining virions will be calculated (in TCID50/mL). Dilutions can otherwise be made in 6-well plates. In that case, after culture, the formed plaques will be counted (using a light microscope) and the number of remaining virions calculated in pfu/mL.

F-2-04. Test report

1. As many details as possible about the trials should be indicated in the test report. For example, the following information should be reported:

a. Details about the decontaminant: name, manufacturer, concentration…,

b. Details about the micro-organisms employed: species, strain, concentration…,

c. Characteristics of the material panels and eventual treatments that could have been applied to them,

d. Experimental conditions: contamination method, contamination rate, drying time of the panels, exposure time of decontamination, neutralization method chosen…,

e. Experimental results: number of remaining micro-organisms in test and control samples, efficacy of the decontamination process expressed by the log (N/N') value…

f. Possible modifications of the protocol,

g. Conclusions of the trials: acceptance of the decontaminant or not, hypothesises and recommendations.

ANNEX G
RADIOLOGICAL EFFICIENCY DECONTAMINATION EVALUATION

G01. Objectives

1. The following Annex outlines protocols for the evaluation of decontamination technologies for radiological contamination. It describes the type and quantity of contaminants that could be expected from a RDD, example of permissible levels of contamination after decontamination for unrestricted release of material (clearance decontamination), and the calculation methodology for evaluating decontamination results.

2. This Annex is to act as a guide to establish laboratory decontamination protocols based on the needs of the individual laboratories. Even if a scenario is not considered in this document, the methodology for the methodology may still be used and adapted for this need.

G02. Objective of Radiological/Nuclear Decontamination

1. Radiological/Nuclear Decontamination's goal is to reduce the hazard to individual using, handling, servicing and/or transporting the contaminated item. As described in the body of document, the hazard from radiological/Nuclear contamination can be separated into two categories, internal hazard and external hazard. Both can be reduced by decontamination, the decrease in hazard maybe different for the same decontamination method. In extreme cases, a method which could reduce the internal hazard to negligible levels may make the future reduction of the external hazard practically impossible, leaving the disposal of the item the only viable option.

2. The above is a result of the concept of fixed and non-fixed contamination. Contamination can be generally an internal and external hazard, but for fixed contamination the internal hazard is reduced to almost negligible levels. The external hazard can be reduced only by the fact that possibility of getting contaminated will be minimized

G03. Radiological/Nuclear (Fallout) material of Interest

1. As stated in the main body of the text radiological material can come in different chemical and physical form as well as a variety of isotopes. Some listed in IAEA-TECDOC-1344 Categorization of radioactive sources are ^{90}Sr, ^{60}Co, ^{137}Cs, ^{192}Ir, ^{170}Tm, ^{169}Yb, ^{75}Se, ^{241}Am(including Am/Be) and ^{252}Cf.

2. The evaluation of decontamination solution may not be feasible for all radiological material. Table 1 lists a suggested list which contains isotopes with a wide range of chemical forms, salt, metal, ceramic and oxide. The table contains suggested short half life isotopes as surrogates

Table G-1 Recommended Isotopes

Isotopes	Half Life (yr)	Chemical Forms	Surrogate Isotopes	Half Life (Days/hours))	Chemical Forms
^{60}Co	5.2	Metal	^{192}Ir	74 d	Metal
^{137}Cs	30.1	CsCl	^{24}Na	15.2 h	$NaI/Na_2CO_3/NaNO_3$
^{90}Sr	28.5	$SrTi0_3$	$^{82}Sr/^{85}Sr$	25/65 d	$SrTiO_3$
$^{241}Am/Be$	433	Oxide	$^{141}Ce/^{143}Ce$	32/1.4 d	Oxide
NF	na	Multiple	^{140}La, ^{152m}Eu	40.3/9.2 h	Oxide, Nitrate

3. The use of radiological material for testing may be limited or not permitted based on regulations. Using non active material has been and is used, but do lead to some difficulties in quantification of the decontamination efficiency.

