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13. ABSTRACT *(Maximum 200 words)*

This Test Operations Procedure (TOP) furnishes basic nuclear, biological, and chemical (NBC) contamination survivability testing information to facilitate test planning, conducting, and reporting, and to achieve standardized testing of mission-essential Army materiel. It describes typical facilities, equipment, and procedures used to contaminate the external surfaces of large items of equipment, to decontaminate the items, to sample for contamination remaining on the items' exterior surfaces, to assess the resulting degradation/damage to the items, and to assess the item/operator/NBC protective gear compatibility. This TOP is intended primarily for testing the survivability of externally contaminated large items of equipment such as combat vehicles, vans, shelters, and large packages of materiel that are decontaminated at the unit/support level, using power-driven decontaminating apparatus. This TOP was prepared in response to the requirements prescribed by Army Regulation (AR) 70-75.

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TEST OPERATIONS PROCEDURE

*Test Operations Procedure (TOP) 8-2-510 17 April 1998
AD No.

NBC CONTAMINATION SURVIVABILITY, LARGE ITEM EXTERIORS

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1. SCOPE.

1.1 Purpose.

a. Nuclear, biological, and chemical (NBC) contamination survivability is the capability of a system and its operators to withstand an NBC contaminated environment, including decontamination, without losing the ability to accomplish the assigned mission. Characteristics of NBC contamination survivability are decontaminability, hardness, and compatibility. To survive NBC contamination, materiel must meet criteria for all three. Agent must be used to measure decontaminability and hardness. Measuring hardness against decontamination agents can be accommodated without use of chemical agents. NBC contamination survivability should be monitored throughout the materiel acquisition cycle, and evaluated and assessed during development and operational testing.

b. This test operations procedure (TOP) provides basic information to facilitate planning, conducting, and reporting, and to standardize NBC survivability testing of military materiel. It is designed to provide results to demonstrate that large items of mission-essential equipment have met the provisions of Army Regulation (AR) 70-75[a*] as implemented by Quadripartite Standardization Agreement (QSTAG 747) 747, edition 1[1] (included as Appendix B of this TOP). It describes typical facilities, equipment, and procedures used to contaminate equipment, sample for contamination density, decontaminate, sample for residual contamination, determine degradation of mission-essential functions resulting from the contamination/decontamination procedures, and analyze crew/test item compatibility. Neutron-induced gamma activity (NIGA) is not addressed in the TOP. Information on NIGA can be obtained from other sources.

1.2 Limitations.

a. This TOP provides standard procedures for testing the contamination survivability of externally contaminated large items of equipment such as combat vehicles, vans, shelters, and large items of packaged materiel that are decontaminated at the unit/support level. It does not cover testing of small items of equipment intended to be decontaminated by the individual soldier using decontamination kits or by two- or three-man decontamination teams operating hand-held, portable decontamination equipment. Testing small items of equipment is described in TOP 8-2-111, NBC Contamination Survivability, Small Items of Equipment[b]. Also, this TOP does not cover testing of the interior spaces of large items of equipment, which will be described in another TOP to be published.

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* Reference letters/numbers correspond to letters and numbers in Appendix D. Many of the referenced documents apply to requirements of United States laws and regulations. Other nations should use their own laws and regulations.

b. The NBC contamination survivability criteria and implementation of the procedures of this TOP are not related to the safety criteria of AR 385-61[2] and Department of the Army Pamphlet (DA PAM) 385-61[3] or other local regulations governing the safety, handling, storage, and disposition of chemically-contaminated equipment.

c. Nuclear contamination survivability testing of equipment and systems, as specified in the NBC contamination survivability criteria, includes neutron-induced activity and activity resulting from fallout of radioactive dust and debris. When determining the nuclear contamination survivability of an item, the contribution from both sources must be considered. Induced radiation cannot be removed or reduced by present NBC field decontamination materials and procedures, and induced activity hazard testing requires different facilities, instruments, and safety considerations. Therefore, the procedures for nuclear decontamination in this TOP pertain only to removal of simulated nuclear fallout.

1.3 Method of Evaluation.

The following procedures must be used to evaluate the ability of the item tested to meet the criteria for decontaminability, hardness, and compatibility.

a. Decontaminability.

(1) Vapor Hazard. The effective concentration of agent vapor desorbed over time is C_e (see Paragraph 4.1.6.2.e). The mission time provided by the user is t. Then $C_e t = k$, which should be compared with the appropriate concentration value in Table 1 of Reference 1 (included in Appendix B of this TOP).

(2) Contact Hazard. The mass collected by the contact samplers should be adjusted for the average area of human contact with the item. This value should be compared with the appropriate mass value in Table 1 of Reference 1 (included in Appendix B of this TOP).

b. Hardness.

(1) Obtain the mission-essential performance characteristics from the material developer (i.e., voltage output, airflow, pressure, etc.).

(2) Measure these parameters on the as-received item.

(3) Perform the contamination/decontamination cycles. Measure the same parameters after each cycle.

(4) Compare pre- and post-contamination/decontamination measurements to obtain the percent degradation (if any).

c. Compatibility.

(1) Obtain the mission-essential soldier tasks from the user.

(2) Perform these tasks (timed) in the standard garment.

(3) Perform these tasks (timed) in mission-oriented protective posture level 4 (MOPP4).

(4) Compare the times and effectiveness of the operator(s).

1.4 Definitions.

Unique terms are defined in Reference 1 (see Appendix B of this TOP).

2. FACILITIES AND INSTRUMENTATION.

Facilities, instrumentation, and safety procedures used for chemical, biological, and nuclear survivability testing are strictly controlled. The principle controlling regulations are cited below. Additional discussion and requirements for facilities and instrumentation are included in the test procedures of Paragraphs 4.1 through 4.4.

2.1 Facilities.

Item	Requirement
Chemical laboratory and chemical agent storage facility.	Constructed to ensure safe and secure storage, handling, analysis, and decontamination of chemical agents used for research, development, test, and evaluation (RDT&E) quantities of chemical agents. The chemical agent laboratory, instruments, and personnel assignments must meet all requirements of AR 50-6[4], AR 190-59[5], and the safety requirements of reference 2 and Army Materiel Command Regulation (AMCR) 385-100[6].

Item	Requirement
Chemical agent test facility (chemical agent test chamber).	To house the test item during agent contamination, decontamination, and sampling. The chamber should have sufficient volume to allow free air circulation around the test item. Must be equipped and approved for work with chemical agents. All exhaust air must be filtered; equipment, interior surfaces, tools, and waste must be easily decontaminated. No agent may be released to the environment. Ability to control temperature, relative humidity (RH), and wind speed is required. The facility must be designed to ensure safe and secure storage, transfer, handling, challenge, and disposal of chemical agents, decontaminating solutions, and solvents. The toxic agent test facility and personnel screening must meet all requirements of References 4 and 5 and the safety requirements of References 2, 3, and 6.
Standard power-driven decontaminating apparatus.	To decontaminate the test item as part of the test procedure. To decontaminate the toxic test facilities after test completion. To stand by for emergency decontamination.
Fluorescent particle (FP) and biological assay laboratories.	Required to store and prepare test quantities of biological and residual nuclear contamination simulant materials, to charge disseminating devices, to prepare samplers, and to analyze all biological agent simulant and nuclear simulant (FP) materials.
Chambers for biological and residual nuclear simulant testing.	Equipped with an air intake and an exhaust system which exhausts through high efficiency particulate filters (capable of retaining 99.7 percent of particles 0.3 μm or greater in diameter) into an exhaust system. The chamber should have sufficient volume to allow free air circulation around the test item.
Personnel change room and shower facility.	To allow test personnel to shower and change into clean test clothing before and after assay of samples, and to reduce cross-contamination and contamination of facilities and non-test personnel.

Item	Requirement
Test range or appropriate operational test facility.	To allow the test item to be operated and to perform all mission-essential functions and tasks that are required to accomplish a typical mission profile. This includes tasks such as communications, aiming and tracking targets, firing weapons, using optical instruments, operating controls and switches, reading instruments, resupply, and decontamination. Must allow observation and measurement of any degradation of test item mission-essential functions attributable either to the contamination/decontamination procedures or the test item operators having to wear NBC protective gear.

2.2 Instrumentation.

Measuring Devices	Permissible Error of Measurement
Air temperature	±0.5°C
Relative humidity (RH)	±5 %
Wind speed	±0.1 m/sec
Still color camera	Adequate to document typical test procedures, details of contamination techniques, and any discrepancies from planned procedures necessitated by operational conditions.
Television camera, motion picture camera, and/or recorder	Adequate to monitor the test chamber or test range in real-time and to document test events and procedures.

2.2.1 Chemical Test Instrumentation.

Measuring Devices	Permissible Error of Measurement
Sampling chemical agent vapor off-gassing from contaminated surfaces [bubblers, miniature automatic continuous air monitoring system (MINICAMS®), solid sorbent tubes, or equivalent] with sampling efficiency >95 percent.	Flow rate in L/min, ±5 percent.
Chemical agent off-gassing (agent vapor sampling basket).	Sized as required to cover up to 1000±10 cm^2 area of the test item. Used as an airtight agent vapor accumulation chamber. See Paragraph 4.1.5.8.a for sizes and shapes. Must be made with a flexible wire frame, covered with appropriate low-absorbency plastic material (e.g., metallic-coated) to fit over curved surfaces. Must have a volume of approximately 10 liters, calculable or measurable to ±0.5 liters. The inlet must either have an in-line charcoal filter or be supplied with clean air.
Contamination density and droplet size (Printflex® cards, Kromecoat® cards, filter papers, or equivalent).	Contamination density, in g/m^2, ±10 percent; droplet size diameter in mm, ±10 percent.
Agent concentration in samples (spectrophotometer, automated or hand-injected gas-liquid chromatograph, or equivalent).	Agent/sample in mg, ±8 percent. (In automated mode. Better precision is achievable at additional cost and time).
Measuring and counting spot size instrument (Hamamatsu Image Analyzer™, Quantimet™, or equivalent).	Droplet stain size in mm, ±10 percent; droplet stain number by size, ±10 percent.

Measuring Devices	Permissible Error of Measurement
Chemical contact hazard samplers (silicone rubber samplers or equivalent). The silicone rubber that has been used is 1 mm thick, translucent, unfilled, poly (dimethylsiloxane) with a Durometer reading of 60[c]. The silicone rubber should be rinsed with water, then dried for 24 hours at 85°C. Circular disks of this material, 3.64 cm in diameter (area of 25 cm^2) were used as samplers.	Agent extraction efficiency from sampler in µg/sample, ±10 percent.
Applying chemical agent contamination to the test item.	Contamination density, in g/m^2, ±10 percent; droplet size, within range specified for the agent when using a syringe as the disseminator and best effort using an agent disseminator such as a spray nozzle.
Monitoring for agent within the toxic test chamber and safety monitoring of personnel in the toxic test facility. MINICAMS®, real-time monitor (RTM), miniature infrared analyzer (MIRAN®), automatic continuous air monitoring system (ACAMS), or their equivalent, may be used.	Near real-time. All instruments have differing sensitivities. The available instruments with the best sensitivity shall be used.

2.2.2 Biological Test Instrumentation.

Measuring Devices	Permissible Error of Measurement
Applying biological agent simulant contamination to the test item (Collison atomizer or equivalent).	Air contamination of $1\pm0.5x10^6$ colony forming units (CFU)/L of air.
Swab sampling of the test item (calcium alginate swabs, test tubes, and diluent).	Swab surface sampling efficiency in CFU/sample, ±10 percent.
Assay of biological simulants (microscopes, automatic colony counters, etc.).	Number of CFU/sample, ±10 percent.

2.2.3 Radiological Test Instrumentation.

Measuring Devices	Permissible Error of Measurement
Dissemination of fluorescent particles (FP).	Air contamination of $1\pm0.5x10^6$ particles/L of air.
Sampling FP surface contamination (Microtiter® plate-sealing tape, or equivalent).	>95 percent sampling efficiency.
Sampling airborne FP contamination (membrane filter samplers or equivalent).	>95 percent sampling efficiency.
Counting FP samples.	Number of FP particles/sample, ±5 percent.

2.2.4 NBC Compatibility and Hardness Test Instrumentation.

Measuring Devices	Permissible Error of Measurement
Measuring the differences in soldier tasks during operation of the test item while in (a) battledress uniform, and (b) NBC protective clothing. Devices for time-and-motion measurements will be standard items, but test-specific devices may also be required.	Precision and accuracy requirements must be compatible with the nature of the test item and function being studied, but must allow the detection of 15 percent degradation in the item/operator mission-essential performance in five trials or less.
Measuring the test item mission-essential performance characteristics before and after each of five nuclear, biological, or chemical contamination/decontamination cycles.	Precision and accuracy requirements must be compatible with the nature of the test item and type of function, but must allow for the detection of 20 percent degradation in the mission-essential performance characteristic after completion of the five contamination/decontamination cycles.

3. REQUIRED TEST CONDITIONS.

NBC contamination survivability testing requires the handling and use of chemical agents. Such testing is strictly controlled by Army Materiel Command (AMC) regulations. The procedures described in this TOP have been safely used by trained operators for many years. They are intended to provide general procedures only and should not be construed as regulatory in nature. Throughout testing, primary emphasis must be on operator and test safety, but the importance of technical quality, completeness of test data, and conformance with specified test and operating procedures cannot be overemphasized. Each NBC contamination survivability test plan must be reviewed for technical accuracy and conformance to regulations, safety procedures, and standing operating procedures (SOPs) applicable to the specific item and tests being conducted.

3.1 Pretest Preparation.

a. Review published test records, procedures, and the case files of tests of similar items to identify potential problem areas. Consult applicable safety and surety regulations to ensure compliance of all test procedures. Review all SOPs and procedures to be used for applicability, adequacy, and completeness.

b. Review the requirements documents, the operational mode summary/ mission profile (OMS/MP), and failure definition/scoring criteria (FD/SC). Use the independent evaluation plan (IEP) or the independent assessment plan (IAP) to determine the overall test structure, the data required, criteria, and analysis to be used. List the mission-essential performance characteristics and the mission-essential soldier tasks specified by the materiel developer and the combat developer respectively. These will be used to measure degradation in performance caused by NBC contamination and decontamination and by the need for the operator to wear the NBC protective ensemble. Identify the units of measurement and the accuracy and precision required for each parameter measured. Resolve all problems concerning measurable performance and degradation.

c. Review, coordinate with the assigned evaluator and assessor, and determine a realistic test item sample size. The sample size may be determined by test item availability, cost, or other factors and be less than optimum. If sample size is less than optimum, devise a testing scheme to optimize test item utilization and required data output.

d. Examine the test item design and the materials of construction. Compare them with the NBC survivability handbook[d] material lists and perform an analysis based on previous test experience and technical information from the materials' data base concerning their ability to survive exposure to contamination, decontaminants, and the decontamination process. Note any areas where agent could pool or seep, such as cracks, crevices, hinges, joints, countersunk screw heads or other difficult to decontaminate features. Although very difficult to accomplish, ensure that any identifiable vulnerabilities or questionable design or materials are adequately tested. If the steps above reveal any aspects of design or identify material that appears to make test failure probable, testing of the suspect design or material should be performed early in the test cycle. Preliminary results can often be determined from a pilot study and analysis of the collected information. However, test success can only be confirmed by using chemical agents.

e. Select and identify areas of the test item to be contaminated, decontaminated, and sampled for residual contamination. Identify areas that must be handled or touched by the operators. Ensure that the areas selected are typical and representative of the total test item surface and materials of construction and that they are areas likely to be contaminated and present an operator risk in an NBC environment.

3.2 Environmental Documentation.

An environmental assessment must be on file covering the storage, use, and disposal of the simulants, hazardous and contaminated materials, and agents used in NBC contamination survivability testing. The assessment must fully address the potential environmental impact of the specific survivability testing being planned. The detailed test plan (DTP) must cite the

environmental assessment (EA) and/or a record of environmental consideration (REC) that cites the EA and the appropriate categorical exclusion. The REC must be approved before testing begins. If the planned survivability testing is not adequately addressed in the existing environmental assessment, an environmental assessment specifically addressing the survivability testing to be conducted must be prepared, as required by the National Environmental Policy Act (NEPA[e]) and AR 200-2[f].

3.3 Test Controls and Limitations.

Controls and limitations applicable to a specific subtest are presented in Paragraph 4 as part of the procedure to which they apply.

a. A quality control plan should be prepared for each test program to ensure that variables are controlled and that appropriate records are kept throughout the duration of testing. Test variables include purity and stability of agents and simulants used, purity and stability of decontaminants and decontamination solutions, calibration and maintenance of instrumentation and disseminators, accuracy and precision of the laboratory analysis, and quality and uniformity of all test samples.

b. The condition of the test item at the time of testing is an important test variable. Unless receipt inspection was accomplished as part of a subtest completed before NBC contamination survivability testing, the test item should be inspected in accordance with (IAW) TOP 8-2-500[7]. Inspection data, certificates of compliance, or similar documentation, should be reviewed to ensure that exterior surfaces, finishes, and packaging meet specifications. Generally, the item should be tested in "as-received" condition, matching its condition when issued to troops in the theater of operations as closely as possible. NBC contamination survivability testing may be required periodically throughout the equipment life cycle if the effect of normal wear is a major factor in survivability.

c. Available robotics and automatic devices should be used whenever possible in test chamber operations to minimize exposure of test personnel to chemical agents.

d. Testing must always be conducted IAW approved test documentation, such as technical manuals, field manuals, equipment operating instructions, SOPs, the approved test planning directive, IEP/IAP, and the DTP. Deviations from test documentation will be put in writing and approved by the appropriate authority.

4. TEST PROCEDURES.

4.1 Chemical Contamination Survivability.

4.1.1 Objectives.

a. Decontaminability. Determine the chemical agent vapor and percutaneous hazards, including eye effects, associated with troop use of equipment that has been contaminated with chemical agent and decontaminated using standard and/or item-specific decontamination procedures.

b. Hardness. Determine the degree of performance degradation in mission-essential functions of military materiel after chemical agent contamination and decontamination by standard and/or test item-specific procedures.

c. Compatibility. Determine the degree of degradation in mission-essential soldier tasks as a result of operating a piece of equipment in MOPP4. See Paragraph 4.4 for details.

4.1.2 Criteria/Conditions.

4.1.2.1 Criteria.

a. Mission-essential equipment shall be hardened to ensure that exposure to five contamination/decontamination cycles does not degrade the operational mission-essential performance of the equipment more than 20 percent (or that specified by the combat developer) measured over a 30-day period. The five-cycle requirement refers to a cumulative total of five exposures to one or more contaminants (nuclear, biological, or chemical) and the associated decontamination processes.

b. The exterior surfaces of materiel developed to perform mission-essential functions shall be designed so that NBC contamination remaining on, or desorbed from, the surface following decontamination shall not result in more than a negligible risk to unprotected individuals working inside, on, or 1 meter from the item. The following NBC contamination survivability test conditions (Paragraph 4.1.2.2) apply.

4.1.2.2 Conditions.

a. General Conditions.

(1) Exterior surfaces initially are uniformly contaminated to a contamination density of 10 g/m^2 with 5- to 70-mg droplets of thickened soman (TGD), or 1- to 2-mg droplets of

unthickened distilled mustard (HD) or VX. The purity of the chemical agents used must be known and recorded as test data, and the quantity applied must be adjusted to achieve the required pure agent contamination density of 10 g/m^2.

(2) Decontamination begins 1 hour after contamination, using standard field and/or item-specific decontaminants, equipment, and procedures. The decontamination process, excluding monitoring, should last no longer than 75 minutes.

(3) The item surface temperature is 30°C and exterior wind speed is no greater than 1 m/sec.

(4) Hazard levels will be calculated assuming an exposure time based on the mission profile specified for the item by the combat developer, not to exceed 12 hours.

b. Detailed Conditions. Detailed conditions for chemical agent contamination survivability testing are given below.

(1) Chamber temperature and relative humidity (RH): 30±5°C and RH of 40±10 percent or as specified in the IEP or IAP.

(2) Chamber air circulation over the test item: <1 m/sec.

(3) Chamber pressure: negative to atmosphere.

(4) Agent contamination density: 10±1 g/m^2.

(5) Contamination drop size: (a) VX and HD: mass median diameter (MMD) 1.4±0.16 mm and (b) thickened soman (GD): MMD 3.5±1.5 mm.

(6) Time from sample collection to analysis: <7 days.

(7) Time from first test item hardness contamination to last hardness data collection: 30 days.