4. The contamination can be applied as a liquid solution or a dry powdered depending on the conditions that are being reproduced.

5. The efficiency of decontamination depends strongly on the chemical and physical properties of the contaminant. For comparative testing it is therefore inevitable to refer to the same type of contamination.

G04. Contamination Limits for Radiological Contamination

1. STANAG 2473 describes the radiological contamination level acceptable (Thorough Decontamination) to NATO forces for different types of operational times. These contamination levels serve as guidance for commanders in the field for the level of action required when operating in a contaminated environment. The levels in Table 3 are the lowest level that some action is required due to the contamination.

Table G-2 Lowest contamination levels in STANAG 2473.

Mission time	Levels of High-Toxicity alpha emitters Contamination (Bq/cm^2)	Levels for Beta and Low-toxicity alpha emitters (Bq/cm^2)
7 Days	5	50
3 months	0.5	5

2. The contamination levels in Table 3 are generally higher compared to levels required for unrestricted release limits as seen in Table 4.

Table G-3 Example of Unrestricted Release Radiological Contamination Values Canadian Director of Nuclear Safety Limits

Fixed Contaminants		Non-Fixed Contaminants	
Alpha	**Beta / Gamma**	**Alpha**	**Beta / Gamma**
0.5 Bq/cm^2	5.0 Bq/cm^2	0.05 Bq/cm^2	0.5 Bq/cm^2

3. The values in Table 4 are the concentration limits for unrestricted (civilian) use of an area, also known as clearance levels, as outlined e.g. in the Canadian Department of National Defence (DND) Nuclear Safety Orders and Directives (NSODs) and other national regulations. These limits are normally set by the governing or regulatory body of nuclear/radiation safety of particular countries. It is important to note that depending on the location of the contamination item limits will vary.

4. Fixed contaminants are considered adhered to the surface and cannot be removed by swiping the surface. The contamination can be considered fixed after two to three applied decontaminations. Non-fixed contamination is contamination that is considered removable and can be detected using swipe, as described in AEP-49. Clearance decontamination is defined as the level of contamination where deployment, transportation, maintenance, employment, handling and disposal can be done without any restrictions. One may reference other decontamination limits, such as immediate, operational or thorough, based on the objectives of the decontamination procedure. For the purpose of this document clearance and thorough levels as stated above will be used since no values for the other decontamination are available, since they are specific to a particular situation.

5. Guidance for the initial level of contamination for the testing and evaluation of decontamination procedures are based on the values separated in three categories: high, medium and low level as seen in Table 5.

Table G-4 Initial Contamination Levels

	Alpha (Bq/cm^2)	**Beta / Gamma (Bq/cm^2)**
High	30-80	300-800
Medium	3-8	30-80
Low	0.5-2	5-20

6. These mid levels equate to approximately 100, 10 and 2 times the fixed level of contamination for the Alpha and Beta/Gamma material release level as listed in Table 4. The medium mid level equates to approximately the “up to 7 days maximum” contamination limits detailed in STANAG 2473.

G05. Contamination Limits for Nuclear Contamination

1. In cold ware times, the main goal of a nuclear decontamination was to reduce the radiation exposure to be able to carry on the mission. Exposure guidance is given in STANAG 2083 CBRN (EDITION 7) - COMMANDERS' GUIDE ON THE EFFECTS FROM NUCLEAR RADIATION EXPOSURE DURING WAR.