4.1.3 Controls and Limitations. The controls and limitations for chemical agent contamination survivability testing are:

a. Surface of the Test Item:

(1) Paint type, specifications, and application must comply with the military standards for the item. If the item requires repainting, all old paint must be removed to ensure a standard thickness and application of paint.

(2) Surface areas selected for sampling must be representative of the surface materials, texture, paint, and areas where the user will have direct contact.

(3) Before each trial, inspect and sample (vapor and contact) the surfaces of the test item for background contamination. All residual decontaminant and other foreign substances that could interfere with sample analysis must be removed before testing.

b. Sampler (Vapor and Contact) and Analysis Control Data. These will include:

(1) Nonoperated sampler control (a sampler taken into the room surrounding the test chamber but not aspirated).

(2) Operated sampler control (a sampler taken into the room surrounding the test chamber and aspirated, but not exposed to agent).

(3) Standard analytical controls (standard samples of known concentration, interspersed among the unknown samples, generally at a ratio of one control for each 10 unknown samples). The chemical analysis procedure shall be conducted using an appropriate number of standards, blanks, and analytical controls whose current concentrations are the same as when prepared, to ensure the reliability of the analytical procedure and to document the precision obtained with each batch of test samples. The standards need not be at equal concentration intervals; rather, they should be spaced closer together near the low concentration end of the calibration curve.

4.1.4 Data Required. Report the following data in the units indicated. Record the data in the smallest increments that the instrumentation/procedure is designed to achieve and be easily read.

a. Test chamber/hood: temperature --°C, RH -- percent, wind speed (airflow) -- m/sec.

b. Agent: name and control number, purity -- percent, viscosity after adding thickener (if thickened) -- centistokes (cSt), age since thickened (if thickened), quantity of dye and thickener (if thickened) -- g/L, and quantity of agent dispensed -- grams.

c. Quantity of agent dispensed -- grams.

d. Agent contamination density -- g/m^2.

e. Agent droplet diameter -- mm.

f. Results of each post-decontamination agent vapor and contact sample (collected during the 12-hour sampling period) -- µg/sample.

g. Results of sampling and analysis controls and standards.

h. Sample history with elapsed time to analysis -- days.

i. Contamination, weathering, decontamination, and sampling times -- minutes.

j. Names and titles of principal test participants.

k. Description of decontamination solutions (i.e., formulation, active ingredients, and age), methods, equipment, and item-specific procedures used.

l. Description of test item exterior surface condition (pretest), including construction materials, paint type, paint thickness (number of coats), paint condition, and surface cleanliness (mud, grease, and other), with photographs.

m. Description and photographs of test item joints, cracks, crevices, and other features that could allow contaminants to enter and may be difficult to decontaminate.

n. Pretest (baseline) and posttest (30 days after the first contamination) mission-essential functional performance data, recorded to the highest level of accuracy and precision that is commensurate with the parameter being measured.

o. A system safety risk assessment of test findings IAW guidance in Military Standard (MIL-STD)-882B[g] (also see TOP 1-1-060[h]).

p. The stain size on the surface caused by the agent drops (if safety procedures permit, and if these data are desired).

q. A description of the use concept requiring the contact sampling times specified [Paragraph 4.1.5.8.b (3)].

4.1.5 Methods and Procedures. The use of the actual test item is the most reliable and realistic method for assessing all aspects of the item's decontaminability. These aspects include assessing for agent trapped in cracks, in crevices, between components, in angles, and in odd shapes not

easily decontaminable, and evaluating all of the item's textures, and geometry. However, it is not always feasible and/or cost effective to use the actual item to determine decontaminability. Proper scaling techniques must be applied if the whole item is not contaminated. The data requirements, scaled down test methods, and data analysis for the actual item and component testing are essentially the same and may be the only source of data. If the small section or component method is selected for testing all or a portion of a large item, follow the procedures in Reference b. Actual item testing is the preferred method and should be used when feasible and cost effective. The test methods and procedures that follow are for the actual item of equipment.

4.1.5.1 Test Location. The test will be conducted inside a toxic test facility (test chamber) approved for use with chemical agents.

4.1.5.2 Agents. Agents to be used are listed below.

a. Neat VX with a purity greater than 85 percent. The agent may be dyed with approximately 0.5 percent (weight/volume) of a suitable dye.

b. Neat GD with a purity greater than 85 percent and thickened with 5 percent (weight/volume) of Rohm and Haas Acryloid™ K125 poly(methyl methacrylate), lot no. 3-6326. This should provide thickened agent with a viscosity of 2300 cSt at 25°C[j]. Batch-to-batch variability in viscosity can be greater than 10 percent. Complete solution of the polymer in GD is slow; therefore, mixing should continue until the measured viscosity is constant. The agent may be dyed with approximately 0.5 percent (weight/volume) of a suitable dye.

c. Neat HD with a purity greater than 85 percent. The agent may be dyed with approximately 0.5 percent (weight/volume) of a suitable dye.

4.1.5.3 Receipt Inspection and Functional Performance.

a. Before testing, perform a receipt inspection on the test item(s) (see Paragraph 3.3.b). Inspect for shipping damage, completeness of assembly, required accessories, and necessary manuals, logbooks, etc. Document any missing components, damage, or other discrepancies noted.

b. Inspect the surfaces for foreign materials normally not present on the item (dust, mud, grease, or marking). Remove foreign materials by brushing, vacuum cleaning, or washing with soapy water and sponge. Record the surface condition, surface cleanliness, corrosion, materials of construction, variance from standard painting, and paint condition.

c. Operate the test item according to the operator's manual. Measure and record mission-essential functional performance characteristics identified by the combat developer. Based on the selected functional performance characteristics, each functional performance characteristic should be classified as either a functional performance attribute (go, no-go) or as a functional

performance variable measured over a continuous range of values. Measure each parameter at least twice, depending on the inherent difficulty of reproducing a precise value, and record to the smallest significant units of measure. Do not proceed with testing if any damage, surface condition, or a mission-essential functional performance characteristic falls outside developer specifications.

d. "Mockups" may be used on some tests in lieu of expensive or nonexpendable test items. The mockups may be specially fabricated to simulate the test item or may be the actual test item with expensive optical, electronic, or other internal components removed. The mockups should be furnished and/or approved by the materiel developer. Carefully analyze and document the similarities and differences between the mockup and the test item it simulates.

4.1.5.4 Test Preparation.

a. Use qualified and trained operators, standard equipment (the same type of equipment that would be used by troops for that test item), and standard decontamination procedures as specified in Field Manual (FM) 3-5[8] or the item-specific technical manual.

b. Examine each test item and select the areas to be contaminated with agent and then sampled. Before each trial, inspect and sample the surfaces of the test item. All residual decontaminant and other foreign substances that could interfere with sample analysis must be removed before testing. Selection of the number, location, and shape of the areas to be tested will depend primarily on the OMS/MP. Other considerations include test item size, geometry, materials of construction, paint, surface texture, and presence of joints and crevices. Crew assignments, the locations most likely to contribute to crew vapor and contact hazard, and any areas that might allow contaminating agents and decontaminating solutions to seep into and degrade delicate or vulnerable equipment are primary considerations. Select an appropriate number of such areas (minimum of three) to be contaminated and sampled. The number of areas selected should be supported by statistical analysis to provide quality data. Each area should be approximately 1000 cm^2 and representative of the test item's surfaces and vulnerable areas. Photograph and describe each test area selected. Prepare a line drawing, sketch, or photograph of each test area, showing the locations designated for sampling. Vapor sampling will be performed with the aid of a sampling basket (Paragraph 4.1.5.8.a). Do not place any marks on the item test areas to be sampled.

c. Before testing begins, rehearsals should be held to familiarize test crews with the functioning of the test item, test procedures, and data requirements. Crews should practice, using simulants, until agent-dispensing, decontamination, and sampling become reproducible and routine. The test items to be used on the actual test should not be used on rehearsals with simulants. It is recommended that one or more "dry-runs" be performed to give operators an opportunity to demonstrate, standardize, and confirm operational procedures. An operational

readiness inspection (ORI) will be performed and the data evaluated before testing begins.

d. Place the test item in the test chamber and bring the chamber to the environmental conditions specified for the test. Condition the test item until it has equilibrated at 30±5°C. Temperature and RH should be recorded continuously throughout the test.

e. Before agent contamination, background swab and vapor samples should be taken from or near areas designated for contamination testing. The sampling and analysis must be tailored to detect materials that could interfere with the chemical analysis for the agent being used.

f. Place appropriate sampling cards on or adjacent to the test item when droplet sizing and contamination density assessments are required. Place the cards in an area that will be representative of the surface that will be contaminated IAW the OMS/MP.

g. Agent contamination procedures may result in undesirable contamination of certain areas of the test item, chamber floor, instrumentation, etc. The use of a protective pattern (a cover with a 1 square-meter hole in it) cut to the dimensions of the contamination area(s) and easily-removable covers for the floor and instrumentation are recommended to minimize undesirable background contamination.

4.1.5.5 Test Chamber Operation. The test chamber will be operated using the procedures, controls, and SOPs used to approve the chamber and/or those approved for the agent in use. Some general technical data requirements for the test chamber are presented below.

a. The test chamber environmental conditions should be computer-monitored and data should be recorded at least every 15 minutes. The environmental conditions include air temperature, RH, wind speed, test item surface temperature, and pressure (chamber vs. atmospheric).

b. Real-time safety sampling for agent vapor concentration will be performed at a minimum of two locations within the test chamber, with the readout displayed visually and recorded. Instruments used must be calibrated for the agent used and may include miniature infrared analyzer (MIRAN®), miniature automatic continuous air monitoring system (MINICAMS®), automatic continuous air monitoring system (ACAMS), or their equivalents.

c. Real-time safety sampling will be performed in spaces occupied by unprotected individuals. Instruments must be matched to the agent used and may include M8 alarm, real-time monitor (RTM), MIRAN®, ACAMS, MINICAMS®, or their equivalents.

d. The test chamber exhaust system will be activated before the start of agent dissemination and will operate at the maximum rate that will allow the chamber environmental

conditions to remain within the test limits. The purpose is to reduce the chamber agent vapor concentration to the lowest possible level.

4.1.5.6 Agent Application.

a. Contaminate the selected areas of the test item with agent of known purity and viscosity. Apply the agent with a suitable dissemination device that has been calibrated with material of similar physical properties and operated at the flow rate and pressure to achieve the drop size and contamination density specified in the DTP. Avoid contaminating areas of the test item beyond the areas selected for sampling.

b. Immediately after contamination, all agent on the floor or on areas not required for test data should be immediately decontaminated. Be careful not to adversely affect instrumentation and data collection. Remove the particle size and contamination density samplers; decontaminate the agent disseminators, being careful of the agent disseminators and other support equipment. Place the contamination density samplers in a jar with the appropriate type and quantity of solvent, seal tightly, label, and transport to the chemical laboratory for analysis. Place the particle-size sampling cards in a carrying tray and, depending on the type of card and agent used, either process immediately or allow the predetermined time for the drops to spread. Count and size with a Hamamatsu Image Analyzer™, or with equivalent instruments.

NOTE: To prevent excessive drop overlap when counting and sizing drops, it may be necessary to adjust the disseminator and contamination procedures so that more than one disseminator pass is required to achieve the required contamination density. Remove the drop-size samplers after one pass.

4.1.5.7 Decontamination of the Test Item.

a. Decontamination should begin 1 hour after completion of contamination. Use standard procedures, decontaminants, and equipment as described in Reference 8, and/or any test item-specific procedures when supplied as part of the test-documentation package (i.e., the manual).

b. To avoid bias, the individuals performing the decontamination shall not be the same persons who performed the contamination.

c. Start decontamination with areas contaminated first and end with areas contaminated last. Predetermine the time allowed for decontamination of each test item, and remain within the time established. The decontamination process should last no longer than 75 minutes, including decontaminant residence time, but excluding agent monitoring time.

d. Decontamination procedures should be performed as if the entire surface of the test item

were contaminated. The contaminated sampling areas should receive no more or no less attention, time, or effort than uncontaminated areas. Appropriate time should be spent on angles and hard-to-work areas.

e. Document decontamination procedures. Video documentation is recommended.

4.1.5.8 Post-decontamination Sampling.

a. Vapor Sampling Baskets.

(1) When the surfaces of the sampling areas are no longer visibly wet with decontamination/water solutions, place a 10-liter agent vapor sampling basket over the selected 1000-cm^2 sampling area and make an airtight seal with tape. Measure or calculate the volume of the basket when attached and sealed. The basket requires a diffusing device on the intake and exhaust ports to help ensure uniform air movement over the entire selected surface area; the inlet must either have an in-line charcoal filter or be supplied with fresh air.

(2) If the surface configuration of the test item does not permit a 1000-cm^2 sampling area, smaller baskets can be used. When using smaller vapor sampling areas, select the areas and construct the baskets to maintain the ratio of 1000-cm^2 surface evaporation area to 10-liter basket volume.

(3) Aspirate fresh air through the sampling basket at the rate of 15 liters per minute for 4 minutes (minimum of six air changes) to remove trapped agent vapor.

NOTE: Use temperature-conditioned, clean air or filtered chamber air to replace the air aspirated from the basket.

(4) Start and continuously sample the air in the sampling basket. Use samplers appropriate to the measurement required. Sample for agent vapor in the basket air for the prescribed sampling periods over the total 12-hour period.

(5) If a sampling basket with a smaller evaporation surface area is used, the sampling basket must be engineered to consider flow rate so that the average air exchange rate and velocity over the evaporation surface will remain constant in baskets of different sizes.

(6) If cumulative samplers (bubblers or solid sorbent tubes) are used, select a sampling schedule to match the expected agent vapor off-gassing rate. Ensure that a minimum of two vapor samples are obtained for any time interval (three samples are desirable). An exact vapor sampling sequence must be specified in the DTP for the 12-hour period.

b. Agent Contact Hazard Sampling.

(1) Locations on the test item where direct contact with the operator's skin or hands or prolonged contact with other clothed body parts is expected shall be sampled. The DTP will specify other locations to be selected.

(2) Take a minimum of two contact samples from each area selected for contact sampling. The "0-hour" sample shall be taken simultaneously with the sampling basket 4-minute aspiration period [Paragraph 4.1.5.8.a(3)] before starting vapor sampling. The final contact sample shall be taken after all vapor samples have been collected. If an area is of particular concern for contact hazard, a contact sample may be taken each time the vapor samplers are changed.

(3) Prepare contact samplers [a thin disk of silicone rubber (1 mm thick) or other suitable material] with a nominal size of 25 cm^2. The contact sampler should be backed by aluminum foil to prevent contamination of the weight, and then by a material such as sponge rubber to force contact with all surface irregularities. Place the assembled sampler on the selected area using a pressure of approximately 65 g/cm^2 for 10 seconds. Additional contact samplers can be sequentially placed on the same area, for selected intervals of time up to a total of 60 seconds, in multiples of 5 seconds. These sequential contact sampling times should relate to the use concept of the item (e.g., how long a human might be expected to lean on, touch, hold, etc., the area sampled). A slight rocking motion may be required to apply sampling force more uniformly to surfaces that are slightly curved. Immediately remove the sheet of silicone rubber. Place the sheet in a sample jar with the appropriate type and quantity of solvent, seal the jar, and transport it to the chemical laboratory for analysis.

c. Sampling and Analysis. Sampling and analysis should use test instruments and methods that give precise and accurate values for the primary data parameters. Most military chemical alarms, detectors, detector papers, and kits provide only qualitative "yes/no" answers. Data from such sources should be used to complement data obtained from more precise test instruments.
4.1.5.9 Hardness Determination.

a. After completion of all decontamination and sampling procedures, inspect all surfaces of the test item for visible evidence of leakage and degradation caused by the agents, decontaminants, and decontaminating procedures. Describe any degradation; document with photographs. Operate the test item according to the appropriate manual. Measure and record mission-essential performance characteristics. Measure each parameter at least twice. Interview operators and record all evidence of operational degradation. The hardness data collected must be compatible and comparable with the pretest values recorded (Paragraph 4.1.5.3.c).

b. The required five contamination/decontamination cycles may be conducted with any one or a combination of the three chemical agents, or all five cycles may be conducted with chemical

agents, biological simulant, nuclear fallout simulant, or any combination of these. If more than one replicate of five hardness cycles is required to obtain a hardness determination, a different test item must be used so that no more than five contamination/decontamination cycles are performed on any one test item. Select the sequence and the type of contamination/decontamination procedures required for the five cycles of the hardness determination after evaluation of the test item's identifiable vulnerabilities and questionable materials of construction (Paragraph 3.1.d).

c. Hardness data collection should be performed after each contamination/decontamination cycle and 30 days after the first contamination. Hardness data must be sufficiently accurate and precise to define any degradation over five cycles and a 30-day period.

4.1.6 Data Reduction, Presentation, and Evaluation.

4.1.6.1 Receipt Inspection.

a. Assemble and collate all data on item damage, missing components, surface condition, other discrepancies, and test item history. Summarize and present results in tabular form, emphasizing deviations from developer specifications and surface cleaning or maintenance performed.

b. Assemble and present "mockup" receipt-inspection data, noting differences between the mockup and the test item.

c. Assemble data pertaining to surface materials and their finishes in a form that can be presented to compare pre- and posttest hardness functional performance data.

4.1.6.2 Decontaminability. Chemical decontaminability will be determined by comparing post-test residual hazards with established criteria for each agent (Paragraph 4.1.2.1). The item will be considered chemical agent decontaminable if residual vapor and contact hazards are reduced to levels at or below the established decontamination criteria.

a. Describe each sampling area, including the location, material of construction, surface geometry, and surface texture. Cite the agent, contamination procedure, decontaminant, and the decontaminating procedures used, including item-specific procedures and time expended on each procedure. Obtain video coverage of the decontamination operation, if possible. Describe the statistical analysis used to define the number of areas to be tested to provide quality data (Paragraph 4.1.5.4.b).

b. Summarize and present the chamber conditions during the test period. Present the agent physical properties, agent contamination density, and the drop size for each item or sampling

area. Identify deviations from specified values.

c. Tabulate the quantity of agent recovered from each agent contact sampler, identified by the location and time at which the sample was taken.

d. Determine the probable contact hazard level for each test item and compare it with the approved NBC contamination survivability criteria in Table 1 of Appendix B [also see Paragraph 1.3.a(2)]. Consider the test item MP, probability of contact, type of contact, contact time, type of agent, and contact hazard sampler-to-skin correlation factors (bare skin, clothed, and contact pressure). The factors to be considered will vary significantly for every type of item tested. The procedures for assessing operator contact hazard must be tailored to each test item and mission scenario.

e. Tabulate the average concentration of agent vapor recovered from each test item sampling location (component, if used) identified by time. Consider the test item mission, probable mission scenario(s), and operator location and estimate the effective average concentration (C_e), that is, the fraction of the average concentration that is likely to be presented to and be inhaled by the operator [Paragraph 1.3 a(1)]. Compare the results with the approved NBC contamination survivability criteria for military materiel in [Table 1 of Appendix B and Paragraph 1.3 a(1)].

(1) No simple procedure exists for determining vapor hazard to the test item operator(s). The credible dosage received is a function of agent desorption from the decontaminated test item, worst-case or other selected scenarios that have almost unlimited variables, and the established "no effects" criteria.

(2) One approach to determine if agent vapor dosages from a test item are likely to exceed the established criteria has been presented[j]. This approach hypothesizes exposure scenarios on a case-by-case basis, depending on the test item and its expected use in the field.

f. If an area fails the decontaminability criterion, attempt to identify the material composition responsible for the failure.

4.1.6.2 Hardness.

a. Summarize and tabulate all post-trial mission-essential performance data, identified by test cycle number, agent, and decontaminant.

b. Compare the mission-essential performance data for each contamination/decontamination cycle with the receipt inspection performance data. Use the mission-essential performance data and operator interview data to determine whether more than 20 percent degradation in item performance has occurred (Paragraph 1.3 b). Highlight and discuss significant results.

4.1.7 Adapting to Simulant Agent Testing.

a. As a general rule, the data requirements, facilities, and procedures for simulant testing will be similar to those used for toxic agent testing. The major differences will be in the level of safety and environmental protection restrictions required and the lower approval requirements for simulant test chamber work than for toxic agent work. Simulants must be used when a test is performed by soldier, operator, maintainer, tester and evaluator (SOMTE) personnel; when toxic test facilities are not available; when the nature of the equipment being tested makes the use of chemical agents impractical; or when an out-of-doors test setting is required. However, testing hardness with simulants tests only the effects of the decontaminant and the decontamination procedures. Any adverse effects that could be caused by chemical agents are not tested.

b. Many test items that fail hardness testing will not fail because of the agent contamination, but will fail because of the wetting and corrosive action of the decontamination solutions and procedures on delicate optical, electronic, and mechanical components. However, when performing decontaminability tests using simulants, determination of residual hazard after decontamination loses some relevance and may require agent testing for a final determination of decontaminability. That is, agent tests may be required to demonstrate that an item meets survivability requirements. Agent tests may still be needed to demonstrate the adverse effects caused by the chemical agent on the hardness of the item.

4.1.7.1 Facilities and Instrumentation.

a. The facilities required for simulant testing are the same as for agent testing, except for the test chamber. The chamber size, environmental controls, and instrumentation will be the same; however, less stringent safety and environmental protection equipment and approval for testing will be needed.

b. The instrumentation required for simulant testing will generally be the same as for agent testing. Occasionally, different sampling equipment and procedures may be required.

c. Simulant use makes out-of-doors testing possible. Under these conditions, the requirement for a test chamber is eliminated, but the need for other facilities and for most of the instrumentation remains unchanged.

(1) Out-of-doors testing will require that the acceptable temperature, RH, and wind speed limits be expanded so as to cover the variability expected during the test period. Also, limits on other environmental parameters will have to be included, such as limits on precipitation, dew, solar radiation (sunshine), and cloud cover.

(2) Out-of-doors testing will result in more realistic environmental test conditions, but will complicate data analysis and comparison of different sets of test data.

4.1.7.2 Procedures. Most aspects of simulant testing procedures will be the same as for agent testing. These include objectives, criteria, controls and limitations, data required, receipt inspection, pretest preparation, test chamber operation, test item contamination, and test item sampling. Safety procedures may be somewhat relaxed when working with simulants; however, test controls, test procedures, and data collection should be emphasized just as rigorously as when conducting agent testing.

4.1.7.3 Agent Simulant Selection.

a. The selection of chemical compounds to simulate chemical agents is a critical step in testing with simulants. The simulants selected should be safe to handle and require minimum protective gear, equipment, and procedures; cause little or no environmental concern; and require minimum handling and storage problems. Selection of appropriate simulants is difficult.

b. Simulants selected for hardness testing should have volatility, viscosity, and surface tension values similar to the agent being simulated; require approximately the same mechanical energy to remove from surfaces; and be easily seen when applied in the appropriate drop size. Such simulants must also simulate the probability of damage to mechanical, optical, electrical, or thermal properties by the agent. Even if a simulant adequately mimics all of these properties, there is no assurance that the simulant will have the same effect on the test item as chemical agent.

c. Simulants selected for decontaminability testing must closely match the properties listed above, as well as sorption/solubility in the surface, and diffusion coefficient, and must also have similar chemical interactions with the decontaminants used, solubility in the decontamination solution, and have a sensitive laboratory analysis procedure. Decontaminability and residual hazard data lose relevance without adequate side-by-side agent/simulant comparison data to confirm test procedure validity. Such agent/simulant comparison data must be obtained in a laboratory study. Experience has demonstrated that no single compound will simulate all of the

important properties of an agent. Performing replicate decontaminability tests using two or more simulants with different properties on each test may be needed to meet selected data requirements.

4.1.7.4 Decontamination. The procedures used during decontamination will be the same as used for agent testing. However, the chemical reaction between the simulant agent and the decontaminating solution will not be the same or may not proceed at the same rate as with agent.

4.1.7.5 Sampling and Analysis. The sampling devices and analytical procedures used to sample and analyze the simulant should be selected to be as sensitive as those used in agent testing.

4.2. Biological Contamination Survivability.

4.2.1 Objectives.

a. Decontaminability. Determine hazards associated with troop use of equipment that has been contaminated with biological material (simulant spores) and then decontaminated using standard and/or item-specific biological decontamination techniques.

b. Hardness. Determine degradation in mission-essential performance characteristics of military materiel after biological agent contamination and then decontamination, using standard and/or item-specific techniques.

4.2.2 Criteria/Conditions

4.2.2.1 Criteria.

a. Materiel developed to perform mission-essential functions shall be hardened to ensure that exposure to five NBC contamination/decontamination cycles does not degrade the mission-essential performance of the equipment more than 20 percent or that specified by the combat developer measured over a 30-day period. The five-cycle requirement refers to a cumulative total of five exposures of one test item to one or more contaminants (nuclear, biological, or chemical) and the associated decontamination process.

b. After decontamination, residual contamination levels for mission-essential equipment must constitute a negligible risk at most to unprotected users of the equipment. In the determination of biological simulant survivability, the following NBC contamination survivability test conditions apply (Appendix B).

4.2.2.2 Conditions.

a. General Conditions.

(1) Exterior surfaces initially are uniformly contaminated with $1x10^7$ CFU/m^2 of biological agent simulant 1 to 5 µm in size.

(2) Decontamination begins 1 hour after contamination, using standard field and/or item-specific decontaminants, equipment, and procedures. The decontamination process lasts no longer than 75 minutes. The item surface temperature is 30°C, and the wind speed (air movement) is no greater than 1 m/sec.

(3) Hazard levels will be calculated assuming an exposure time based on the mission profile (MP), as specified by the combat developer, not to exceed 12 hours.

b. Detailed Conditions. The detailed conditions for simulant biological agent/contamination survivability testing are given below.

(1) Chamber temperature and RH: 30±5°C and ambient RH.

NOTE: Cooler temperatures and higher RH are worst-case contamination hazards for most biological agents (e.g., 10°C and 75 percent RH).

(2) Test chamber air circulation over the test time: <1 m/sec.

(3) Test chamber pressure: negative to room/atmospheric pressure.

(4) Exterior simulant contamination density: $1\pm0.5x10^7$ CFU/m^2.

(5) Simulant particle size: 1 to 5 µm.

(6) Sample and analysis controls: test-item background control sample, swab control (unused swab), diluent control, plate control, and maximum time of 18 hours between sample collection and analysis.

4.2.3 Controls and Limitations. The controls and limitations for simulant biological agent/contamination survivability testing are:

a. Test Item:

(1) Paint type, specifications, and application must comply with military standards for the test item.

(2) Surface areas selected for sampling must be representative of the exterior surface paint, materials, texture, and the areas where the user will have direct contact.

b. Sample and Analysis Controls: (l) laboratory control, (2) swab control (unused swab), (3) swab of a noncontaminated surface in the field, (4) diluent control, (5) plate control, and (6) a maximum of 18 hours between sample collection and analysis.

c. Decontamination Control:

(1) Describe decontaminating solution: formulation, active ingredients, and age.

(2) Contamination weathering time before start of decontamination: 1 hour ±2 minutes after completion of contamination. The decontamination process should last no longer than 75 minutes.

(3) Use qualified and trained operators, standard equipment (the same type of equipment that would be used by troops for that test item), and standard procedures.

4.2.4 Data Required. Report the following data in the units indicated.

a. Chamber temperature -- °C, RH -- percent, and wind speed (airflow) -- m/sec.

b. Agent simulant *Bacillus subtilis* var. *niger* (BG): control number, diluent used, viscosity (centistokes), percent solids, date harvested and/or reconstituted, date used, and CFU per mL.

c. Disseminator used, quantity of BG suspension disseminated -- mL, air pressure -- psi, and dissemination time -- seconds.

d. Still color photographs and written description of each area contaminated.

e. Simulant contamination density for each sampling area before and after decontamination, expressed in CFU/sample.

f. Chamber air simulant contamination level immediately after dissemination, expressed in CFU/L of air.

g. Results of swab sampling before and after decontamination, expressed in CFU/sample.

h. Results of sampling and analysis controls and standards, expressed in CFU/control.

i. Sample history with elapsed time to analysis -- hours.

j. Elapsed time required to complete simulant contamination, weathering time before decontamination, decontamination time, and time of each sample -- minutes.

k. Description of the decontamination solutions (i.e., formulation, active ingredients, and age), methods, equipment, and item-specific procedures used.

l. Names and titles of principal test participants.

m. Description of test item exterior materials of construction, paint type, and surface condition (pretest and posttest), including cleanliness (mud, grease, and other). Photographs should be made of joints, crevices, textures, or other areas that may be difficult to decontaminate or allow liquid to penetrate.

n. Pretest and posttest mission-essential functional performance characteristics used as the measure of the test item's mission performance before and after exposure to simulant contaminants, decontaminants, and decontaminating procedures.

o. Results of posttest operator questionnaires and comments.

p. A system safety risk assessment of test findings IAW guidance addressed in Reference g (also see Reference h).

4.2.5 Methods and Procedures.

4.2.5.1 Test Location. The test will be conducted inside a test chamber, building/room, or shelter approved for dissemination of biological simulant.

4.2.5.2 Biological Agent Simulant. The simulant of choice for this test is a spore suspension of BG. Experience has shown it simulates the behavior of anthrax and is a worst case simulant for other biological agents.

4.2.5.3 Receipt Inspection and Functional Performance. Perform a receipt inspection and pretest mission-essential functional performance test as described in Paragraph 4.1.5.3, if not previously performed as part of another test phase.

4.2.5.4 Pretest Preparation.

a. Before each trial, sample the surfaces of the test item for residual decontaminant and for other foreign substances that could interfere with sample analysis.

b. Analyze the test item and identify the locations and materials to be sampled for simulant contamination. Selection of the number, shape, and location of areas to be sampled will depend on the OMS/MP, and concept of use. Also consider test item size, geometry, materials of construction, paint, surface texture, cracks, crevices, and accessibility for decontamination. Consider crew assignments, the locations most likely to contribute to crew inhalation and contact hazard, and any areas that might allow contamination and decontaminating solutions to seep into and degrade sensitive equipment. Identify three 25-cm^2 sampling areas from each material and/ or location selected. Duplicate sampling of each material and location is desirable, making a total of six 25-cm^2 sampling areas per material/location. Describe and sketch or photograph each sampling area. If any areas or components of the test item have been identified by the combat developer for item-specific decontamination procedures, identify such areas, components, and procedures. Do not place any marks on the surfaces to be sampled.

c. Use qualified and trained operators, standard equipment (the same type of equipment that troops would use with the test item), and standard decontamination procedures.

d. BG is a common microorganism living in most soils and is safe to handle and use as a simulant test organism without wearing protective equipment. However, to control laboratory background contamination and preclude any possibility of operators developing an allergic reaction to the organism, conduct all testing with BG inside a test chamber approved for the testing of biological simulants. Always follow the procedure controls and SOPs in effect at the time the chamber was approved for biological simulant testing.

e. Before the start of testing, rehearsals may be required to familiarize test crews with all test procedures and data requirements. Allow crews to practice until operations for simulant dispensing, decontamination, and sampling become reproducible and routine. For rehearsals, do not use the test item to be used for testing.

f. Place the test item in the test chamber and bring the chamber to the environmental conditions specified for the test. Temperature-condition the test item for a minimum of 24 hours. Record temperature, RH, and wind speed at a minimum of every 15 minutes for the duration of the test.

g. Before simulant contamination of the test item, swab sample the first of each three 25-cm^2 sampling areas to determine the background contamination level and residual substances (decontaminant) that could interfere with sample assay.

h. Contamination procedures will result in simulant contamination of unwanted areas of the test item, chamber floor, instrumentation, etc. The use of easily removable covers or templates for unsampled areas of the test item, chamber floor, and instrumentation are recommended for reducing the background contamination level.

4.2.5.5 Contamination and Contamination Density Sampling.

a. Calibrate a nebulizer (Collison disseminator or equivalent) to disperse BG containing particles in the 1- to 5-µm size range and determine the appropriate operating time, air pressure, and slurry concentration. Contaminate the air inside the chamber to a level of approximately 1x 10^6 CFU/L of air. The exact BG slurry count, the generator air pressure, the duration of generator operation, and the number of BG CFU/L of chamber air to meet the test item contamination target of $1x10^7$ CFU/m^2 will be determined by the project biologist.

b. Immediately after completion of chamber air contamination, sample the chamber air for BG concentration, using all glass impinges without preimpingers. Allow 1 hour for fallout contamination of the test item. After the 1 hour fallout, air-wash the chamber for 1 hour to reduce chamber contamination. The 1-hour air-wash will also serve as the 1-hour weathering time.

c. Immediately after air-wash, swab sample the second 25-cm^2 area in each set to determine the test item simulant contamination density.

4.2.5.6 Decontamination of the Test Item.

a. Because biological spores can be reaerosolized easily, be careful to avoid unwanted BG contamination of test samples. Instrumentation and other nontest item surfaces may be decontaminated immediately after test item contamination density sampling has been completed. If practicable, the test item may be removed from the test chamber or room for decontamination and residual contamination sampling.

b. Start decontamination immediately after contamination density sampling. Use standard decontamination procedures, solutions, and equipment as described in Reference 8, and any test item-specific procedures furnished as part of the test documentation package.

c. Perform decontamination procedures as if the entire surface of the test item were uniformly contaminated. The sampling areas should receive no more or no less attention, time,

or effort than the areas not sampled. Appropriate time should be spent on rough surfaces, joints, angles, and hard-to work areas. The decontamination process should last no longer than 75 minutes.

d. Record all decontamination procedures, equipment, tools, and time used in the decontamination process, including item-specific procedures. Chlorine containing compounds such as supertropical bleach, calcium hypochlorite, or sodium hypochlorite are the decontaminating solutions of choice for biological agents. However, chemical agent decontaminating solution number 2 (DS-2) is effective against biological agents and may be specified in the test documentation as the decontaminating solution to use for some biological testing.

4.2.5.7 Residual Hazard Sampling After Biological Contamination/Decontamination. When the test item surface is dry following decontamination, swab sample the third 25-cm^2 area in each set to determine the residual contamination remaining on the test item. For porous materials such as ropes, tarpaulins, harness, cable, etc., extract the item with saline solution which should then be filtered, cultured, and counted. When sampling data are available, calculate the contamination reduction values for each material/location sampled. If the contamination reduction values do not meet the NBC contamination survivability criteria, decontaminate the test item again and sample for residual contamination. Repeat the decontamination and residual contamination sampling a second time if required to meet the contamination reduction criteria.

4.2.6 Hardness Determination.

a. If the review of the probable modes for hardness failure of the test item (Paragraph 3.1.d) indicate that biological contamination/decontamination could affect mission-essential performance significantly, the hardness determination should include one or more contamination/decontamination cycles with biological simulants.

b. After biological simulant decontamination is complete and the final set of swab samples have been taken, visually inspect the test item for evidence of corrosion caused by the biological test procedures. Operate the item, measure, and record all mission-essential functional performance characteristics. Measure each parameter at least twice, depending on the inherent difficulty in reproducing a specific value, and compare with pretest values. These data must be compatible with receipt inspection data (Paragraph 4.1.5.3.c). Interview operators and record any indication of operational degradation attributable to the biological contamination/decontamination cycles. Measurement of hardness degradation should be for five nuclear, biological, or chemical contamination/decontamination cycles on one test item, scheduled over a 30-day period.

4.2.7 Data Reduction, Presentation, and Evaluation.

a. Describe each sampling area, including the location, material of construction, surface geometry, and surface texture. Cite the decontaminant, decontamination time, and decontaminating procedures used, including item-specific procedures furnished by the materiel developer.

b. Summarize and describe the chamber conditions during the test period. Record the simulant batch or lot number, simulant physical property data, and aerosol disseminator operating data. Identify and explain any deviations from target values.

c. For each material/location, summarize and describe the CFU recovered from the control samples, the chamber air contamination level, the test item contamination level, and the residual sample level after decontamination, including any residual sample values obtained after the second and third decontaminations.

d. Calculate the biological spore decontamination reduction ratio achieved by the decontamination process (the item challenge contamination level divided by the residual contamination level) for each material/location sampled. Present the spore reduction ratio and the raw challenge and hazard data. Compare the calculated decontamination ratio values with the NBC contamination survivability criterion for biological spores. The item will be considered decontaminable for biological agent if the contamination is reduced to levels at or below the established criterion. If alternative methods of decontamination appear likely to improve decontamination effectiveness, recommend them for consideration.

e. The biological hardness determination will be the same and may be performed jointly with those described in Paragraph 4.1.6.3.

4.2.8 Adapting to Pathogenic Agents.

a. Most of the facilities, instrumentation, and procedures required for pathogenic agent testing are essentially the same as described for simulant testing. The safety procedures, environmental controls, and test chamber certification would be much more stringent when testing with pathogens. There is no known chamber that will accommodate large pieces of army equipment (tanks, vans, and vehicles) that is approved (or approval expected) for work with pathogenic biological agents.

b. If pathogenic biological contamination survivability data are required, they may be obtained from swatches, components, and panels of test item material small enough to be tested inside laboratories equipped with state-of-the-art biological safety hoods and devices; these data may then be extrapolated to larger pieces of equipment.

4.3 Nuclear Contamination Survivability.

4.3.1 Objectives

a. Decontaminability. Determine the hazards associated with troop use of equipment that has been contaminated with radioactive fallout debris and then decontaminated using standard and/or test item-specific procedures.

b. Hardness. Determine performance degradation in mission-essential functions of military materiel after nuclear contamination and decontamination using standard and/or test item-specific procedures.

4.3.2 Criteria/Conditions.

4.3.2.1 Criteria

a. Mission-essential equipment shall be hardened to ensure that exposure to five contamination/decontamination cycles does not degrade the mission-essential functional performance of the equipment more than 20 percent, or that specified by the combat developer, measured over a 30-day period. The five-cycle requirement refers to a cumulative total of five exposures to one or more contaminants (nuclear, biological, or chemical) and the associated decontamination processes.

b. Following decontamination of the test item to remove nuclear fallout debris, the residual radiation activity on/in the test item will result in no more than negligible risk to unprotected users of the item. In the determination of the risk level, the following conditions (Paragraph 4.3.2.2) apply.

4.3.2.2 Conditions.

a. General Conditions.

(1) One-half of the activity could be induced activity resulting from the initial blast effects and nontest item-related sources and would not be measured in this test. The other half of the activity (which would be determined in this test) would result from radioactive debris remaining on the item after radioactive fallout decontamination.

(2) The unprotected users of the item would arrive H+2 hours and remain inside, on, or 1 meter from the item for a period of time based on the item MP, not to exceed 12 hours.

(3) Decontamination begins 1 hour after contamination and lasts no longer than 75 minutes. Only standard field decontaminants, equipment, and procedures and/or item-specific procedures provided by the combat developer will be used to decontaminate the equipment.

(4) The item surface temperature is 30°C and wind speed is less than 1 m/sec.

b. Detailed Conditions. The detailed conditions for simulant nuclear fallout contamination survivability testing are given below:

(1) Test chamber: temperature 30±5°C, ambient RH, wind speed (air circulation over the test item) <1 m/sec, and chamber sealed.

(2) Nuclear fallout simulant: fluorescent particles (FP).

(3) Exterior target contamination density: $2.5\pm0.5\times10^5$ particles/cm^2.

(4) Fallout simulant particle size: 1 to 5 μm.

(5) Sampling and counting controls: test item background control, laboratory control, and particle counting control.

(6) Surface areas selected for sampling must be representative of the test item materials, surface texture, paint, and areas where the user will have contact with the item.

(7) Contamination weathering time before start of decontamination will be 1 hour ±2 minutes after completion of contamination. The decontamination process should last no longer than 75 minutes.

4.3.3 Controls and Limitations.

a. Paint type, specifications, and application must comply with combat developer specifications for the test item.

b. Before each trial, sample the surfaces to be tested for background contamination and foreign substances that could interfere with sample analysis.

c. Use qualified and trained operators, standard equipment, and standard procedures (the same type of equipment and procedures that troops would use in the field with that test item).

4.3.4 Data Required. Report the following data in the units indicated:

a. Description of the test item exterior materials of construction, paint type, and surface condition, including cleanliness (mud, grease). Photographs of joints, crevices, textures, or other subjects that may prove difficult to decontaminate.

b. Photograph and written description of each area selected for sampling.

c. Chamber: temperature -- °C, RH -- percent, and wind speed (airflow) -- m/sec.

d. FP lot number, particle count/g, color, and particle size range -- μm.

e. FP disseminator used, operating air pressure -- psi, dissemination time -- seconds, mass of FP disseminated -- grams, and chamber air contamination density -- FP particles/L of air.

f. Test item FP background control counts, test item FP surface contamination density counts, test item FP residual contamination counts -- particle/cm^2, and FP counting control values.

g. All pertinent test event times and sample times -- minutes.

h. A description of decontamination methods, equipment, solutions (if used), and any item-specific decontamination procedures and special devices used.

i. Results of the receipt inspection and visual inspection of the test item surfaces after each contamination/decontamination cycle.

j. Receipt inspection results and pretest (baseline) and posttest mission-essential functional performance data used to determine test item hardness (degradation).

k. A system safety risk assessment of test findings IAW guidance in Reference g (also see Reference h).