2. Decontamination levels and criteria can be found in FINABEL Report N.32.R, Sub Concept Nuclear decontamination.

3. For thorough decontamination, the following residual dose rates, measured at 10 cm distance, have to be achieved:
0.05 cGy/h (0,5 mSv/h) for vehicles and large equipment
0.01 cGy/h (0.1 mSv/h) for clothing and personal equipment
0.002 cGy/h (0.02 mSv/h) for personnel / skin

4. Many countries have national regulations, these are mainly comparable to the limits given in FINABEL N.32.R

G06. Measurements and Analysis

1. The measurement techniques used is based on the measurements done with the Spectrometer (typically portable High-Purity Germanium (HPGe) detectors or NaI), and/or contamination probe. Results from contamination probes may indicate higher decontamination efficiency than actual one. This is due to the contamination probe being more effective in measuring the contamination on the surface and less sensitive measuring contamination that has migrated into the surface (more sensitive to Beta and Alpha particles). Contamination probes able to discriminate between Gamma, Beta and Alpha are more desirable. Gamma survey meters such as GM tubes are also used due to their availability and ease of use, but they can have limitations when very low levels (close to background levels) are measured.

2. The comparison of the gamma and beta (or alpha) reductions in activity gives an indication of the penetration of the contamination inside the test coupons. Each coupon is measured once after contamination and once after decontamination or subsequent treatment of the coupon. It is important to note the geometry of the detection system (including the test coupon) be kept the same for all measurements. Difference in orientation or distances could significantly affect the results. Keeping the geometry constant is normally achieved by marking position of the placement of the test coupon or using a jig.

3. Analysis using counts from a spectrometer:

$$C_R = (C_i - C_{Nbkg}) \times 2^{(t_i - t_R)/t_{1/2}} - C_{Abkg} \qquad [1]$$

Where C_R = decay corrected measurement at Reference time t_R
C_i = measurement (counts) at time t_i in the Region of Interest (ROI)
C_{Nbkg} = natural background measurement (counts) in the ROI.

t_i = time of measurement in hours
t_R = reference time for all measurements in hours
$t_{1/2}$ = half life of the isotope in hours
C_{Abkg} = measurement (counts) of background (Short half life contribution to the background at time t_R, in the same ROI at the same reference time).

Note: Minimum Counts in the ROI is 100.

4. Analysis using dose rate or cps from a contamination probe or gamma survey meter:

$$C_R = (C_i - C_{Nbkg}) \times 2^{(t_i - t_R)/t_{1/2}}$$

Where C_R = decay corrected measurement at Reference time t_R
C_i = measurement (dose rate or Counts per Second (CPS)) at time t_i
C_{Nbkg} = natural background measurement
t_i = time of measurement in hours
t_R = reference time for all measurements in hours
$t_{1/2}$ = half life of the isotope in hours

G07. Decontamination Efficiency Calculation

1. The decontamination efficiency is determined by measurement before and after the decontamination process, the ratio of activities indicates directly the quality of decontamination. The results can be expressed in three different ways :

1. Percent Decontamination Efficiency

$$D = \frac{C_o - C_t}{C_o} x100$$

Where D = Percent Decontamination Efficiency
C_0 = Average or individual measurement values of initial contamination
C_t = Average or individual measurement values post decontamination

2. Percent Residual

$$R = \frac{C_t}{C_o} x100$$

Where R = Percent Residual
C_0 = Average or individual measurement values of initial contamination
C_t = Average or individual measurement values post decontamination

3. Decontamination Factor

The Decontamination Factor is the ratio between the initial activities divided by the final activity.

$$DF = \frac{C_{initial}}{C_{Decon}}$$

Where $C_{initial}$ is the activity before decontamination and C_{Decon} is the activity after the decontamination step.

In certain conditions a Lower Limit of Detection (LLD) maybe required to be calculated. The principal condition requiring the calculation of a LLD is when the measurement after decontamination cannot be distinguished from the background. The LLD is defined as the lowest activity that can be measured above the background and stated in the report. For this document methodology a 95% confidence level based on a Gaussian distribution when calculating the LLD is considered appropriate.

Where a limit of detection is required the Curie or modified Curie formula should be used, note that Bgd is the count rate and the LLD is expressed as counts

$$LLD = 2.71 + 4.65\sqrt{Bgd}$$

or $LLD = 2.71 + 4.65\sqrt{Bgd + 1.36}$ if Bgd is less than 100 counts

If actual counts or count rate are used for the decontamination experiments then a simple square root of the counts or the square root of the count rate multiplied by the count time can be used as S_{bkg}. If measurements are done in other units, the standard deviation calculation must be calculated based on a series of background measurements (Equation 2).

$$S_{bkg} = \sqrt{\frac{\sum (X_i - \overline{X})^2}{(N-1)}}$$

[2]

Where: Xi are the individual observations.