4.3.5 Methods and Procedures.

4.3.5.1 Nuclear Fallout Simulant. The nuclear fallout simulant to be used is zinc sulfide FP in the 1 to 5 μm size range. Before the start of testing, the FP to be used should be tested for fluorescent color.

4.3.5.2 Receipt Inspection and Functional Performance. Perform receipt inspection and a pretest mission-essential functional performance test as described in Paragraph 4.1.5.3.c, if not previously performed as part of another test phase.

4.3.5.3 Test Preparation.

a. Perform an analysis of the test item as discussed in Paragraph 4.1.5.4.b to help identify locations and materials to be sampled. Selection of the number and location of the areas to be sampled will depend on the OMS/MP and the test item size, geometry, materials of construction, paint, surface texture, cracks, crevices, and the accessibility for decontamination. Consider crew assignments, the locations most likely to contribute to crew hazard, and any areas that might allow decontaminating solutions to seep into and degrade delicate equipment. Identify three 4-cm^2 sampling areas from each material/location to be sampled. Duplicate areas for each material/location are desirable. Make special note of any material or surface selected that requires the sampling areas to be less than 4-cm^2. If any areas or components of the test item have been identified by the combat developer for item-specific decontamination procedures, identify such areas and components.

b. Calibrate a dry FP-disseminating apparatus to disperse FP particles in the 1- to 5-μm size range. Determine a precalculated time, air pressure, and FP quantity to contaminate the test item to the target level.

c. Before FP tests begin, rehearsals may be required to familiarize test crews with all test procedures and data requirements. Allow crews to practice until the operation of dispensing equipment, decontamination procedures, and sampling become reproducible and routine. Do not use the test item to be used during hardness and decontaminability tests during rehearsals; do not disseminate the FP.

d. To reduce FP contamination of instruments and equipment, templates and protective covers may be useful. Do not use plastic sheeting or other materials capable of carrying a high static charge in the chamber because the static charge can influence FP behavior; Velostat® or equivalent sheeting can be used.

4.3.5.4 Contamination and Sampling.

a. Select, describe, and photograph representative areas of the test item for FP sampling. Each of these areas should also be subdivided so as to contain a set of three smaller areas, each containing a minimum of 4 cm^2. Identify at least three such sets.

b. Before the start of a trial, use a 4-cm^2 patch of Microtiter® plate-sealing tape and sample the first area in each set. This patch sample will be used to measure pretest (background) contamination.

c. Contaminate the air inside the chamber to a level of approximately $1x10^6$ FP particles/L of air by aerosolizing dry FP, using a laboratory FP dissemination apparatus. The desired contamination level on exterior surfaces is $2.5x10^5$ particle/cm^2. The exact weight of dry FP material and the length of time the disseminator is operated to meet that value will be determined by the senior operator and reported as required data.

d. Immediately after completion of FP aerosol dissemination, sample the chamber air for FP concentration at two locations, one on each end of the chamber. Sample for 30 to 60 seconds, using two 6-L/min membrane filters oriented face-downward. Allow 1 hour for fallout contamination of the test item. Air-wash the chamber for 1 hour to reduce chamber air contamination.

e. After the 1-hour air-wash and before decontamination of the test item, use a second 4-cm^2 patch of Microtiter® tape and sample the second area from each set of three to measure the surface FP contamination density.

4.3.5.5 Decontamination of the Test Item.

a. Because FP can be re-aerosolized easily, exercise appropriate care to avoid unwanted FP contamination of test samples. Instrumentation and other nontest item surfaces may be vacuumed immediately after contamination sampling has been completed. If practicable, the test item may be removed from the test chamber or room for decontamination and residual contamination sampling.

b. Start decontamination immediately after FP contamination density sampling. Use standard decontamination procedures, solutions, and equipment as described in Reference 8, and any item-specific procedures furnished by the combat developer.

c. Decontamination procedures should be performed on all exposed surfaces of the test item. The sampling areas should receive no more or no less attention, time, or effort than the areas not sampled. Appropriate time should be spent on rough surfaces, joints, angles, and hard-to-work areas. Make detailed records of any area that falls into this category. The decontamination process should last no longer than 75 minutes.

d. Record all decontamination procedures, equipment, tools, and time used in the decontamination process, including item-specific procedures.

4.3.5.6 Post-decontamination Sampling.

a. After decontamination and when the test item surface is dry, use a patch of Microtiter® plate-sealing tape and sample for residual FP contamination remaining on each material/location selected for sampling. Calculate the contamination reduction values for each material/location sampled. If the contamination reduction values do not meet the NBC contamination survivability criteria, decontaminate the test item again and sample for residual contamination. Repeat the decontamination and residual contamination sampling a second time, if required, to meet the contamination reduction criteria. Record the time and procedures used for each additional decontamination and sampling cycle.

b. After each contamination/decontamination cycle, inspect all exterior surfaces of the test item for evidence of deterioration or buildup of deposits or sludge that could affect test item performance. Give special attention to any area that might allow contaminants or decontaminants to penetrate below the surface.

4.3.6 Hardness Determination.

a. If the review of the probable modes for hardness failure of the test item (Paragraph 3.1.d) indicate that nuclear contamination/decontamination could affect mission-essential performance significantly, the hardness determination should include one or more contamination/decontamination cycles with nuclear simulant FP.

b. After each contamination/decontamination cycle is complete, visually inspect the test item external surfaces and interior spaces for evidence of corrosion and degradation caused by the nuclear test procedures. Operate the item and measure and record all mission-essential functional performance parameters. Measure each task at least twice, depending on the inherent difficulty in reproducing a specific value; compare with the pretest values. These data must be compatible with receipt inspection data (Paragraph 4.3.5.2). Interview test item operators and record any indications of operational degradation attributable to the nuclear contamination/decontamination cycles. Measurement of hardness degradation should be for five nuclear, biological, or chemical contamination/decontamination cycles on one test item, scheduled over a 30-day period.

4.3.7 Data Reduction, Presentation, and Evaluation.

a. Describe each sampling area and give the location, material of construction, surface geometry, and surface texture. Cite the decontaminant and the decontaminating procedures used, including references to field manuals and/or item-specific decontamination procedures.

b. Summarize and present the chamber conditions during the test period, including air movement, temperature, and RH. Compare the contamination densities achieved with the target values. Present FP contamination density and the residual contamination remaining for each sampling area. Identify and explain any deviations from established criteria.

c. Calculate the FP decontamination reduction ratio achieved by the decontamination process (the item challenge contamination level divided by the residual contamination level) for each location sampled. Compare the calculated decontamination ratio values with the NBC contamination survivability criteria for nuclear debris.

d. Data reduction and presentation for nuclear simulant contamination survivability will be the same as for biological contamination survivability (Paragraph 4.2.7).

4.4 NBC Compatibility.

4.4.1 Objective. Determine if mission-essential equipment can be operated, maintained, and resupplied by troops wearing the full NBC protective ensemble (MOPP4).

4.4.2 Criterion/Conditions.

4.4.2.1 Criterion. Excluding heat stress, degradation of crew performance of mission-essential tasks will be no greater than 15 percent below the levels specified for these tasks when accomplished in a non-NBC environment.

4.4.2.2 Controls and Limitations.

a. Meteorological conditions during testing must match those of areas of intended use. Paired comparisons should be planned, thus eliminating meteorological conditions as a source of variation in comparing test item performance with and without the wearing of NBC protective clothing.

b. NBC compatibility tests should be based on a test design that considers all variables, such as the level of operator NBC training, degree of acclimatization, familiarity and experience with the equipment, and test environmental variables.

c. All operators of the equipment will be properly trained and certified to operate the test equipment.

d. SOMTE personnel will be used in NBC compatibility tests to the maximum extent possible.

e. Any crews who have been in MOPP4 clothing for more than 75 minutes should be given an overnight rest period before they participate in another trial.

4.4.3 Data Required.

a. A listing of mission-essential tasks identified by the combat developer for the equipment undergoing the NBC compatibility test. The listing should indicate how each task is to be measured and whether the function is to be classified as an attribute (go, no-go) or a variable measured over a continuous range of variables.

b. Determination of baseline mission-essential performance characteristics for the equipment.

c. Measurement of mission-essential soldier tasks/equipment performance with operators in standard battledress and in NBC protective clothing.

d. Temperature, wind speed, relative humidity, light conditions, cloud cover, and heat stress level recorded throughout the testing procedure.

e. A training record, military occupation specialty (MOS) qualification score, experience with the equipment, medical or physical profile, and anthropomorphic data for each operator-participant.

f. Copies of operator, supervisor, and "umpire" questionnaires.

g. A test incident report to document out-of-tolerance performance, breakdown, or other anomalous performance occurring during compatibility tests.

4.4.4 Methods and Procedures.

4.4.4.1 Equipment Operation. Equipment to be tested will be operated and maintained in strict compliance with operating manuals, instructions, and SOPs. In performing maintenance tasks, only tools and repair procedures specified for the equipment will be used.

4.4.4.2 Test Site Operations. Configure the decontamination test site to match the deliberate decontamination site described in Reference 8. Although the simulants used in decontamination test are generally common industrial chemicals of low toxicity and negligible environmental impact, many decontaminants are highly reactive compounds or may contain hazardous components and must be recovered for disposal IAW hazardous waste guidelines.

4.4.4.3 Test Planning and Preparation.

a. Prepare a test scenario specifying functions and operations to be evaluated during a typical mission profile. Include which test items will be used, the type and number of SOMTE personnel, and the sequence of tasks to be measured. Clearly specify the exact measurement to be taken, the sequence in which it is to be taken, and the instrument or measuring device. Maximum use of videotapes should be considered. Clearly explain the role of umpires or field observers. The scenario must ensure that all functions or tasks identified as essential are executed and evaluated.

b. Request a minimum of two SOMTE test crews to allow battledress trials and NBC protective gear trials to be conducted simultaneously, partially eliminating environmental conditions and heat stress levels as variables. Perform a sufficient number of rehearsals to ensure that equipment familiarization is not a factor in the compatibility determination.

4.4.4.4 Test Conduct.

a. Perform the scenario once in battledress and another time in NBC protective clothing, with both crews operating simultaneously. Switch crews and repeat. Repeat the scenario until the decision point specified in the DTP or IAP/IEP has been reached. To avoid bias on the final trial, do not inform SOMTE personnel of the number of replicate trials to be conducted.

b. Complete any questionnaires used at the completion of each pair of trials. Whenever possible, review videotapes between trials to ensure that the test is meeting objectives.

c. Degradation of crew performance caused by heat stress while wearing NBC protective clothing will be observed and recorded. To help avoid heat stress, schedule trials at the time of day and seasons when heat stress will be at a minimum. The factors outlined in Technical Bulletin-Medical (MED) 507[9], together with the use of a stress meter, will serve as guides in identifying and controlling heat stress whenever meteorological conditions and level of exertion indicate that a potential heat-stress problem exists.

4.4.5 Data Reduction, Presentation and Evaluation.

a. Summarize and present crew/test item performance data in tabular form as paired comparisons. Highlight differences in performance attributable to type of clothing worn.

b. If questionnaires are used, tabulate and summarize questionnaire data, highlighting any operational difficulties attributed to the wearing of NBC protective clothing by crew members or observers. Contrast questionnaire data for the two sets of trials and interpret results (also see Paragraph 1.3 c).

c. Summarize and present meteorological data and heat-stress meter data.

d. Identify data gaps and discuss instances where data were inconclusive.

5. DATA REQUIRED.

Separate data sets are required for the three test procedures, Chemical Contamination Survivability, Biological Contamination Survivability, and Nuclear Contamination Survivability.

5.1 Chemical Contamination Survivability.

Requirements are specified in paragraphs 4.1.4a through 4.1.4q.

5.2 Biological Contamination Survivability.

Requirements are specified in paragraphs 4.2.4a through 4.2.4o.

5.3 Nuclear Contamination Survivability.

Requirements are specified in paragraphs 4.3.4a through 4.3.4j.

6. PRESENTATION OF DATA.

6.1 Chemical Contamination Survivability.

6.1.1 Decontaminability data should include a description of the as received test item or "mock-up", identifying any damage and specific conditions of the surface to be exposed to agents. Receipt inspection photographs are important. Differences between the mock-up and test item are described. Levels of contamination agent and decontaminant should be presented for each test, along with residual levels. Video of the decontamination process should be made and reviewed to identify any unique techniques or cautions. Compile a tabulation of results (residual contamination) along with the Approved NBC contamination survivability criteria (Table 1, Appendix B). Prepare a narrative analysis of the decontamination procedure and a separate analysis of effects, considering test item mission, operator position, and possible remedial measures to counter hazardous conditions where present. Refer to paragraph 4.1.6 for further detail on processing of data.

6.1.2 Hardness data will be presented in a format to show direct comparison of pre-exposure and post-exposure mission essential performance of the test item.

6.2 Biological Contamination Survivability.

6.2.1 Decontaminability data should include a description of the as received test item or "mock-up", identifying any damage and specific conditions of the surface to be exposed to biological spores. Receipt inspection photographs are important. Differences between the mock-up and test item are described. For each agent used, identify the contamination density (spores per square meter), area to which applied, surface material, texture and temperature, and chamber temperature, humidity and wind conditions. Also tabulate decontamination solutions, equipment, procedures, and decontamintion time. Video of the decontamination process should be made and reviewed to identify any unique techniques or cautions. Compile a tabulation of results (residual contamination) along with the Approved NBC contamination survivability criteria of 500 spores/square meter.

6.2.2 Hardness data will be presented in a format to show direct comparison of pre-exposure and post-exposure mission essential performance of the test item.

6.3 Nuclear Contamination Survivability.

6.3.1 Decontaminability data should include a description of the as received test item or "mock-up", identifying any damage and specific conditions of the surface to be exposed to nuclear fallout simulant. Receipt inspection photographs are required of exterior materials, construction, paint, cleanliness, joints and crevices. Record the contamination level on exterior surfaces (as close to 2.5×10^5 particles/cm^2 as possible). Also tabulate decontamination solutions, equipment, procedures, and decontamination time. Video of the decontamination process should be made and reviewed to identify any unique techniques or cautions. Compile a tabulation of results (residual contamination) along with the Approved NBC contamination survivability criteria of 25cGy rad/mission.

6.3.2 Hardness data will be presented in a format to show direct comparison of pre-exposure and post-exposure mission essential performance of the test item.

6.4 NBC Compatibility.

6.4.1 Present crew performance data (time to perform function) in tabular form comparing regular battledress and MOPP IV clothing.

6.4.2 Summarize questionnaire data in narrative form highlighting crew difficulties.

6.4.3 Tabulate meteorological and heat-stress meter data.

APPENDIX A. CHECKLISTS.
CHECKLIST A.1. CHEMICAL AGENT TEST

TEST PLAN PREPARATION	COMPLETED
1. Literature search.	_____
a. Case files reviewed.	_____
b. Item specific decontamination procedures identified and summarized.	_____
c. Surety and safety regulations reviewed, and safety assessment report (SAR) available.	_____
d. SOP review completed.	_____
2. Essential operating characteristics identified.	_____
a. Specific operating characteristics to be measured.	_____
b. Measuring equipment on hand.	_____
3. Test item examination and analysis.	_____
a. Areas handled or touched identified; sampling and decontamination techniques for those areas established.	_____
b. Materials of construction reviewed.	_____
c. Cracks, joints, and crevices identified.	_____
d. Use of live agent and simulant approved.	_____
e. System support package available.	_____
4. Proper safety and environmental documents on file.	_____
5. Quality assurance (QA) plan requirements outlined.	_____
6. Receipt inspection requirements reviewed.	_____

CHECKLIST A.1. CHEMICAL AGENT TEST

TEST PLAN PREPARATION (cont'd)	COMPLETED
7. Test item condition before testing determined.	_____
8. The number of test items determined.	_____
9. Pretest sampling requirements established.	_____
10. Use of robotics considered.	_____
11. Training requirements prepared.	_____
12. Approved test plan documentation assembled.	_____

PRETEST PREPARATION

1. Current certification of storage, laboratory, and test areas confirmed.	_____
2. All assigned people enrolled in chemical surety program.	_____
3. Chemical agent physical data obtained.	_____
4. Receipt inspection.	_____
a. Test item(s) received.	_____
b. Test item(s) inventoried and test item identification number (TIIN) assigned, if not assigned previously.	_____
c. Test item damage documented.	_____
d. Surfaces of test item(s) inspected and described.	_____
e. System support package received, inventoried, and determined to be complete.	_____

CHECKLIST A.1. CHEMICAL AGENT TEST

PRETEST PREPARATION (cont'd)	COMPLETED
5. Test item analysis.	_____
a. Drawings, specifications, and photographs of test item on hand.	_____
b. OMS/MP available and category of material to which test item belongs (FM 3-5) identified.	_____
c. Areas likely to present vapor or contact hazard identified.	_____
d. Crevices, angles, cracks, or any area that might be difficult to decontaminate identified.	_____
e. Areas where control samples, contamination density, droplet size samplers, and residual samples are to be located are identified.	_____
f. Items 5.c through 5.e identified on sketch of test item.	_____
6. Standard decontaminants and procedures from FM 3-5 and item-specific procedures identified and ready.	_____
7. Rehearsals completed.	_____
8. Chamber environmental controls operating and test item temperature-conditioned.	_____
9. Pretest control samples taken.	_____
10. Number of samplers identified and prepared.	_____

CHECKLIST A.1. CHEMICAL AGENT TEST

DATA REQUIRED	COMPLETED
1. Record of chamber environmental and operating conditions.	_____
2. Test participant data.	_____
a. Technicians' names and qualifications recorded.	_____
b. Name, rank, MOS, NBC training, length of service, and familiarity with procedures.	_____
3. Test item description.	
a. Condition of surface.	_____
b. Photographs of cracks, crevices, or other areas difficult to decontaminate.	_____
4. Agent contamination.	_____
a. Agent name, purity, and viscosity.	_____
b. Agent contamination densities.	_____
c. Average agent droplet size.	_____
d. Agent application and sample time.	_____
e. Test control and laboratory standard data.	_____
f. Description of agent application techniques, and quantity dispensed.	_____
g. Identification of sampling techniques used.	_____
h. The average area of the surface wetted by individual drops, if safety procedures permit the measurement and if the area is desired.	_____

CHECKLIST A.1. CHEMICAL AGENT TEST

DATA REQUIRED (cont'd) — COMPLETED

5. Decontamination. _____
   a. Decontaminant name, chemical composition, and age recorded. _____
   b. Methods, equipment, tools, or special devices used recorded. _____
   c. Standard and item-specific procedures recorded. _____
   d. Video documentation showing elapsed times for the decontamination process. _____
6. Posttest performance data. _____
   a. Pretest performance data recorded. _____
   b. Posttest performance data recorded. _____
   c. Notes or comments from operators. _____
   d. Visual inspection of test item with documentary photographs completed. _____

TEST PROCEDURES

1. Safety procedures, chamber certification confirmed, safety samplers in place and operating. _____
2. Agent disseminating equipment calibrated and performance confirmed. _____
3. Test item temperature-conditioned. Chamber operating and test conditions recording. _____
4. Test rehearsals conducted and test participants ready. _____
5. Control samples taken; contamination density and droplet size samplers ready. _____

CHECKLIST A.1. CHEMICAL AGENT TEST

TEST PROCEDURES (cont'd)	COMPLETED
6. Decontamination equipment checked and ready.	_____
7. Agent applied to the test item within droplet size range and contamination density specified.	_____
8. Droplet size samples and contamination density samples taken.	_____
9. One-hour agent weathering time and chamber ventilation complete.	_____
10. Test item decontamination completed.	_____
a. Start time.	_____
b. DS-2 dwell time.	_____
c. Stop time.	_____
d. Standard and item-specific procedures recorded.	_____
11. Residual hazard sampling.	_____
a. Vapor sampling initiated.	_____
b. Contact hazard areas sampled.	_____
c. Sequential vapor samples completed and time recorded.	_____
12. Chamber and equipment decontamination completed.	_____
13. Mission-essential performance characteristics measurements and visual inspection completed.	_____