$\overline{X}$ is the mean of the measurements.

N is the number of measurements.

The LLD should be calculated before the efficiency or calibration calculation.

G08. Operational Significance

1. The operational significance of the evaluation may depend on the conditions that are being reproduced in the laboratory setting. Using non complex shape (small plates) may not represent a complex shape as vehicle. Decontamination results will vary based on a variety of operational conditions.

2. Decontamination of a freshly contaminated item will reduce the hazard, by either fixing the contamination on the object, thus reducing the possibility of internalization, or removing the contamination from the item reducing both the external and internal hazard. Vehicle design may hinder the reduction of external hazard by allowing accumulation into the vehicle i.e. through engine air intake grills or inspection hatches, increasing the external hazard in certain areas.

G09. Procedures for decontamination testing

1. Decontamination testing can vary from laboratory size on small material samples up to technical size on real equipment and vehicles

2. Different contamination types and procedures can be applied

3. Liquid – radionuclides in aqueous solution
   - Immersing in radioactive water (laboratory)
   - Spray contamination (half-technical scale)
   - Simulated rain (technical scale, special facilities like Wehrwissenschaftliches Institut für Schutztechnologien (WIS) in Germany (DEU) or DEP in France (FRA))
   - Soluble particles under influence of humidity

4. Particles – insoluble compounds (e.g. oxides of Lanthanum or Europium, simulated fallout (nuclides fixed on sand of defined grain size)
   - Manual dispersion (“saltshaker” method)
   - blow-off method for fine particles with compressed air
   - simulated fallout deposition (facilities DEP and WIS)

5. The procedure for decontamination testing can be generalized for all types of contamination according to the following **Experimental Flow Chart**