CHECKLIST A.2. BIOLOGICAL SIMULANT TEST

PRETEST PROCEDURES	COMPLETED
1. Current certification of storage, laboratory, and test chamber for BG aerosols verified.	_____
2. Biological simulant physical property data recorded.	_____
3. Test item analysis and sketch of sampling areas completed.	_____
4. Number of samplers determined and prepared.	_____
5. Surface of the test item inspected; damage and surface condition recorded.	_____
6. Decontamination procedures from FM 3-5 and item-specific procedures identified.	_____
7. BG nebulizer calibrated and operating conditions determined.	_____
8. Test item temperature-conditioned.	_____
9. Rehearsals completed and test crews ready.	_____
10. Test chamber operating and environmental conditions within specifications.	_____

DATA REQUIRED	
1. Chamber environmental and operating conditions.	_____
2. Test participants' qualifications and training.	_____
3. Description of test item material and surfaces.	_____
4. Description and photographs of crack, crevices, and other areas difficult to decontaminate.	_____

CHECKLIST A.2. BIOLOGICAL SIMULANT TEST

DATA REQUIRED (cont'd) — COMPLETED

5. Biological simulant data. _____
   a. Simulant count and physical properties. _____
   b. Control/background sample data. _____
   c. Chamber air contamination density. _____
   d. Test item surface contamination density. _____
   e. Test item residual contamination density. _____
6. Nebulizer description and operating and time data. _____
7. Decontaminant name and chemical composition. _____
8. Decontamination equipment, tools, procedures, and item-specific procedures. _____
9. Test item data. _____
   a. Pretest mission-essential performance. _____
   b. Posttest mission-essential performance. _____
   c. Visual inspection for test item degradation with documentary photographs. _____
   d. Operator interview, notes, or comments. _____

TEST PROCEDURES

1. BG nebulizer calibrated and performance verified. _____
2. Receipt inspection completed and mission-essential tasks measured. _____
3. Test rehearsals completed and test crews ready. _____

CHECKLIST A.2. BIOLOGICAL SIMULANT TEST

TEST PROCEDURES (cont'd) — COMPLETED

4. Test item temperature-conditioned and test chamber conditions within specifications. _____
5. Control/background samples taken. _____
6. Templates and disposable covers in place (if used). _____
7. Simulant physical property data recorded. _____
8. Decontamination equipment checked and ready. _____
9. Simulant aerosolized. Nebulizer operating data recorded. _____
10. Chamber air contamination level sampled. _____
11. One-hour simulant settling time completed. _____
12. One-hour chamber ventilation/weathering completed. _____
13. Test item contamination density sampling completed. _____

DATA REQUIRED

1. Decontamination time, FM 3-5 procedures used, and item-specific procedures documented. _____
2. Test item residual contamination density sampling completed. _____
3. Chamber and equipment decontamination completed. _____
4. Mission-essential performance measurements and visual inspection completed. _____

CHECKLIST A.3. NUCLEAR SIMULANT TEST

PRETEST PROCEDURES	COMPLETED
1. Test chamber certified for FP aerosols and laboratory procedures verified.	_____
2. Simulant FP physical properties data recorded.	_____
3. Test item mission evaluation completed, surface materials identified, and sketch of sampling areas completed.	_____
4. Test item inspected; damage and surface condition recorded.	_____
5. The number of samplers determined and prepared.	_____
6. The decontamination procedures from FM 3-5 and item-specific procedures determined.	_____
7. FP disseminator calibrated; operating parameters determined.	_____
8. Rehearsals completed and test crews ready.	_____
9. Test item temperature-conditioned.	_____
10. Test chamber operational and environmental conditions within specifications.	_____

DATA REQUIRED

1. Chamber environmental conditions and operational data.	_____
2. Test crew qualifications and training.	_____
3. Description of the test item materials and surfaces.	_____
4. Description and photographs of test item cracks, crevices, and other areas difficult to decontaminate.	_____

CHECKLIST A.3. NUCLEAR SIMULANT TEST

DATA REQUIRED (cont'd)	COMPLETED
5. Nuclear simulant data.	_____
a. FP count and physical properties.	_____
b. Control/background sample data.	_____
c. Chamber air contamination density.	_____
d. Test item surface contamination density.	_____
e. Test item residual contamination density.	_____
6. FP generator description, operating, and time data.	_____
7. Decontamination equipment, tools, procedures, solutions, and item-specific procedures.	_____
8. Hardness.	_____
a. Pretest mission-essential performance and receipt inspection data.	_____
b. Posttest mission-essential performance data.	_____
c. Posttest visual inspection data with photographs of degradation.	_____
d. Operator interviews, notes, and comments.	_____

TEST PROCEDURES

1. FP generator calibrated and performance verified.	_____
2. Receipt inspection complete and mission-essential tasks measured.	_____
3. Test rehearsals completed and test crews ready.	_____

CHECKLIST A.3. NUCLEAR SIMULANT TEST

TEST PROCEDURES (cont'd)	COMPLETED
4. Test item temperature conditioned, and test chamber operating conditions within specifications.	_____
5. Templates and disposable covers in place (if used).	_____
6. Control/background samples taken.	_____
7. Decontamination equipment checked and ready.	_____
8. FP simulant aerosolized. Disseminator operating data recorded.	_____
9. Chamber air FP contamination level sampled.	_____
10. One-hour FP settling time completed.	_____
11. One-hour chamber ventilation/weathering completed.	_____
12. Test item contamination density sampling completed.	_____
13. Decontamination time, FM 3-5 procedures, and item-specific procedures documented.	_____
14. Test item residual contamination density sampling complete.	_____
15. Chamber and equipment decontamination complete.	_____
16. Test item mission-essential performance measurements and visual inspection complete.	_____

CHECKLIST A.4. NBC COMPATIBILITY TEST

PRETEST PREPARATION	COMPLETED
1. Test item mission profile and task requirements obtained from the combat developer.	_____
2. Compatibility test scenario(s) specifying mission-essential tasks and operations to be evaluated during a typical mission profile prepared and approved.	_____
3. The test scenario mission-essential task measurements defined in detail, including instrumentation required, accuracy and precision of measurement, the number of measurement replications, type of documentation, and the role of field observers.	_____
4. Questionnaires and interview sheets for SOMTE personnel and field observers prepared.	_____
5. Test controls and limitations defined, including meteorological conditions.	_____
6. SOMTE requirements defined. Test crews assembled and certified.	_____

DATA REQUIRED

1. Test meteorological conditions recorded throughout testing.	_____
2. A list of test item mission-essential tasks.	_____
3. The following test item mission-essential task data:	
a. Baseline mission-essential task data (design criteria) provided by the combat developer.	_____
b. Receipt inspection mission-essential task performance data.	_____
c. Test crew mission-essential task performance data while in battledress uniform.	_____

CHECKLIST A.4. NBC COMPATIBILITY TEST

DATA REQUIRED (cont'd) COMPLETED

d. Test crew mission-essential task performance data while dressed in NBC protective ensemble (MOPP4). _____

e. Test item operating crew (SOMTE) MOS, qualifications, and training data. _____

4. Test item operating crew and field observer questionnaires, interview sheets, and comments. _____

5. A list of instrumentation used; accuracy and calibration data. _____

6. Test incident reports or other documentation of test item failure, out-of-tolerance performance, or other anomalous performance. _____

TEST PROCEDURES

1. Test crews fully trained and rehearsals complete. _____

2. Test item operational. All mission-essential systems performing within specifications. _____

3. Test item operators dressed (battledress or MOPP4), inspected, and ready. _____

4. Meteorological conditions within specified limits. _____

5. Test crews and field observers briefed and ready. Test scenario and checklist provided and understood. _____

6. Test data instrumentation operational, including video and photography. _____

7. Test item operator heat stress monitoring procedures ready. _____

CHECKLIST A.4. NBC COMPATIBILITY TEST

TEST PROCEDURES (cont'd) COMPLETED

8. Mission-essential task sequence complete. _____

   a. Mission-essential task number 1 complete. _____

      Battledress _____ Time: _____

      MOPP4 _____ Time: _____

   b. Mission-essential task number 2 complete.

      Battledress _____ Time: _____

      MOPP4 _____ Time: _____

   c. Mission essential task number 3 complete.

      Battledress _____ Time: _____

      MOPP4 _____ Time: _____

   d. Mission-essential resupply task complete.

      Battledress _____ Time: _____

      MOPP4 _____ Time: _____

   e. Mission-essential test item maintenance tasks complete.

      Battledress _____ Time: _____

      MOPP4 _____ Time: _____

9. Questionnaires and interviews of test item operators complete. _____

10. Data sheets, questionnaires, and interviews of field observers complete. _____

APPENDIX B. QUADRIPARTITE STANDARDIZATION AGREEMENT 747 EDITION 1

DECLARATION OF ACCORD

1. SCOPE OF AGREEMENT.

This agreement has been approved for use by the Armies of the United States, United Kingdom, Australia, and Canada as the standard NBC Contamination Survivability Criteria to be applied to all mission-essential military equipment.

The United States, United Kingdom, Canada, and Australia agree that they will, in the course of designing and testing mission-essential military equipment, use the NBC Contamination Survivability Criteria detailed in this agreement. The subscribing Armies also agree that, once applied to a developmental piece of equipment, the criteria will be modified only if they cannot be met for proven economic, technical, or operational reasons.

The subscribing Armies further accept that they will consult and in every possible case reach mutual agreement on all changes of modifications affecting the agreed degree of standardization before the introduction of such changes or modifications. This agreement may be reviewed or canceled by agreement of the subscribing Armies.

2. CONTINUITY AND RELATED AGREEMENTS.

a. Continuity: QSTAG 747 was prepared as a result of recommendations made, and is based on a concept paper agreed at the Third Meeting of the Quadripartite Working Group on Nuclear-Biological-Chemical Defense held in May 81. A final draft of QSTAG 747 was accepted at 9 QWG/NBCD held in May 90. The United States is the Custodian Army.

b. Related Agreements: QSTAG 244, QSTAG 260.

3. RELEASE TO NATO.

This QSTAG will be released to the North Atlantic Treaty Organization by the Primary Standardization Office.

4. National Ratifying References - Details of Implementation.

Nation	Ratifying Reference	National Implementing Document	Date of Implementation Services				
			Forecast	Actual	A	N	A F
US	AMCICP-AA(34-1d) dated 6 Feb 91	Quantitative NBC Contam. Surviv'ty Criteria & Prog Mang't Directive for CW Defense		Feb 89	X	-	R
UK	LSOR4/8333	TBA	On Promulgation		X	-	X
CA	2510-5-747 (DNBCC) dated 26 Oct 90	CFB 316, Vol 12		Jan 91	X	X	X
AS	A90 31986 dated 25 July 1991	TBA	On Promulgation		X	X	X
NZ							

5. Reservations.

US: The US Air Force reserves the right to reduce contamination levels for liquid agents VX and HD based on standards expected to be developed by NATO.

BY THE WASHINGTON STANDARDIZATION OFFICERS:

//signed//
WILLIAM H. FORSTER
Major General
United States Army

//signed//
EDMUND F.G. BURTON
Brigadier
British Army

//signed//
IAN C. DOUGLAS
Brigadier General
Canadian Forces

//signed//
JOHN H. ROBBINS
Brigadier
Australian Army

12 Aug 1991
(Date Signed)

NBC CONTAMINATION SURVIVABILITY CRITERIA FOR MILITARY EQUIPMENT

DETAILS OF AGREEMENT

1. INTRODUCTION.

1.1 PURPOSE.

The purpose of this agreement is to standardize quantitative criteria for all mission-essential military equipment to survive the effects of nuclear, biological, and chemical (NBC) contamination and the resulting decontamination process.

1.2 SCOPE AND USE.

1.2.1 Standard criteria, expressed in terms of decontaminability, hardness, and compatibility, are provided to ensure that the mission-essential military equipment survives the effect of:

-- contamination by chemical and biological agents.
-- radioactive contaminants and neutron induced activity.
-- decontamination processes.

(Criteria for surviving the initial effects of nuclear weapons are excluded from the scope of this agreement and are covered separately in QSTAGS 244 and 620.)

1.2.2 These NBC Contamination Survivability Criteria will be stated as essential characteristics in appropriate requirements documents and used to design and test the survivability of mission-essential equipment under development. Once applied to a developmental piece of equipment, these criteria will be modified only upon consideration of proven economic, technical, and/or operational reasons.

1.2.3 These criteria are engineering design criteria intended for use only in a developmental setting. They do not define doctrine or operational criteria for decontamination, establish protection criteria, provide guidelines on how to achieve the required survivability, establish test protocols, or specify survivability in training environments.

1.3 DEFINITIONS.

1.3.1 NBC Contamination Survivability - capability of a system and its crew to withstand an NBC-contaminated environment, including decontamination, without losing the ability to accomplish the assigned mission. Characteristics of NBC Contamination Survivability are decontaminability, hardness, and compatibility.

1.3.2 Mission-Essential Equipment - equipment necessary to accomplish primary or secondary missions of a unit or organization.

1.3.3 Mission-Essential Functions - minimum operational tasks that a system is required to perform in order to accomplish its mission profile.

1.3.4 Mission Profile - a time-phased description of the operational events and environments an item experiences from beginning to end of a specific mission. It identifies the tasks, events, durations, operating conditions, and environment of the system for each phase of a mission. A mission profile should be based on a typical scenario for the item/system.

1.3.5 Decontaminability - ability of a system to be rapidly and effectively decontaminated to reduce the hazard to personnel operating, maintaining, and resupplying it.

1.3.6 Hardness - ability of a system to withstand the damaging effects of NBC contamination and any decontamination agents and procedures required to decontaminate it.

1.3.7 Compatibility - ability of a system to be operated, maintained, and resupplied by personnel wearing the full NBC protective ensemble.

2. BACKGROUND.

2.1 The nuclear, biological, and chemical threat to ABCA nations is well documented. It follows that ABCA armies must be trained, organized, and equipped to operate effectively on a battlefield that includes nuclear, biological, and chemical environments. Accordingly, mission-essential items of materiel must survive these environments.

2.2 The Quadripartite Working Group on NBC Defense approved in May 1981 a concept for survivability of materiel contaminated by chemical or biological agents or residual nuclear radiation. This QSTAG is based on that concept.

3. PHILOSOPHY.

3.1 Criteria standardized herein are based on the following philosophy:

A soldier or crew surviving an NBC attack should be able to continue using mission-essential systems and equipment in a full protective ensemble if necessary. When the mission permits, the systems and equipment should be capable of rapid restoration to such a condition that all essential operations can be continued in the lowest protective posture consistent with the mission and threat, and without long-term degradation of the materiel.

3.2 NBC contamination is pervasive and can be widespread, but does not generally damage equipment immediately. Thus, equipment would be available for continued use in the mission and could be employed if the soldier can perform his tasks while protected from the toxic effects. Likewise, since equipment is not immediately damaged by NBC contaminants, it should be capable of being decontaminated and restored to conditions such that the soldier can operate in clothing consistent with the threat and such that the equipment does not experience long-term degradation. This philosophy is consistent with the needs of both user and materiel developer because it centers on the essential needs of the soldier.

4. CHARACTERISTICS OF NBC CONTAMINATION SURVIVABILITY.

NBC contamination survivability is comprised of the three elements of decontaminability, hardness, and compatibility. To survive NBC contamination, equipment must meet criteria of all three.

4.1 Decontaminability.

4.1.1 The ability of a system to be decontaminated to reduce the hazard to personnel operating, maintaining, and resupplying it is termed "decontaminability." Key words in this definition are the necessity to reduce the hazard to personnel. Thus, decontaminability criteria are related to personnel response to chemical and biological agents and to residual nuclear radiation.

4.1.2 Even under a "fight dirty" concept of operations where partial decontamination is the rule rather than the exception, decontaminatility is required. NBC contaminants could eventually breach the shield of the protective ensemble and, when operations permit, should be removed where they present a hazard. Further, decontamination reduces the soldier's vulnerability when the shield is dropped to satisfy basic physiological needs or to replace components of the NBC protective ensemble. Thus, decontaminability criteria are related to the response of unprotected personnel.

4.1.3 Decontaminability is enhanced by considering:

4.1.3.1 Materials. Maximize use of materials that do not absorb NBC contaminants and that facilitate their rapid and efficient removal with decontaminants readily available on the battlefield.

4.1.3.2 Design. Incorporate designs that reduce or prevent accumulation of NBC contamination and make those areas that are exposed readily accessible for decontamination.

4.1.3.3 Contamination Control. Employ devices and means that reduce the amount of contamination to be removed, such as positive overpressure systems for combat vehicles, packaging for supplies, and protective covers.

4.1.3.4 NBC Equipment. Provide for integration of NBC detection, measurement, decontamination, and contamination control devices. Consideration for integration of such devices at the earliest stage of the materiel acquisition process promotes maximum achievement of effective contamination avoidance, control, removal, and decontamination verification.

4.1.4 Criteria for decontaminability were developed by analyzing toxicity data, determining agent concentration levels corresponding to a negligible risk to unprotected personnel (or a "best substantiated combat ineffectiveness threshold estimate" in the absence of sufficient data to calculate a negligible risk value); and relating agent concentration to time, temperature, windspeed, and threat parameters.

4.2 Hardness.

4.2.1 The ability of a system to withstand the damaging effects of NBC contamination and decontamination agents and procedures require to carry out the decontamination process is termed "hardness." Although strongly related to decontaminability, hardness is a distinct characteristic; decontaminability is concerned with reducing the hazard to personnel as a result of decontamination efforts, while hardness is concerned with condition of the equipment after it has been subjected to an agent and decontamination.

4.2.2 Criteria for hardness were developed by analyzing vulnerabilities of construction materials to agents and decontaminants, considering mission profiles of classes of materiel designed to perform mission-essential functions; and determining allowable percentage degradations of quantifiable essential performance characteristics such as reliability, availability, and maintainability (RAM) standards.

4.3 Compatibility.

4.3.1 The ability of a system to be operated, maintained, and resupplied by personnel wearing the full NBC protective ensemble is termed "compatibility." Even if a piece of equipment is completely hardened against NBC contamination and decontaminants and can also be easily decontaminated, it still must have the capability of being operated effectively while in an NBC contaminated environment. Thus, in the development of equipment designed to perform mission-essential functions one must consider the combination of the equipment and personnel in anticipated NBC protection.

4.3.2 Collective protection enhances compatibility because it provides crew members a clean environment until they must exit to perform some essential task outside the enclosure. Unless individual protective gear is decontaminated or discarded, reentering crewmen will enter dirty. In some cases, agents may enter collective protection enclosures before the equipment is buttoned up. Thus, although collective protection may provide a "shirt sleeve" environment most of the time during a battle, it does not provide compatibility. However, for those systems for which collective protection does provide a continuous clean environment, the combat developer may elect to fulfill the compatibility requirement by utilizing collective protection. In doing so, he accepts the possibility of crew degradation should contamination enter and the crew be forced to don the individual protection ensemble.

4.3.3 Criteria for compatibility were developed by considering mission profiles of classes of equipment designed to perform mission-essential function, analyzing performance degradation of crew member operating the equipment while in protective ensemble, determining allowable percentage degradations of mission-essential functions, and relating those degradations to time and temperature parameters.

5. STANDARDIZED CRITERIA.

5.1 Decontaminability Criteria. (See explanatory notes in paragraph 5.4.)

DECONTAMINABILITY CRITERION

(CONTAMINANTS)

The exterior and interior surfaces of materiel developed to perform mission-essential functions shall be designed such that NBC contamination remaining on, or desorbed or reaerosolized from, the surface following decontamination shall not result in more than a negligible risk (as defined in table 1) to unprotected personnel working inside, on or 1 meter from the item. The following (worst case) conditions apply:

Exterior surfaces initially are uniformly and separately contaminated with 10 g/m^2 of thickened droplets of GD having a mass median diameter (MMD) of 2-5mm.

10 g/m^2 of unthickened VX.

10 g/m^2 of unthickened HD.

10^5 spores/m^2 of biological agent 1-5 micrometers in size.

4 g/m^2 of insoluble radioactive contaminants 37-200 micrometers in size and 185 GBq/m^2 gamma activity.

Initial contamination levels on interior surfaces subject to contamination are a factor of 10 lower than on exterior surfaces in the absence of evidence to the contrary.

Decontamination begins 1 hour after contamination using standard field decontaminants or simulants, equipment and procedures; and the decontamination process, excluding monitoring, lasts no longer than 75 minutes.

Suitable simulants may be used in lieu of the stated threat agents.

Exposure of unprotected personnel to the decontaminated materiel is not to exceed 12 hours based on the mission profile determined by the combat developer.

Surface temperature is 30°C and exterior wind speed no greater than 1 m/s (3.6 km/h).

(INDUCED ACTIVITY)

Materiel developed to perform mission-essential functions shall be designed such that, when exposed to a neutron fluence from a nuclear detonation that results in a total dose of 3,000 cGy (rad) to the crew of the equipment, the neutron induced activity in the item will result in no more than a negligible risk (as defined in table 1) to unprotected personnel arriving at H+2 and remaining inside, on, or 1 meter from the item for a period of time based on the mission profile, not to exceed 12 hours.

5.2 Hardness Criterion. (See explanatory notes in paragraph 5.4.)

HARDNESS CRITERION

Materiel developed to perform mission-essential functions shall be hardened to ensure that degradation over a 30-day period of no more than 20 percent in selected quantifiable mission-essential performance characteristics is caused by 5 exposures to NBC contaminants, decontaminants, and decontaminating procedures encountered in the field.

5.3 Compatibility Criterion. (See explanatory notes in paragraph 5.4.)

COMPATIBILITY CRITERION

The design of materiel developed to perform mission-essential functions shall take into consideration the combination of equipment and personnel in anticipated NBC protection.

The combination of equipment and NBC protection shall permit performance of mission-essential operations, communications, maintenance, re-supply, and decontamination tasks by trained and acclimatized troops over a typical mission profile in a contaminated environment not to exceed 12 hours:

In meteorological conditions of areas of intended use.

With no degradation, excluding heat stress, of crew performance of mission-essential tasks greater than 15 percent below levels specified for these tasks when accomplished in a non-NBC environment.

5.4 Explanatory Notes.

5.4.1 Selected negligible risk values are in table 1.

5.4.2 A 1-hour delay prior to beginning decontamination allows time for agent sorption, yet is generally not too long enough to allow elimination of surface hazard by weathering.

5.4.3 Initial contamination levels for interiors are a factor of 10 lower to account for the protection provided by the enclosure. Interior surface contamination will be limited to the exposed areas that could reasonably be expected to result from a successful surprise attack on the materiel item postured in its most vulnerable configuration, and to those exposed surfaces normally susceptible to agent transfer from a contaminated crew.

5.4.4 Seventy-five minutes is a typical time for decontaminating items with present decontamination procedures.

5.4.5 Although surface temperatures of equipment in the field will frequently exceed 30°C, this temperature is optimum for assessing decontaminability because it allows sufficient contamination to remain after the 1-hour sorption/weathering process, yet, causes sufficient outgassing of residual agent following decontamination to adequately evaluate the decontaminability process.

5.4.6 Requiring low airspeeds (less than 3.6 km/hr) results in greater chemical agent concentrations over time.

5.4.7 A radioactive fallout contamination of 185 GBq/m^2 would result in a H+1 dose rate of approximately 5 cGy (rad)/hr at 1 meter from a typical large armored vehicle. Using 50 cGy (rad) as a negligible risk dose which could come from exposure over a mission profile period (maximum of 12-hours), one half from operational exposure (i.e., direct radiation from initial

effects or from fallout on the ground) and the other half from equipment contamination, a decontaminability standard of 25 cGy (rad) dose per mission period is reasonable.

5.4.8 A neutron induced activity dose of 25 cGy (rad) per mission (maximum of 12-hour exposure) should be attainable for all items if reasonable attention is given to problem materials.

5.4.9 The "5 exposure" requirement in the hardness criterion refers to a cumulative total of contamination/decontamination cycles using one or more contaminants and associated decontamination processes.

Table 1. Negligible Risk Values for NBC Contaminants.

CONTAMINANT	VAPOR/AEROSOL	LIQUID[b]
CHEMICAL	($mg \cdot min/m^3$)	(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 ($0.01\ mg/cm^2$)[d]
BIOLOGICAL[c]		
RADIOLOGICAL	(maximum of 12 hour exposure)	
Contaminants	25 cGy (rad)	
Induced Activity	25 cGy (rad)	

[a] Applies to pilots.

[b] Applies to skin dose, not absorption through the eyes.

[c] Negligible risk values for biological agents are not determinable with the present database. Since extremely minute quantities of some biological agents can cause incapacitation, equipment should be designed to allow a residue of no more than 500 spores/m^2 of the specified initial contamination levels

[d] Since the effect of HD is localized, it is not appropriate to consider a threshold dose of liquid HD as applying to the entire 70-kg man. Use of mass/body surface area (mg/cm^2) units to describe the dose for which negligible effects are observed is preferable with the provision that the location and surface area must be specified, since mild incapacitation depends on where the contamination exists and the extent of body surface involved.

ANNEX A. REFERENCES.

1. Final Report SPC 810, "Nuclear, Biological, and Chemical Contamination Survivability Standards Study (U)," System Planning Corporation, August 1982. (SECRET)

2. QWG/NBCD Concept Paper, "Nuclear, Biological, and Chemical (NBC) Contamination Survivability for Army Materiel." (UNCLASSIFIED)

3. QSTAG 244, Edition 3, "Nuclear Survivability Criteria for Military Equipment (U)." (CONFIDENTIAL)

4. QSTAG 620, "Consistent Set of Nuclear Survivability Criteria for Communications-Electronics (C-E) Equipment (U)." (CONFIDENTIAL)

APPENDIX C. ABBREVIATIONS.

ACAMS	-	automatic continuous air monitoring system
AMC	-	Army Materiel Command
AMCR	-	Army Materiel Command Regulation
AR	-	Army Regulation
BG	-	*Bacillus subtilis* var. *niger*
C_e	-	effective average concentration
CGy	-	centigray (rad)
CFU	-	colony forming unit(s)
DA	-	Department of the Army
DS-2	-	decontaminating solution number 2
DTP	-	detailed test plan
EA	-	environmental assessment
FD/SC	-	failure definition/scoring criteria
FM	-	field manual
FP	-	fluorescent particle(s)
GD	-	chemical agent soman
HD	-	chemical agent distilled mustard
IAP	-	independent assessment plan
IAW	-	in accordance with
IEP	-	independent evaluation plan
MED	-	medical
MIL-STD	-	military standard
MINICAMS®	-	miniature automatic continuous air monitoring system
MIRAN®	-	miniature infrared analyzer
MMD	-	mass median diameter
MOPP4	-	mission-oriented protective posture level 4
MOS	-	military occupational specialty
NBC	-	nuclear, biological, and chemical
NEPA	-	National Environmental Policy Act
NIGA	-	neutron-induced gamma activity
OMS/MP	-	operational mode summary/mission profile
ORI	-	operational readiness inspection
PAM	-	pamphlet
psi	-	pounds per square inch
QA	-	quality assurance
QSTAG	-	Quadripartite Standardization Agreement
RDT&E	-	research, development, test, and evaluation
REC	-	record of environmental consideration
RH	-	relative humidity

RTM	-	real-time monitor
SAR	-	safety assessment report
SOMTE	-	soldier, operator, maintainer, tester, and evaluator
SOP	-	standing operating procedure
TGD	-	thickened soman
TIIN	-	test item identification number
TOP	-	test operations procedure
VX	-	a persistent nerve agent

APPENDIX D. REFERENCES.

REQUIRED REFERENCES

1. American, British, Canadian, Australian Armies Standardization Program, Quadripartite Standardization Agreement 747, Edition 1, NBC Contamination Survivability Criteria for Military Equipment, 12 August 1991.

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3. Headquarters, Department of the Army, Washington, D.C., Department of the Army Pamphlet (DA PAM) 385-61, Toxic Chemical Agent Safety Standards, 31 March 1997.

4. Headquarters, Department of the Army, Washington, D.C., Army Regulation (AR) 50-6, Chemical Surety, 1 February 1995.

5. Headquarters, Department of the Army, Washington, D.C., Army Regulation (AR) 190-59, Chemical Agent Security Program, 24 June 1994.

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7. US TOP 8-2-500, Receipt Inspection of CB Materiel, U.S. Army Test and Evaluation Command, Aberdeen Proving Ground, Maryland, 1 July 1984.

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9. Office of the Surgeon General, U.S. Army, Washington, D.C., Technical Bulletin MED 507, Heat Stress Casualty Control, 25 July 1980.

FOR INFORMATION ONLY

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j. Salomon, L. L., R. K. Dumbauld, and J. F. Bowers, Dugway Proving Ground Test Procedures for Assessing Compliance with the Chemical Decontaminability Requirements of AR 70-71, Paper presented at the Test Technology Symposium, 26-28 January 1988, The Johns Hopkins University, Laurel, Maryland.

Forward comments, recommended changes, or any pertinent data that may be of use in improving this publication to Commander, U.S. Army Test and Evaluation Command, ATTN: AMSTE-TM-T, Aberdeen Proving Ground, Maryland 21005-5055. Technical information may be obtained from the preparing activity: Commander, U.S. Army Dugway Proving Ground, ATTN: STEDP-WD-C-CT, Dugway, Utah 84022-5000. Additional copies are available from the Defense Technical Information Center, 8725 John J. Kingman Road, Ft. Belvoir, Virginia 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.

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13. ABSTRACT *(Maximum 200 words)*

This Test Operations Procedure (TOP) furnishes basic nuclear, biological, and chemical (NBC) contamination survivability testing information to facilitate test planning, conducting, and reporting, and to achieve standardized testing of mission-essential Army materiel. It describes typical facilities, equipment, and procedures used to contaminate the external surfaces of large items of equipment, to decontaminate the items, to sample for contamination remaining on the items' exterior surfaces, to assess the resulting degradation/damage to the items, and to assess the item/operator/NBC protective gear compatibility. This TOP is intended primarily for testing the survivability of externally contaminated large items of equipment such as combat vehicles, vans, shelters, and large packages of materiel that are decontaminated at the unit/support level, using power-driven decontaminating apparatus. This TOP was prepared in response to the requirements prescribed by Army Regulation (AR) 70-75.

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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure (TOP) 8-2-510 17 April 1998
AD No.

NBC CONTAMINATION SURVIVABILITY, LARGE ITEM EXTERIORS

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1. SCOPE.

1.1 Purpose.

a. Nuclear, biological, and chemical (NBC) contamination survivability is the capability of a system and its operators to withstand an NBC contaminated environment, including decontamination, without losing the ability to accomplish the assigned mission. Characteristics of NBC contamination survivability are decontaminability, hardness, and compatibility. To survive NBC contamination, materiel must meet criteria for all three. Agent must be used to measure decontaminability and hardness. Measuring hardness against decontamination agents can be accommodated without use of chemical agents. NBC contamination survivability should be monitored throughout the materiel acquisition cycle, and evaluated and assessed during development and operational testing.

b. This test operations procedure (TOP) provides basic information to facilitate planning, conducting, and reporting, and to standardize NBC survivability testing of military materiel. It is designed to provide results to demonstrate that large items of mission-essential equipment have met the provisions of Army Regulation (AR) 70-75[a*] as implemented by Quadripartite Standardization Agreement (QSTAG 747) 747, edition 1[1] (included as Appendix B of this TOP). It describes typical facilities, equipment, and procedures used to contaminate equipment, sample for contamination density, decontaminate, sample for residual contamination, determine degradation of mission-essential functions resulting from the contamination/decontamination procedures, and analyze crew/test item compatibility. Neutron-induced gamma activity (NIGA) is not addressed in the TOP. Information on NIGA can be obtained from other sources.

1.2 Limitations.

a. This TOP provides standard procedures for testing the contamination survivability of externally contaminated large items of equipment such as combat vehicles, vans, shelters, and large items of packaged materiel that are decontaminated at the unit/support level. It does not cover testing of small items of equipment intended to be decontaminated by the individual soldier using decontamination kits or by two- or three-man decontamination teams operating hand-held, portable decontamination equipment. Testing small items of equipment is described in TOP 8-2-111, NBC Contamination Survivability, Small Items of Equipment[b]. Also, this TOP does not cover testing of the interior spaces of large items of equipment, which will be described in another TOP to be published.

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* Reference letters/numbers correspond to letters and numbers in Appendix D. Many of the referenced documents apply to requirements of United States laws and regulations. Other nations should use their own laws and regulations.

b. The NBC contamination survivability criteria and implementation of the procedures of this TOP are not related to the safety criteria of AR 385-61[2] and Department of the Army Pamphlet (DA PAM) 385-61[3] or other local regulations governing the safety, handling, storage, and disposition of chemically-contaminated equipment.

c. Nuclear contamination survivability testing of equipment and systems, as specified in the NBC contamination survivability criteria, includes neutron-induced activity and activity resulting from fallout of radioactive dust and debris. When determining the nuclear contamination survivability of an item, the contribution from both sources must be considered. Induced radiation cannot be removed or reduced by present NBC field decontamination materials and procedures, and induced activity hazard testing requires different facilities, instruments, and safety considerations. Therefore, the procedures for nuclear decontamination in this TOP pertain only to removal of simulated nuclear fallout.

1.3 Method of Evaluation.

The following procedures must be used to evaluate the ability of the item tested to meet the criteria for decontaminability, hardness, and compatibility.

a. Decontaminability.

(1) Vapor Hazard. The effective concentration of agent vapor desorbed over time is C_e (see Paragraph 4.1.6.2.e). The mission time provided by the user is t. Then $C_e t = k$, which should be compared with the appropriate concentration value in Table 1 of Reference 1 (included in Appendix B of this TOP).

(2) Contact Hazard. The mass collected by the contact samplers should be adjusted for the average area of human contact with the item. This value should be compared with the appropriate mass value in Table 1 of Reference 1 (included in Appendix B of this TOP).

b. Hardness.

(1) Obtain the mission-essential performance characteristics from the material developer (i.e., voltage output, airflow, pressure, etc.).

(2) Measure these parameters on the as-received item.

(3) Perform the contamination/decontamination cycles. Measure the same parameters after each cycle.

(4) Compare pre- and post-contamination/decontamination measurements to obtain the percent degradation (if any).

c. Compatibility.

(1) Obtain the mission-essential soldier tasks from the user.

(2) Perform these tasks (timed) in the standard garment.

(3) Perform these tasks (timed) in mission-oriented protective posture level 4 (MOPP4).

(4) Compare the times and effectiveness of the operator(s).

1.4 Definitions.

Unique terms are defined in Reference 1 (see Appendix B of this TOP).

2. FACILITIES AND INSTRUMENTATION.

Facilities, instrumentation, and safety procedures used for chemical, biological, and nuclear survivability testing are strictly controlled. The principle controlling regulations are cited below. Additional discussion and requirements for facilities and instrumentation are included in the test procedures of Paragraphs 4.1 through 4.4.

2.1 Facilities.

Item	Requirement
Chemical laboratory and chemical agent storage facility.	Constructed to ensure safe and secure storage, handling, analysis, and decontamination of chemical agents used for research, development, test, and evaluation (RDT&E) quantities of chemical agents. The chemical agent laboratory, instruments, and personnel assignments must meet all requirements of AR 50-6[4], AR 190-59[5], and the safety requirements of reference 2 and Army Materiel Command Regulation (AMCR) 385-100[6].

Item	Requirement
Chemical agent test facility (chemical agent test chamber).	To house the test item during agent contamination, decontamination, and sampling. The chamber should have sufficient volume to allow free air circulation around the test item. Must be equipped and approved for work with chemical agents. All exhaust air must be filtered; equipment, interior surfaces, tools, and waste must be easily decontaminated. No agent may be released to the environment. Ability to control temperature, relative humidity (RH), and wind speed is required. The facility must be designed to ensure safe and secure storage, transfer, handling, challenge, and disposal of chemical agents, decontaminating solutions, and solvents. The toxic agent test facility and personnel screening must meet all requirements of References 4 and 5 and the safety requirements of References 2, 3, and 6.
Standard power-driven decontaminating apparatus.	To decontaminate the test item as part of the test procedure. To decontaminate the toxic test facilities after test completion. To stand by for emergency decontamination.
Fluorescent particle (FP) and biological assay laboratories.	Required to store and prepare test quantities of biological and residual nuclear contamination simulant materials, to charge disseminating devices, to prepare samplers, and to analyze all biological agent simulant and nuclear simulant (FP) materials.
Chambers for biological and residual nuclear simulant testing.	Equipped with an air intake and an exhaust system which exhausts through high efficiency particulate filters (capable of retaining 99.7 percent of particles 0.3 μm or greater in diameter) into an exhaust system. The chamber should have sufficient volume to allow free air circulation around the test item.
Personnel change room and shower facility.	To allow test personnel to shower and change into clean test clothing before and after assay of samples, and to reduce cross-contamination and contamination of facilities and non-test personnel.

Item	Requirement
Test range or appropriate operational test facility.	To allow the test item to be operated and to perform all mission-essential functions and tasks that are required to accomplish a typical mission profile. This includes tasks such as communications, aiming and tracking targets, firing weapons, using optical instruments, operating controls and switches, reading instruments, resupply, and decontamination. Must allow observation and measurement of any degradation of test item mission-essential functions attributable either to the contamination/decontamination procedures or the test item operators having to wear NBC protective gear.

2.2 Instrumentation.

Measuring Devices	Permissible Error of Measurement
Air temperature	±0.5°C
Relative humidity (RH)	±5 %
Wind speed	±0.1 m/sec
Still color camera	Adequate to document typical test procedures, details of contamination techniques, and any discrepancies from planned procedures necessitated by operational conditions.
Television camera, motion picture camera, and/or recorder	Adequate to monitor the test chamber or test range in real-time and to document test events and procedures.

2.2.1 Chemical Test Instrumentation.

Measuring Devices	Permissible Error of Measurement
Sampling chemical agent vapor off-gassing from contaminated surfaces [bubblers, miniature automatic continuous air monitoring system (MINICAMS®), solid sorbent tubes, or equivalent] with sampling efficiency >95 percent.	Flow rate in L/min, ±5 percent.
Chemical agent off-gassing (agent vapor sampling basket).	Sized as required to cover up to 1000±10 cm^2 area of the test item. Used as an airtight agent vapor accumulation chamber. See Paragraph 4.1.5.8.a for sizes and shapes. Must be made with a flexible wire frame, covered with appropriate low-absorbency plastic material (e.g., metallic-coated) to fit over curved surfaces. Must have a volume of approximately 10 liters, calculable or measurable to ±0.5 liters. The inlet must either have an in-line charcoal filter or be supplied with clean air.
Contamination density and droplet size (Printflex® cards, Kromecoat® cards, filter papers, or equivalent).	Contamination density, in g/m^2, ±10 percent; droplet size diameter in mm, ±10 percent.
Agent concentration in samples (spectrophotometer, automated or hand-injected gas-liquid chromatograph, or equivalent).	Agent/sample in mg, ±8 percent. (In automated mode. Better precision is achievable at additional cost and time).
Measuring and counting spot size instrument (Hamamatsu Image Analyzer™, Quantimet™, or equivalent).	Droplet stain size in mm, ±10 percent; droplet stain number by size, ±10 percent.

Measuring Devices	Permissible Error of Measurement
Chemical contact hazard samplers (silicone rubber samplers or equivalent). The silicone rubber that has been used is 1 mm thick, translucent, unfilled, poly (dimethylsiloxane) with a Durometer reading of 60[c]. The silicone rubber should be rinsed with water, then dried for 24 hours at 85°C. Circular disks of this material, 3.64 cm in diameter (area of 25 cm^2) were used as samplers.	Agent extraction efficiency from sampler in µg/sample, ±10 percent.
Applying chemical agent contamination to the test item.	Contamination density, in g/m^2, ±10 percent; droplet size, within range specified for the agent when using a syringe as the disseminator and best effort using an agent disseminator such as a spray nozzle.
Monitoring for agent within the toxic test chamber and safety monitoring of personnel in the toxic test facility. MINICAMS®, real-time monitor (RTM), miniature infrared analyzer (MIRAN®), automatic continuous air monitoring system (ACAMS), or their equivalent, may be used.	Near real-time. All instruments have differing sensitivities. The available instruments with the best sensitivity shall be used.

2.2.2 Biological Test Instrumentation.

Measuring Devices	Permissible Error of Measurement
Applying biological agent simulant contamination to the test item (Collison atomizer or equivalent).	Air contamination of $1\pm0.5x10^6$ colony forming units (CFU)/L of air.
Swab sampling of the test item (calcium alginate swabs, test tubes, and diluent).	Swab surface sampling efficiency in CFU/sample, ±10 percent.
Assay of biological simulants (microscopes, automatic colony counters, etc.).	Number of CFU/sample, ±10 percent.

2.2.3 Radiological Test Instrumentation.

Measuring Devices	Permissible Error of Measurement
Dissemination of fluorescent particles (FP).	Air contamination of $1\pm0.5x10^6$ particles/L of air.
Sampling FP surface contamination (Microtiter® plate-sealing tape, or equivalent).	>95 percent sampling efficiency.
Sampling airborne FP contamination (membrane filter samplers or equivalent).	>95 percent sampling efficiency.
Counting FP samples.	Number of FP particles/sample, ±5 percent.