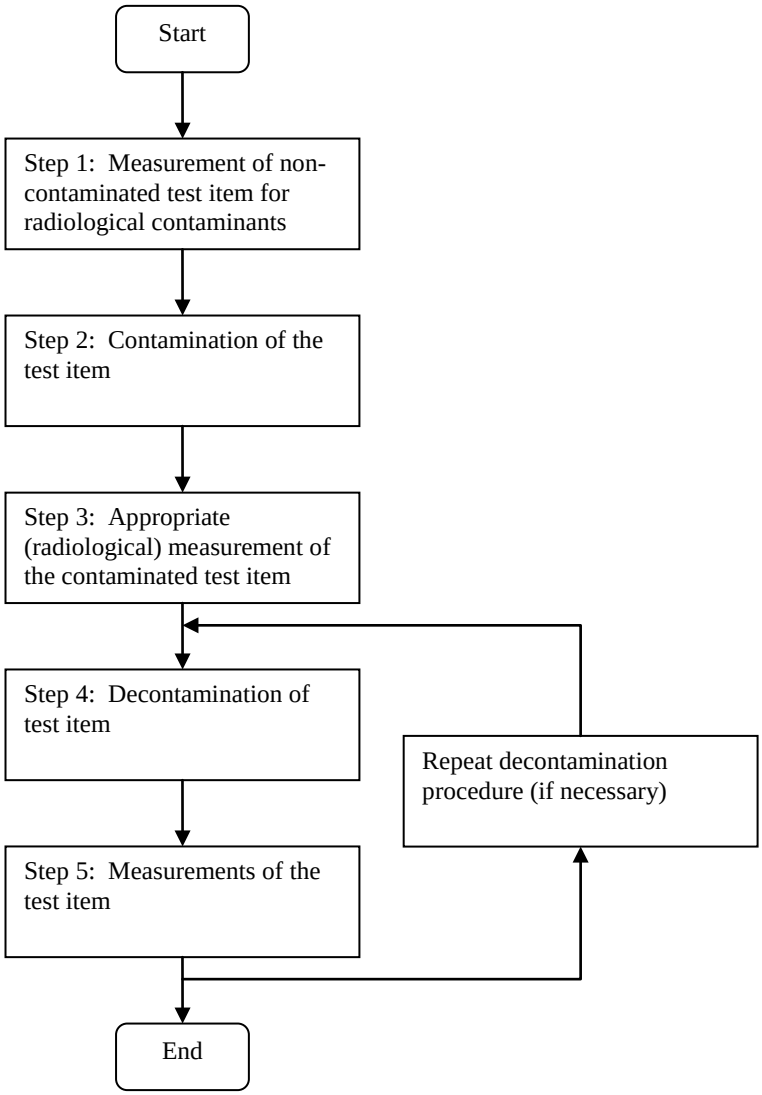

Figure G-1 Radiological Contamination/Decontamination Experimental Flow Chart

6. The decontamination results depend strongly on the type of contamination and the nature of the contaminated surface. For comparative testing it is therefore inevitable to refer to the same type of contamination.

7. Three experimental scales can be applied :

   To examine decontaminants or the decontaminability of specified material surfaces, laboratory scale trials are sufficient. This is mainly done with liquid contaminants on coupons, size 25-100 cm^2.

   For a more realistic approach and the application of different decontamination techniques like foam procedures, high pressure washing or mechanical support, a half-technical experimental scale can be applied.

A test coupon size from 0.2 – 1 m² is recommended. Coupons made of different materials, with different coatings or surface structures can be used.

To simulate the complex structure of real equipment, DEU and FRA have developed a "turret simulator" in form of an irregular pyramid with different angles, surface applications and contamination traps.

These "turrets" proved to be a good substitute for real objects in half technical scale decontamination testing

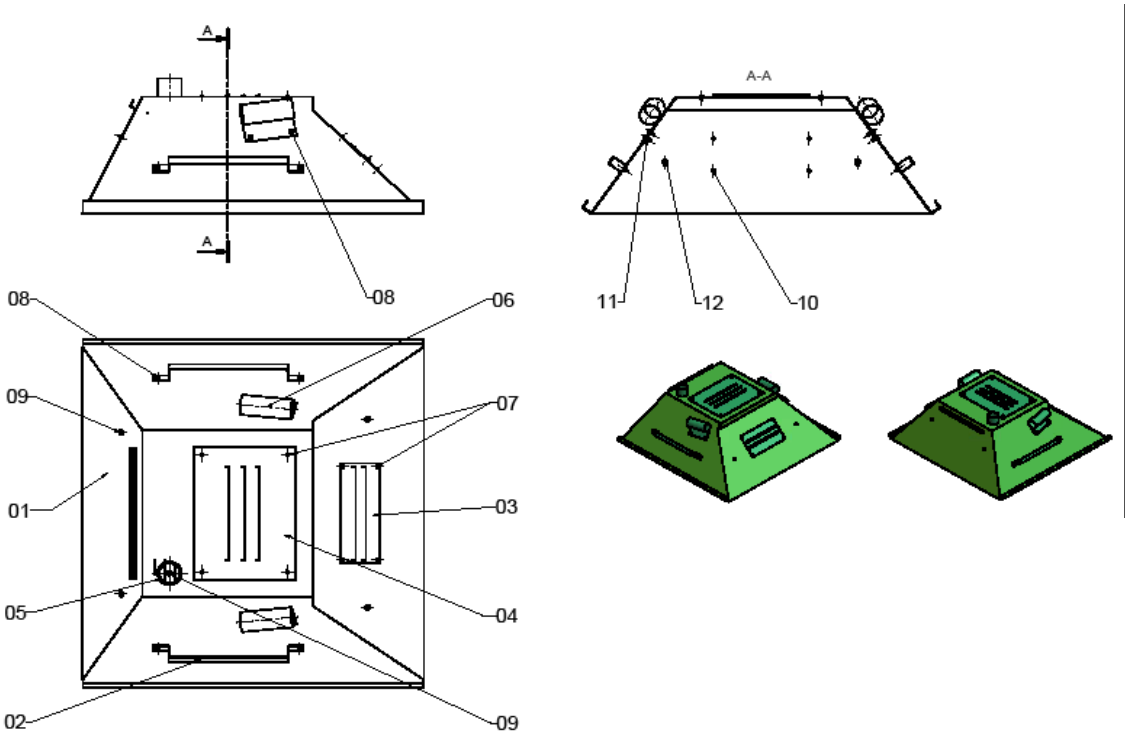

Figure G-2 -Turret Pyramid
Different surface structures (1-12) and applications to simulate real equipment

Full Scale decontamination testing, i.e. contamination of devices up to the size of battle tanks, requires total activities in the dimension of GBq. These can be handled according to radiation safety regulations only in specific technical facilities.

8. For the evaluation of the decontaminability of large equipment (vehicles), only a full scale test will provide all information necessary. Not only the surface contamination can be considered, but also contamination traps and points of accumulation e.g. behind double shieldings, in fissures, not sealed compartments, ventilations grilles etc. These are in many cases not reached by a standard decontamination procedure.

9. To differentiate between surface contamination and not accessible trapped activity, beta-gamma emitters like La-140, simulating a broad spectrum of potential real contaminants, should be used.

10. Measurement devices, that are able to measure beta and gamma radiation in one step, are available. They are applicative to get results for residual contamination on the equipment after decontamination and the gamma dose rate resulting from radioactive material behind the outer shell of the vehicle.

ANNEX H
SUMMARIZED TEMPERATURE AND HUMIDITY CYCLES WORLD WIDE

(AECTP 200 – Environmental Conditions)

Table H-1 Summarized temperature and humidity cycles world wide

Cycle	Meteorological		(1) Storage and Transit	
	Temperature °C	Rel. Humidity %	Temperature °C	Rel. Humidity %
A1	32 to 49	8 to 3	33 to71	-
A2	30 to 44	44 to 14	30 to 63	-
A3	28 to 39	78 to 43	28 to 58	-
[7 days	24	100	24	100
B1 [358 days	23 to 32	88 to 66	23 to 32	88 to 66
B2	26 to 35	100 to 74	30 to 63	74 to 19
B3	31 to 41	88 to 59	33 to 71	80 to 14
CO	-19 to -6	tending to saturation	-21 to -10	tending to saturation
C1	-32 to -21	"	-33 to -25	"
C2	-46 to -37	"	-46 to -37	"
C3	-51	"	-51	"
C4	-57	"	-57	"
M1	29 to 48	67 to 21	30 to 69	64 to 8
M2	25.5 to 35	100 to 53	30 to 63	78 to 13
M3	-34 to -23	tending to saturation	-34 to -23	tending to saturation

LEXICON
PART I - ABBREVIATIONS AND ACRONYMS

The lexicon contains abbreviations and acronyms relevant to AEP-58 and is not meant to be exhaustive. The definitive and more comprehensive list of abbreviations and acronyms is in AAP-15.