2.2.4 NBC Compatibility and Hardness Test Instrumentation.

Measuring Devices	Permissible Error of Measurement
Measuring the differences in soldier tasks during operation of the test item while in (a) battledress uniform, and (b) NBC protective clothing. Devices for time-and-motion measurements will be standard items, but test-specific devices may also be required.	Precision and accuracy requirements must be compatible with the nature of the test item and function being studied, but must allow the detection of 15 percent degradation in the item/operator mission-essential performance in five trials or less.
Measuring the test item mission-essential performance characteristics before and after each of five nuclear, biological, or chemical contamination/decontamination cycles.	Precision and accuracy requirements must be compatible with the nature of the test item and type of function, but must allow for the detection of 20 percent degradation in the mission-essential performance characteristic after completion of the five contamination/decontamination cycles.

3. REQUIRED TEST CONDITIONS.

NBC contamination survivability testing requires the handling and use of chemical agents. Such testing is strictly controlled by Army Materiel Command (AMC) regulations. The procedures described in this TOP have been safely used by trained operators for many years. They are intended to provide general procedures only and should not be construed as regulatory in nature. Throughout testing, primary emphasis must be on operator and test safety, but the importance of technical quality, completeness of test data, and conformance with specified test and operating procedures cannot be overemphasized. Each NBC contamination survivability test plan must be reviewed for technical accuracy and conformance to regulations, safety procedures, and standing operating procedures (SOPs) applicable to the specific item and tests being conducted.

3.1 Pretest Preparation.

a. Review published test records, procedures, and the case files of tests of similar items to identify potential problem areas. Consult applicable safety and surety regulations to ensure compliance of all test procedures. Review all SOPs and procedures to be used for applicability, adequacy, and completeness.

b. Review the requirements documents, the operational mode summary/ mission profile (OMS/MP), and failure definition/scoring criteria (FD/SC). Use the independent evaluation plan (IEP) or the independent assessment plan (IAP) to determine the overall test structure, the data required, criteria, and analysis to be used. List the mission-essential performance characteristics and the mission-essential soldier tasks specified by the materiel developer and the combat developer respectively. These will be used to measure degradation in performance caused by NBC contamination and decontamination and by the need for the operator to wear the NBC protective ensemble. Identify the units of measurement and the accuracy and precision required for each parameter measured. Resolve all problems concerning measurable performance and degradation.

c. Review, coordinate with the assigned evaluator and assessor, and determine a realistic test item sample size. The sample size may be determined by test item availability, cost, or other factors and be less than optimum. If sample size is less than optimum, devise a testing scheme to optimize test item utilization and required data output.

d. Examine the test item design and the materials of construction. Compare them with the NBC survivability handbook[d] material lists and perform an analysis based on previous test experience and technical information from the materials' data base concerning their ability to survive exposure to contamination, decontaminants, and the decontamination process. Note any areas where agent could pool or seep, such as cracks, crevices, hinges, joints, countersunk screw heads or other difficult to decontaminate features. Although very difficult to accomplish, ensure that any identifiable vulnerabilities or questionable design or materials are adequately tested. If the steps above reveal any aspects of design or identify material that appears to make test failure probable, testing of the suspect design or material should be performed early in the test cycle. Preliminary results can often be determined from a pilot study and analysis of the collected information. However, test success can only be confirmed by using chemical agents.

e. Select and identify areas of the test item to be contaminated, decontaminated, and sampled for residual contamination. Identify areas that must be handled or touched by the operators. Ensure that the areas selected are typical and representative of the total test item surface and materials of construction and that they are areas likely to be contaminated and present an operator risk in an NBC environment.

3.2 Environmental Documentation.

An environmental assessment must be on file covering the storage, use, and disposal of the simulants, hazardous and contaminated materials, and agents used in NBC contamination survivability testing. The assessment must fully address the potential environmental impact of the specific survivability testing being planned. The detailed test plan (DTP) must cite the

environmental assessment (EA) and/or a record of environmental consideration (REC) that cites the EA and the appropriate categorical exclusion. The REC must be approved before testing begins. If the planned survivability testing is not adequately addressed in the existing environmental assessment, an environmental assessment specifically addressing the survivability testing to be conducted must be prepared, as required by the National Environmental Policy Act (NEPA[e]) and AR 200-2[f].

3.3 Test Controls and Limitations.

Controls and limitations applicable to a specific subtest are presented in Paragraph 4 as part of the procedure to which they apply.

a. A quality control plan should be prepared for each test program to ensure that variables are controlled and that appropriate records are kept throughout the duration of testing. Test variables include purity and stability of agents and simulants used, purity and stability of decontaminants and decontamination solutions, calibration and maintenance of instrumentation and disseminators, accuracy and precision of the laboratory analysis, and quality and uniformity of all test samples.

b. The condition of the test item at the time of testing is an important test variable. Unless receipt inspection was accomplished as part of a subtest completed before NBC contamination survivability testing, the test item should be inspected in accordance with (IAW) TOP 8-2-500[7]. Inspection data, certificates of compliance, or similar documentation, should be reviewed to ensure that exterior surfaces, finishes, and packaging meet specifications. Generally, the item should be tested in "as-received" condition, matching its condition when issued to troops in the theater of operations as closely as possible. NBC contamination survivability testing may be required periodically throughout the equipment life cycle if the effect of normal wear is a major factor in survivability.

c. Available robotics and automatic devices should be used whenever possible in test chamber operations to minimize exposure of test personnel to chemical agents.

d. Testing must always be conducted IAW approved test documentation, such as technical manuals, field manuals, equipment operating instructions, SOPs, the approved test planning directive, IEP/IAP, and the DTP. Deviations from test documentation will be put in writing and approved by the appropriate authority.

4. TEST PROCEDURES.

4.1 Chemical Contamination Survivability.

4.1.1 Objectives.

a. Decontaminability. Determine the chemical agent vapor and percutaneous hazards, including eye effects, associated with troop use of equipment that has been contaminated with chemical agent and decontaminated using standard and/or item-specific decontamination procedures.

b. Hardness. Determine the degree of performance degradation in mission-essential functions of military materiel after chemical agent contamination and decontamination by standard and/or test item-specific procedures.

c. Compatibility. Determine the degree of degradation in mission-essential soldier tasks as a result of operating a piece of equipment in MOPP4. See Paragraph 4.4 for details.

4.1.2 Criteria/Conditions.

4.1.2.1 Criteria.

a. Mission-essential equipment shall be hardened to ensure that exposure to five contamination/decontamination cycles does not degrade the operational mission-essential performance of the equipment more than 20 percent (or that specified by the combat developer) measured over a 30-day period. The five-cycle requirement refers to a cumulative total of five exposures to one or more contaminants (nuclear, biological, or chemical) and the associated decontamination processes.

b. The exterior surfaces of materiel developed to perform mission-essential functions shall be designed so that NBC contamination remaining on, or desorbed from, the surface following decontamination shall not result in more than a negligible risk to unprotected individuals working inside, on, or 1 meter from the item. The following NBC contamination survivability test conditions (Paragraph 4.1.2.2) apply.

4.1.2.2 Conditions.

a. General Conditions.

(1) Exterior surfaces initially are uniformly contaminated to a contamination density of 10 g/m^2 with 5- to 70-mg droplets of thickened soman (TGD), or 1- to 2-mg droplets of

unthickened distilled mustard (HD) or VX. The purity of the chemical agents used must be known and recorded as test data, and the quantity applied must be adjusted to achieve the required pure agent contamination density of 10 g/m^2.

(2) Decontamination begins 1 hour after contamination, using standard field and/or item-specific decontaminants, equipment, and procedures. The decontamination process, excluding monitoring, should last no longer than 75 minutes.

(3) The item surface temperature is 30°C and exterior wind speed is no greater than 1 m/sec.

(4) Hazard levels will be calculated assuming an exposure time based on the mission profile specified for the item by the combat developer, not to exceed 12 hours.

b. Detailed Conditions. Detailed conditions for chemical agent contamination survivability testing are given below.

(1) Chamber temperature and relative humidity (RH): 30±5°C and RH of 40±10 percent or as specified in the IEP or IAP.

(2) Chamber air circulation over the test item: <1 m/sec.

(3) Chamber pressure: negative to atmosphere.

(4) Agent contamination density: 10±1 g/m^2.

(5) Contamination drop size: (a) VX and HD: mass median diameter (MMD) 1.4±0.16 mm and (b) thickened soman (GD): MMD 3.5±1.5 mm.

(6) Time from sample collection to analysis: <7 days.

(7) Time from first test item hardness contamination to last hardness data collection: 30 days.

4.1.3 Controls and Limitations. The controls and limitations for chemical agent contamination survivability testing are:

a. Surface of the Test Item:

(1) Paint type, specifications, and application must comply with the military standards for the item. If the item requires repainting, all old paint must be removed to ensure a standard thickness and application of paint.

(2) Surface areas selected for sampling must be representative of the surface materials, texture, paint, and areas where the user will have direct contact.

(3) Before each trial, inspect and sample (vapor and contact) the surfaces of the test item for background contamination. All residual decontaminant and other foreign substances that could interfere with sample analysis must be removed before testing.

b. Sampler (Vapor and Contact) and Analysis Control Data. These will include:

(1) Nonoperated sampler control (a sampler taken into the room surrounding the test chamber but not aspirated).

(2) Operated sampler control (a sampler taken into the room surrounding the test chamber and aspirated, but not exposed to agent).

(3) Standard analytical controls (standard samples of known concentration, interspersed among the unknown samples, generally at a ratio of one control for each 10 unknown samples). The chemical analysis procedure shall be conducted using an appropriate number of standards, blanks, and analytical controls whose current concentrations are the same as when prepared, to ensure the reliability of the analytical procedure and to document the precision obtained with each batch of test samples. The standards need not be at equal concentration intervals; rather, they should be spaced closer together near the low concentration end of the calibration curve.

4.1.4 Data Required. Report the following data in the units indicated. Record the data in the smallest increments that the instrumentation/procedure is designed to achieve and be easily read.

a. Test chamber/hood: temperature --°C, RH -- percent, wind speed (airflow) -- m/sec.

b. Agent: name and control number, purity -- percent, viscosity after adding thickener (if thickened) -- centistokes (cSt), age since thickened (if thickened), quantity of dye and thickener (if thickened) -- g/L, and quantity of agent dispensed -- grams.

c. Quantity of agent dispensed -- grams.

d. Agent contamination density -- g/m^2.

e. Agent droplet diameter -- mm.

f. Results of each post-decontamination agent vapor and contact sample (collected during the 12-hour sampling period) -- µg/sample.

g. Results of sampling and analysis controls and standards.

h. Sample history with elapsed time to analysis -- days.

i. Contamination, weathering, decontamination, and sampling times -- minutes.

j. Names and titles of principal test participants.

k. Description of decontamination solutions (i.e., formulation, active ingredients, and age), methods, equipment, and item-specific procedures used.

l. Description of test item exterior surface condition (pretest), including construction materials, paint type, paint thickness (number of coats), paint condition, and surface cleanliness (mud, grease, and other), with photographs.

m. Description and photographs of test item joints, cracks, crevices, and other features that could allow contaminants to enter and may be difficult to decontaminate.

n. Pretest (baseline) and posttest (30 days after the first contamination) mission-essential functional performance data, recorded to the highest level of accuracy and precision that is commensurate with the parameter being measured.

o. A system safety risk assessment of test findings IAW guidance in Military Standard (MIL-STD)-882B[g] (also see TOP 1-1-060[h]).

p. The stain size on the surface caused by the agent drops (if safety procedures permit, and if these data are desired).

q. A description of the use concept requiring the contact sampling times specified [Paragraph 4.1.5.8.b (3)].

4.1.5 Methods and Procedures. The use of the actual test item is the most reliable and realistic method for assessing all aspects of the item's decontaminability. These aspects include assessing for agent trapped in cracks, in crevices, between components, in angles, and in odd shapes not

easily decontaminable, and evaluating all of the item's textures, and geometry. However, it is not always feasible and/or cost effective to use the actual item to determine decontaminability. Proper scaling techniques must be applied if the whole item is not contaminated. The data requirements, scaled down test methods, and data analysis for the actual item and component testing are essentially the same and may be the only source of data. If the small section or component method is selected for testing all or a portion of a large item, follow the procedures in Reference b. Actual item testing is the preferred method and should be used when feasible and cost effective. The test methods and procedures that follow are for the actual item of equipment.

4.1.5.1 Test Location. The test will be conducted inside a toxic test facility (test chamber) approved for use with chemical agents.

4.1.5.2 Agents. Agents to be used are listed below.

a. Neat VX with a purity greater than 85 percent. The agent may be dyed with approximately 0.5 percent (weight/volume) of a suitable dye.

b. Neat GD with a purity greater than 85 percent and thickened with 5 percent (weight/volume) of Rohm and Haas Acryloid™ K125 poly(methyl methacrylate), lot no. 3-6326. This should provide thickened agent with a viscosity of 2300 cSt at 25°C[j]. Batch-to-batch variability in viscosity can be greater than 10 percent. Complete solution of the polymer in GD is slow; therefore, mixing should continue until the measured viscosity is constant. The agent may be dyed with approximately 0.5 percent (weight/volume) of a suitable dye.

c. Neat HD with a purity greater than 85 percent. The agent may be dyed with approximately 0.5 percent (weight/volume) of a suitable dye.

4.1.5.3 Receipt Inspection and Functional Performance.

a. Before testing, perform a receipt inspection on the test item(s) (see Paragraph 3.3.b). Inspect for shipping damage, completeness of assembly, required accessories, and necessary manuals, logbooks, etc. Document any missing components, damage, or other discrepancies noted.

b. Inspect the surfaces for foreign materials normally not present on the item (dust, mud, grease, or marking). Remove foreign materials by brushing, vacuum cleaning, or washing with soapy water and sponge. Record the surface condition, surface cleanliness, corrosion, materials of construction, variance from standard painting, and paint condition.

c. Operate the test item according to the operator's manual. Measure and record mission-essential functional performance characteristics identified by the combat developer. Based on the selected functional performance characteristics, each functional performance characteristic should be classified as either a functional performance attribute (go, no-go) or as a functional

performance variable measured over a continuous range of values. Measure each parameter at least twice, depending on the inherent difficulty of reproducing a precise value, and record to the smallest significant units of measure. Do not proceed with testing if any damage, surface condition, or a mission-essential functional performance characteristic falls outside developer specifications.

d. "Mockups" may be used on some tests in lieu of expensive or nonexpendable test items. The mockups may be specially fabricated to simulate the test item or may be the actual test item with expensive optical, electronic, or other internal components removed. The mockups should be furnished and/or approved by the materiel developer. Carefully analyze and document the similarities and differences between the mockup and the test item it simulates.

4.1.5.4 Test Preparation.

a. Use qualified and trained operators, standard equipment (the same type of equipment that would be used by troops for that test item), and standard decontamination procedures as specified in Field Manual (FM) 3-5[8] or the item-specific technical manual.

b. Examine each test item and select the areas to be contaminated with agent and then sampled. Before each trial, inspect and sample the surfaces of the test item. All residual decontaminant and other foreign substances that could interfere with sample analysis must be removed before testing. Selection of the number, location, and shape of the areas to be tested will depend primarily on the OMS/MP. Other considerations include test item size, geometry, materials of construction, paint, surface texture, and presence of joints and crevices. Crew assignments, the locations most likely to contribute to crew vapor and contact hazard, and any areas that might allow contaminating agents and decontaminating solutions to seep into and degrade delicate or vulnerable equipment are primary considerations. Select an appropriate number of such areas (minimum of three) to be contaminated and sampled. The number of areas selected should be supported by statistical analysis to provide quality data. Each area should be approximately 1000 cm^2 and representative of the test item's surfaces and vulnerable areas. Photograph and describe each test area selected. Prepare a line drawing, sketch, or photograph of each test area, showing the locations designated for sampling. Vapor sampling will be performed with the aid of a sampling basket (Paragraph 4.1.5.8.a). Do not place any marks on the item test areas to be sampled.

c. Before testing begins, rehearsals should be held to familiarize test crews with the functioning of the test item, test procedures, and data requirements. Crews should practice, using simulants, until agent-dispensing, decontamination, and sampling become reproducible and routine. The test items to be used on the actual test should not be used on rehearsals with simulants. It is recommended that one or more "dry-runs" be performed to give operators an opportunity to demonstrate, standardize, and confirm operational procedures. An operational

readiness inspection (ORI) will be performed and the data evaluated before testing begins.

d. Place the test item in the test chamber and bring the chamber to the environmental conditions specified for the test. Condition the test item until it has equilibrated at 30±5°C. Temperature and RH should be recorded continuously throughout the test.

e. Before agent contamination, background swab and vapor samples should be taken from or near areas designated for contamination testing. The sampling and analysis must be tailored to detect materials that could interfere with the chemical analysis for the agent being used.

f. Place appropriate sampling cards on or adjacent to the test item when droplet sizing and contamination density assessments are required. Place the cards in an area that will be representative of the surface that will be contaminated IAW the OMS/MP.

g. Agent contamination procedures may result in undesirable contamination of certain areas of the test item, chamber floor, instrumentation, etc. The use of a protective pattern (a cover with a 1 square-meter hole in it) cut to the dimensions of the contamination area(s) and easily-removable covers for the floor and instrumentation are recommended to minimize undesirable background contamination.

4.1.5.5 Test Chamber Operation. The test chamber will be operated using the procedures, controls, and SOPs used to approve the chamber and/or those approved for the agent in use. Some general technical data requirements for the test chamber are presented below.

a. The test chamber environmental conditions should be computer-monitored and data should be recorded at least every 15 minutes. The environmental conditions include air temperature, RH, wind speed, test item surface temperature, and pressure (chamber vs. atmospheric).

b. Real-time safety sampling for agent vapor concentration will be performed at a minimum of two locations within the test chamber, with the readout displayed visually and recorded. Instruments used must be calibrated for the agent used and may include miniature infrared analyzer (MIRAN®), miniature automatic continuous air monitoring system (MINICAMS®), automatic continuous air monitoring system (ACAMS), or their equivalents.

c. Real-time safety sampling will be performed in spaces occupied by unprotected individuals. Instruments must be matched to the agent used and may include M8 alarm, real-time monitor (RTM), MIRAN®, ACAMS, MINICAMS®, or their equivalents.

d. The test chamber exhaust system will be activated before the start of agent dissemination and will operate at the maximum rate that will allow the chamber environmental

conditions to remain within the test limits. The purpose is to reduce the chamber agent vapor concentration to the lowest possible level.

4.1.5.6 Agent Application.

a. Contaminate the selected areas of the test item with agent of known purity and viscosity. Apply the agent with a suitable dissemination device that has been calibrated with material of similar physical properties and operated at the flow rate and pressure to achieve the drop size and contamination density specified in the DTP. Avoid contaminating areas of the test item beyond the areas selected for sampling.

b. Immediately after contamination, all agent on the floor or on areas not required for test data should be immediately decontaminated. Be careful not to adversely affect instrumentation and data collection. Remove the particle size and contamination density samplers; decontaminate the agent disseminators, being careful of the agent disseminators and other support equipment. Place the contamination density samplers in a jar with the appropriate type and quantity of solvent, seal tightly, label, and transport to the chemical laboratory for analysis. Place the particle-size sampling cards in a carrying tray and, depending on the type of card and agent used, either process immediately or allow the predetermined time for the drops to spread. Count and size with a Hamamatsu Image Analyzer™, or with equivalent instruments.

NOTE: To prevent excessive drop overlap when counting and sizing drops, it may be necessary to adjust the disseminator and contamination procedures so that more than one disseminator pass is required to achieve the required contamination density. Remove the drop-size samplers after one pass.

4.1.5.7 Decontamination of the Test Item.

a. Decontamination should begin 1 hour after completion of contamination. Use standard procedures, decontaminants, and equipment as described in Reference 8, and/or any test item-specific procedures when supplied as part of the test-documentation package (i.e., the manual).

b. To avoid bias, the individuals performing the decontamination shall not be the same persons who performed the contamination.

c. Start decontamination with areas contaminated first and end with areas contaminated last. Predetermine the time allowed for decontamination of each test item, and remain within the time established. The decontamination process should last no longer than 75 minutes, including decontaminant residence time, but excluding agent monitoring time.

d. Decontamination procedures should be performed as if the entire surface of the test item

were contaminated. The contaminated sampling areas should receive no more or no less attention, time, or effort than uncontaminated areas. Appropriate time should be spent on angles and hard-to-work areas.

e. Document decontamination procedures. Video documentation is recommended.