Abbreviation/Acronym - Meaning/Definition

ABO - agents of biological origin

AECTP - Allied Environmental Conditions and Test Publications

AEP - Allied Engineering Publication

ATP - Allied Tactical Publication

B – biological

C – chemical

C2ISR - command, control, intelligence, surveillance and reconnaissance

CARC - chemical agent resistant coating

CB – chemical and biological

CBRN - chemical, biological, radiological and nuclear

CBT - computer based training

CFU – colony-forming unit

COLPRO – collective CBRN protection

CPS - Counts per Second

CSG – Challenge Sub-group

DND – Department of National Defence

ETL – Emergency Tolerance Limits

EU – European Union

eV – energy

FRA - France

G – nerve agent

GA - tabun

GB - sarin

GC – Gas Chromatography

GD - soman

DEU - Germany

GF - cyclosarin

HD – sulphur mustard

HMSG – Hazard Management Sub-group

HPGe - High-Purity Germanium detectors

HQ - headquarter

IAEA - International Atomic Energy Agency

IAEA-TECDOC - International Atomic Energy Agency Technical Documents

IATA – International Air Transport Association

ID 5 % - incapacitating dose for 5% of the exposed population

IPE - individual protective equipment

IPOE - Intelligence preparation of the operational environment

IR - infrared

ISO - International Organization for Standardization

ITF - International Task Force

JOA - joint operations area

Kg - kilogramme

LLD – lower limit of detection

MSDS - material safety data sheet

MTBF - mean time between failures

N – nuclear

N/A – not applicable

NSOD – nuclear safety orders and directives

PBS – Phosphate buffered saline

PVC - poly-vinyl-chloride

R – radiological

R & D - research and development

RADIAC - radioactive detection, indication and computation

RDD - radiological dispersal devices

ROI – region of interest

STANAG - NATO standardization agreement

Sv – Sievert

TBM – theatre ballistic missile

TIB - toxic industrial biological

TIC - toxic industrial chemical

TIM – toxic industrial material

TIR - toxic industrial radiological

USA- United States of America

UV – ultraviolet

V – V-series of nerve agents

VX – nerve agent
WEU – Western European Union
WIS - Wehrwissenschaftliches Institut für Schutztechnologien

PART 2 – TERMS AND DEFINITIONS

Notes:

1. The terms and the definitions used within AEP-58 are drawn from AAP-6 '*NATO Glossary of Terms and Definitions*' and AAP-21'*NATO Glossary of CBRN Terms and Definitions*'. The terms found in these glossaries are not repeated here.

2. Bracket indicates the short title of the source when applicable.

Biological decontamination
Biological decontamination is the process of killing (live), destroying (toxins), or removing the agents of biological origin (ABO) to an acceptable level by any product or method.

Compatibility (CBRN)
Ability of a system to be operated, maintained, and resupplied by personnel wearing the full individual protective equipment in climates for which the system is designed and for the time period specified in the system requirements.

Compatibility
The suitability of products, processes or services for use together under specific conditions to fulfil relevant requirements without causing unacceptable interactions. Related terms: commonality; common user item; force interoperability; interchangeability; interoperability; military interoperability; standardization. [ISO-IEC] 04 Oct 2000

Contact Characteristic
The contact curve is defined as the cumulative amount of agent absorbed by skin contact with time. Like the desorption curve it is not a single measurement but a profile in time (a curve rather than a single point).

Contamination survivability (CBRN)
Capability of a system and its crew to withstand a CBRN contaminated environment, including decontamination, without losing the ability to accomplish the assigned mission. Note: The three main principles of CBRN contamination survivability are hardness, decontaminability and compatibility.

Ct-value
"Ct" stands for Concentration x Time**;** The lower the Ct-value, the more effective the toxic agent is
A Ct-value of 10 could mean
Exposure to 10 ppm for 1.0 minute (10 x 1 = 10) or
Exposure to 1.0 ppm for 10 minutes (1 x 10 = 10)

Decontaminability (CBRN)
The ability of a system to be rapidly and effectively decontaminated using standard CBRN decontaminants and procedures available in the field to the point that any remaining

contaminant poses no casualty-producing hazard to unprotected personnel exposed for the duration of the mission.

Decontamination System
Materiel and machinery required to perform a particular type of decontamination operation (e.g. Large Scale System for Thorough Decontamination). This includes the dissemination (application) equipment and any decontaminants, which may be employed in the process.

Desorption Characteristic
Relates to the desorption curve, which is the amount of agent desorbing into the atmosphere just above a (de)contaminated (piece of) equipment as a function of time, assuming a continuous removal of desorbed agent. Note: The curve allows for direct evaluation of residual off-gassing hazards (be it inhalation or eye effects), but needs to be evaluated as a curve and not only at a fixed time. The reason for this is that the shape of the curve will depend on the initial contamination (the residual agent distribution), and this shape will most likely not be a straight line (constant value) and may even have a maximum away from the time origin.

$ECt_{X\%}$
The exposure concentration (grams multiplied by time per volume air or water) to which a population is exposed during a period t and resulting in x percent of the exposed population to exhibit the indicated effect.

$ED_{X\%}$
The administered dose (grams per kilogram bodyweight) resulting in x percent of the exposed population to exhibit the indicated effect.

$ETL_{X\%}$
The toxic load calculated as the integration over time of the exposure concentration raised to a certain power, property of the toxic substance. Note: The toxic load for a given effect can then be calculated from a range of available Ct-values valid for different exposure periods.

Formulation
Procedure for the preparation of a solution; the formula or recipe.

Hardness
The capability of materiel or system to withstand the damaging effects of CBRN contamination and any decontaminants and procedures required to decontaminate it.

Hardening (CBRN)
The design or modification of equipment, structures or materiel to preserve functionality following exposure to chemical, biological or residual radiation hazards by reducing the retention or adsorption of contaminants, increasing their susceptibility to decontamination or allowing their continued employment by personnel wearing the IPE.

Hazard
The presence of an identifiable risk.

Mission-essential functions
Minimum operational tasks that a system is required to perform to accomplish its mission profile.

Operational characteristics
A statement of user requirements.

Radiation dispersal device
An improvised assembly other than nuclear explosive device specifically designed to employ radioactive material by disseminating it to cause damage, fear or injury by the radioactive decay of the material.

Residual hazard
Hazard to personnel due to residual contamination remaining after a decontamination procedure has been completed.

Sensitive Equipment
Mission essential equipment that requires special handling in order to remain functional when being exposed to a decontaminant or decontamination process. Note: AEP-58 refers to small individual equipment such as masks, helmets, electronics, optics, computers, and the interior of equipment and inside platforms as sensitive equipment. (AEP-7)

Shelf Life
Depot, long-term controlled storage.

Stability (decontaminant)
The period after final preparation until the loss of effectiveness of unused decontaminant in batch processes.

Stability (CBRN agent)
The viability of an agent is affected by various environmental factors, including temperature, relative humidity, atmospheric pollution, and sunlight. Note: A quantitative measure of stability is an agent's decay rate (for example, "aerosol decay rate").

Storage (Deployed)
The period after issue of decontaminants from depot, until seals are broken on active components.

Surface Contamination
Particles or liquid, which remain on the surface of materiel or on the human skin.

Surface contamination
Particles, or liquid which remains on the surface of materiel and which can be decontaminated by physical removal as well as chemical neutralization.

Survivability (CBRN)
The capability of a system to avoid, withstand, or operate during and/or after exposure to a CBRN environment (and decontamination process) without losing the ability to accomplish the assigned mission. Note: CBRN survivability is concerned with contamination that includes fallout and initial nuclear weapon effects.

Technical specifications
Specific parameters that the equipment must meet to satisfy the operational characteristics.

Test procedures and evaluation criteria
Test criteria are numerical values against which the performance of the system can be evaluated. Test parameters describe the conditions to which the system is to be evaluated.

Toxic industrial biological (TIB)
Any infectious material in solid, liquid, aerosolised or gaseous form which may be used, or stored for use for industrial, commercial, medical, military or domestic purposes.

Toxic industrial chemical (TIC)
Any toxic compound in solid, liquid, aerosolised or gaseous form which may be used or stored for use for industrial, commercial, medical, military or domestic purposes. Note: To classify as a TIC facility, the chemical has to have LCt_{50} of less than 100,000 mg.min/m^3 in mammals and the production has to be greater than 30 tonnes/year at one facility. TIC could include pesticides, solvents, petrochemicals and radiological materials such as medical and diagnostic isotopes.

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