4.1.5.8 Post-decontamination Sampling.

a. Vapor Sampling Baskets.

(1) When the surfaces of the sampling areas are no longer visibly wet with decontamination/water solutions, place a 10-liter agent vapor sampling basket over the selected 1000-cm^2 sampling area and make an airtight seal with tape. Measure or calculate the volume of the basket when attached and sealed. The basket requires a diffusing device on the intake and exhaust ports to help ensure uniform air movement over the entire selected surface area; the inlet must either have an in-line charcoal filter or be supplied with fresh air.

(2) If the surface configuration of the test item does not permit a 1000-cm^2 sampling area, smaller baskets can be used. When using smaller vapor sampling areas, select the areas and construct the baskets to maintain the ratio of 1000-cm^2 surface evaporation area to 10-liter basket volume.

(3) Aspirate fresh air through the sampling basket at the rate of 15 liters per minute for 4 minutes (minimum of six air changes) to remove trapped agent vapor.

NOTE: Use temperature-conditioned, clean air or filtered chamber air to replace the air aspirated from the basket.

(4) Start and continuously sample the air in the sampling basket. Use samplers appropriate to the measurement required. Sample for agent vapor in the basket air for the prescribed sampling periods over the total 12-hour period.

(5) If a sampling basket with a smaller evaporation surface area is used, the sampling basket must be engineered to consider flow rate so that the average air exchange rate and velocity over the evaporation surface will remain constant in baskets of different sizes.

(6) If cumulative samplers (bubblers or solid sorbent tubes) are used, select a sampling schedule to match the expected agent vapor off-gassing rate. Ensure that a minimum of two vapor samples are obtained for any time interval (three samples are desirable). An exact vapor sampling sequence must be specified in the DTP for the 12-hour period.

b. Agent Contact Hazard Sampling.

(1) Locations on the test item where direct contact with the operator's skin or hands or prolonged contact with other clothed body parts is expected shall be sampled. The DTP will specify other locations to be selected.

(2) Take a minimum of two contact samples from each area selected for contact sampling. The "0-hour" sample shall be taken simultaneously with the sampling basket 4-minute aspiration period [Paragraph 4.1.5.8.a(3)] before starting vapor sampling. The final contact sample shall be taken after all vapor samples have been collected. If an area is of particular concern for contact hazard, a contact sample may be taken each time the vapor samplers are changed.

(3) Prepare contact samplers [a thin disk of silicone rubber (1 mm thick) or other suitable material] with a nominal size of 25 cm^2. The contact sampler should be backed by aluminum foil to prevent contamination of the weight, and then by a material such as sponge rubber to force contact with all surface irregularities. Place the assembled sampler on the selected area using a pressure of approximately 65 g/cm^2 for 10 seconds. Additional contact samplers can be sequentially placed on the same area, for selected intervals of time up to a total of 60 seconds, in multiples of 5 seconds. These sequential contact sampling times should relate to the use concept of the item (e.g., how long a human might be expected to lean on, touch, hold, etc., the area sampled). A slight rocking motion may be required to apply sampling force more uniformly to surfaces that are slightly curved. Immediately remove the sheet of silicone rubber. Place the sheet in a sample jar with the appropriate type and quantity of solvent, seal the jar, and transport it to the chemical laboratory for analysis.

c. Sampling and Analysis. Sampling and analysis should use test instruments and methods that give precise and accurate values for the primary data parameters. Most military chemical alarms, detectors, detector papers, and kits provide only qualitative "yes/no" answers. Data from such sources should be used to complement data obtained from more precise test instruments.
4.1.5.9 Hardness Determination.

a. After completion of all decontamination and sampling procedures, inspect all surfaces of the test item for visible evidence of leakage and degradation caused by the agents, decontaminants, and decontaminating procedures. Describe any degradation; document with photographs. Operate the test item according to the appropriate manual. Measure and record mission-essential performance characteristics. Measure each parameter at least twice. Interview operators and record all evidence of operational degradation. The hardness data collected must be compatible and comparable with the pretest values recorded (Paragraph 4.1.5.3.c).

b. The required five contamination/decontamination cycles may be conducted with any one or a combination of the three chemical agents, or all five cycles may be conducted with chemical

agents, biological simulant, nuclear fallout simulant, or any combination of these. If more than one replicate of five hardness cycles is required to obtain a hardness determination, a different test item must be used so that no more than five contamination/decontamination cycles are performed on any one test item. Select the sequence and the type of contamination/decontamination procedures required for the five cycles of the hardness determination after evaluation of the test item's identifiable vulnerabilities and questionable materials of construction (Paragraph 3.1.d).

c. Hardness data collection should be performed after each contamination/decontamination cycle and 30 days after the first contamination. Hardness data must be sufficiently accurate and precise to define any degradation over five cycles and a 30-day period.

4.1.6 Data Reduction, Presentation, and Evaluation.

4.1.6.1 Receipt Inspection.

a. Assemble and collate all data on item damage, missing components, surface condition, other discrepancies, and test item history. Summarize and present results in tabular form, emphasizing deviations from developer specifications and surface cleaning or maintenance performed.

b. Assemble and present "mockup" receipt-inspection data, noting differences between the mockup and the test item.

c. Assemble data pertaining to surface materials and their finishes in a form that can be presented to compare pre- and posttest hardness functional performance data.

4.1.6.2 Decontaminability. Chemical decontaminability will be determined by comparing post-test residual hazards with established criteria for each agent (Paragraph 4.1.2.1). The item will be considered chemical agent decontaminable if residual vapor and contact hazards are reduced to levels at or below the established decontamination criteria.

a. Describe each sampling area, including the location, material of construction, surface geometry, and surface texture. Cite the agent, contamination procedure, decontaminant, and the decontaminating procedures used, including item-specific procedures and time expended on each procedure. Obtain video coverage of the decontamination operation, if possible. Describe the statistical analysis used to define the number of areas to be tested to provide quality data (Paragraph 4.1.5.4.b).

b. Summarize and present the chamber conditions during the test period. Present the agent physical properties, agent contamination density, and the drop size for each item or sampling

area. Identify deviations from specified values.

c. Tabulate the quantity of agent recovered from each agent contact sampler, identified by the location and time at which the sample was taken.

d. Determine the probable contact hazard level for each test item and compare it with the approved NBC contamination survivability criteria in Table 1 of Appendix B [also see Paragraph 1.3.a(2)]. Consider the test item MP, probability of contact, type of contact, contact time, type of agent, and contact hazard sampler-to-skin correlation factors (bare skin, clothed, and contact pressure). The factors to be considered will vary significantly for every type of item tested. The procedures for assessing operator contact hazard must be tailored to each test item and mission scenario.

e. Tabulate the average concentration of agent vapor recovered from each test item sampling location (component, if used) identified by time. Consider the test item mission, probable mission scenario(s), and operator location and estimate the effective average concentration (C_e), that is, the fraction of the average concentration that is likely to be presented to and be inhaled by the operator [Paragraph 1.3 a(1)]. Compare the results with the approved NBC contamination survivability criteria for military materiel in [Table 1 of Appendix B and Paragraph 1.3 a(1)].

(1) No simple procedure exists for determining vapor hazard to the test item operator(s). The credible dosage received is a function of agent desorption from the decontaminated test item, worst-case or other selected scenarios that have almost unlimited variables, and the established "no effects" criteria.

(2) One approach to determine if agent vapor dosages from a test item are likely to exceed the established criteria has been presented[j]. This approach hypothesizes exposure scenarios on a case-by-case basis, depending on the test item and its expected use in the field.

f. If an area fails the decontaminability criterion, attempt to identify the material composition responsible for the failure.

4.1.6.2 Hardness.

a. Summarize and tabulate all post-trial mission-essential performance data, identified by test cycle number, agent, and decontaminant.

b. Compare the mission-essential performance data for each contamination/decontamination cycle with the receipt inspection performance data. Use the mission-essential performance data and operator interview data to determine whether more than 20 percent degradation in item performance has occurred (Paragraph 1.3 b). Highlight and discuss significant results.

4.1.7 Adapting to Simulant Agent Testing.

a. As a general rule, the data requirements, facilities, and procedures for simulant testing will be similar to those used for toxic agent testing. The major differences will be in the level of safety and environmental protection restrictions required and the lower approval requirements for simulant test chamber work than for toxic agent work. Simulants must be used when a test is performed by soldier, operator, maintainer, tester and evaluator (SOMTE) personnel; when toxic test facilities are not available; when the nature of the equipment being tested makes the use of chemical agents impractical; or when an out-of-doors test setting is required. However, testing hardness with simulants tests only the effects of the decontaminant and the decontamination procedures. Any adverse effects that could be caused by chemical agents are not tested.

b. Many test items that fail hardness testing will not fail because of the agent contamination, but will fail because of the wetting and corrosive action of the decontamination solutions and procedures on delicate optical, electronic, and mechanical components. However, when performing decontaminability tests using simulants, determination of residual hazard after decontamination loses some relevance and may require agent testing for a final determination of decontaminability. That is, agent tests may be required to demonstrate that an item meets survivability requirements. Agent tests may still be needed to demonstrate the adverse effects caused by the chemical agent on the hardness of the item.

4.1.7.1 Facilities and Instrumentation.

a. The facilities required for simulant testing are the same as for agent testing, except for the test chamber. The chamber size, environmental controls, and instrumentation will be the same; however, less stringent safety and environmental protection equipment and approval for testing will be needed.

b. The instrumentation required for simulant testing will generally be the same as for agent testing. Occasionally, different sampling equipment and procedures may be required.

c. Simulant use makes out-of-doors testing possible. Under these conditions, the requirement for a test chamber is eliminated, but the need for other facilities and for most of the instrumentation remains unchanged.

(1) Out-of-doors testing will require that the acceptable temperature, RH, and wind speed limits be expanded so as to cover the variability expected during the test period. Also, limits on other environmental parameters will have to be included, such as limits on precipitation, dew, solar radiation (sunshine), and cloud cover.

(2) Out-of-doors testing will result in more realistic environmental test conditions, but will complicate data analysis and comparison of different sets of test data.

4.1.7.2 Procedures. Most aspects of simulant testing procedures will be the same as for agent testing. These include objectives, criteria, controls and limitations, data required, receipt inspection, pretest preparation, test chamber operation, test item contamination, and test item sampling. Safety procedures may be somewhat relaxed when working with simulants; however, test controls, test procedures, and data collection should be emphasized just as rigorously as when conducting agent testing.

4.1.7.3 Agent Simulant Selection.

a. The selection of chemical compounds to simulate chemical agents is a critical step in testing with simulants. The simulants selected should be safe to handle and require minimum protective gear, equipment, and procedures; cause little or no environmental concern; and require minimum handling and storage problems. Selection of appropriate simulants is difficult.

b. Simulants selected for hardness testing should have volatility, viscosity, and surface tension values similar to the agent being simulated; require approximately the same mechanical energy to remove from surfaces; and be easily seen when applied in the appropriate drop size. Such simulants must also simulate the probability of damage to mechanical, optical, electrical, or thermal properties by the agent. Even if a simulant adequately mimics all of these properties, there is no assurance that the simulant will have the same effect on the test item as chemical agent.

c. Simulants selected for decontaminability testing must closely match the properties listed above, as well as sorption/solubility in the surface, and diffusion coefficient, and must also have similar chemical interactions with the decontaminants used, solubility in the decontamination solution, and have a sensitive laboratory analysis procedure. Decontaminability and residual hazard data lose relevance without adequate side-by-side agent/simulant comparison data to confirm test procedure validity. Such agent/simulant comparison data must be obtained in a laboratory study. Experience has demonstrated that no single compound will simulate all of the

important properties of an agent. Performing replicate decontaminability tests using two or more simulants with different properties on each test may be needed to meet selected data requirements.

4.1.7.4 Decontamination. The procedures used during decontamination will be the same as used for agent testing. However, the chemical reaction between the simulant agent and the decontaminating solution will not be the same or may not proceed at the same rate as with agent.

4.1.7.5 Sampling and Analysis. The sampling devices and analytical procedures used to sample and analyze the simulant should be selected to be as sensitive as those used in agent testing.

4.2. Biological Contamination Survivability.

4.2.1 Objectives.

a. Decontaminability. Determine hazards associated with troop use of equipment that has been contaminated with biological material (simulant spores) and then decontaminated using standard and/or item-specific biological decontamination techniques.

b. Hardness. Determine degradation in mission-essential performance characteristics of military materiel after biological agent contamination and then decontamination, using standard and/or item-specific techniques.

4.2.2 Criteria/Conditions

4.2.2.1 Criteria.

a. Materiel developed to perform mission-essential functions shall be hardened to ensure that exposure to five NBC contamination/decontamination cycles does not degrade the mission-essential performance of the equipment more than 20 percent or that specified by the combat developer measured over a 30-day period. The five-cycle requirement refers to a cumulative total of five exposures of one test item to one or more contaminants (nuclear, biological, or chemical) and the associated decontamination process.

b. After decontamination, residual contamination levels for mission-essential equipment must constitute a negligible risk at most to unprotected users of the equipment. In the determination of biological simulant survivability, the following NBC contamination survivability test conditions apply (Appendix B).

4.2.2.2 Conditions.

a. General Conditions.

(1) Exterior surfaces initially are uniformly contaminated with $1x10^7$ CFU/m^2 of biological agent simulant 1 to 5 µm in size.

(2) Decontamination begins 1 hour after contamination, using standard field and/or item-specific decontaminants, equipment, and procedures. The decontamination process lasts no longer than 75 minutes. The item surface temperature is 30°C, and the wind speed (air movement) is no greater than 1 m/sec.

(3) Hazard levels will be calculated assuming an exposure time based on the mission profile (MP), as specified by the combat developer, not to exceed 12 hours.

b. Detailed Conditions. The detailed conditions for simulant biological agent/contamination survivability testing are given below.

(1) Chamber temperature and RH: 30±5°C and ambient RH.

NOTE: Cooler temperatures and higher RH are worst-case contamination hazards for most biological agents (e.g., 10°C and 75 percent RH).

(2) Test chamber air circulation over the test time: <1 m/sec.

(3) Test chamber pressure: negative to room/atmospheric pressure.

(4) Exterior simulant contamination density: $1\pm0.5x10^7$ CFU/m^2.

(5) Simulant particle size: 1 to 5 µm.

(6) Sample and analysis controls: test-item background control sample, swab control (unused swab), diluent control, plate control, and maximum time of 18 hours between sample collection and analysis.

4.2.3 Controls and Limitations. The controls and limitations for simulant biological agent/contamination survivability testing are:

a. Test Item:

(1) Paint type, specifications, and application must comply with military standards for the test item.

(2) Surface areas selected for sampling must be representative of the exterior surface paint, materials, texture, and the areas where the user will have direct contact.

b. Sample and Analysis Controls: (l) laboratory control, (2) swab control (unused swab), (3) swab of a noncontaminated surface in the field, (4) diluent control, (5) plate control, and (6) a maximum of 18 hours between sample collection and analysis.

c. Decontamination Control:

(1) Describe decontaminating solution: formulation, active ingredients, and age.

(2) Contamination weathering time before start of decontamination: 1 hour ±2 minutes after completion of contamination. The decontamination process should last no longer than 75 minutes.

(3) Use qualified and trained operators, standard equipment (the same type of equipment that would be used by troops for that test item), and standard procedures.

4.2.4 Data Required. Report the following data in the units indicated.

a. Chamber temperature -- °C, RH -- percent, and wind speed (airflow) -- m/sec.

b. Agent simulant *Bacillus subtilis* var. *niger* (BG): control number, diluent used, viscosity (centistokes), percent solids, date harvested and/or reconstituted, date used, and CFU per mL.

c. Disseminator used, quantity of BG suspension disseminated -- mL, air pressure -- psi, and dissemination time -- seconds.

d. Still color photographs and written description of each area contaminated.

e. Simulant contamination density for each sampling area before and after decontamination, expressed in CFU/sample.

f. Chamber air simulant contamination level immediately after dissemination, expressed in CFU/L of air.

g. Results of swab sampling before and after decontamination, expressed in CFU/sample.

h. Results of sampling and analysis controls and standards, expressed in CFU/control.

i. Sample history with elapsed time to analysis -- hours.

j. Elapsed time required to complete simulant contamination, weathering time before decontamination, decontamination time, and time of each sample -- minutes.

k. Description of the decontamination solutions (i.e., formulation, active ingredients, and age), methods, equipment, and item-specific procedures used.

l. Names and titles of principal test participants.

m. Description of test item exterior materials of construction, paint type, and surface condition (pretest and posttest), including cleanliness (mud, grease, and other). Photographs should be made of joints, crevices, textures, or other areas that may be difficult to decontaminate or allow liquid to penetrate.

n. Pretest and posttest mission-essential functional performance characteristics used as the measure of the test item's mission performance before and after exposure to simulant contaminants, decontaminants, and decontaminating procedures.

o. Results of posttest operator questionnaires and comments.

p. A system safety risk assessment of test findings IAW guidance addressed in Reference g (also see Reference h).

4.2.5 Methods and Procedures.

4.2.5.1 Test Location. The test will be conducted inside a test chamber, building/room, or shelter approved for dissemination of biological simulant.

4.2.5.2 Biological Agent Simulant. The simulant of choice for this test is a spore suspension of BG. Experience has shown it simulates the behavior of anthrax and is a worst case simulant for other biological agents.

4.2.5.3 Receipt Inspection and Functional Performance. Perform a receipt inspection and pretest mission-essential functional performance test as described in Paragraph 4.1.5.3, if not previously performed as part of another test phase.

4.2.5.4 Pretest Preparation.

a. Before each trial, sample the surfaces of the test item for residual decontaminant and for other foreign substances that could interfere with sample analysis.

b. Analyze the test item and identify the locations and materials to be sampled for simulant contamination. Selection of the number, shape, and location of areas to be sampled will depend on the OMS/MP, and concept of use. Also consider test item size, geometry, materials of construction, paint, surface texture, cracks, crevices, and accessibility for decontamination. Consider crew assignments, the locations most likely to contribute to crew inhalation and contact hazard, and any areas that might allow contamination and decontaminating solutions to seep into and degrade sensitive equipment. Identify three 25-cm^2 sampling areas from each material and/ or location selected. Duplicate sampling of each material and location is desirable, making a total of six 25-cm^2 sampling areas per material/location. Describe and sketch or photograph each sampling area. If any areas or components of the test item have been identified by the combat developer for item-specific decontamination procedures, identify such areas, components, and procedures. Do not place any marks on the surfaces to be sampled.

c. Use qualified and trained operators, standard equipment (the same type of equipment that troops would use with the test item), and standard decontamination procedures.

d. BG is a common microorganism living in most soils and is safe to handle and use as a simulant test organism without wearing protective equipment. However, to control laboratory background contamination and preclude any possibility of operators developing an allergic reaction to the organism, conduct all testing with BG inside a test chamber approved for the testing of biological simulants. Always follow the procedure controls and SOPs in effect at the time the chamber was approved for biological simulant testing.

e. Before the start of testing, rehearsals may be required to familiarize test crews with all test procedures and data requirements. Allow crews to practice until operations for simulant dispensing, decontamination, and sampling become reproducible and routine. For rehearsals, do not use the test item to be used for testing.

f. Place the test item in the test chamber and bring the chamber to the environmental conditions specified for the test. Temperature-condition the test item for a minimum of 24 hours. Record temperature, RH, and wind speed at a minimum of every 15 minutes for the duration of the test.

g. Before simulant contamination of the test item, swab sample the first of each three 25-cm^2 sampling areas to determine the background contamination level and residual substances (decontaminant) that could interfere with sample assay.

h. Contamination procedures will result in simulant contamination of unwanted areas of the test item, chamber floor, instrumentation, etc. The use of easily removable covers or templates for unsampled areas of the test item, chamber floor, and instrumentation are recommended for reducing the background contamination level.

4.2.5.5 Contamination and Contamination Density Sampling.

a. Calibrate a nebulizer (Collison disseminator or equivalent) to disperse BG containing particles in the 1- to 5-µm size range and determine the appropriate operating time, air pressure, and slurry concentration. Contaminate the air inside the chamber to a level of approximately 1x 10^6 CFU/L of air. The exact BG slurry count, the generator air pressure, the duration of generator operation, and the number of BG CFU/L of chamber air to meet the test item contamination target of $1x10^7$ CFU/m^2 will be determined by the project biologist.

b. Immediately after completion of chamber air contamination, sample the chamber air for BG concentration, using all glass impinges without preimpingers. Allow 1 hour for fallout contamination of the test item. After the 1 hour fallout, air-wash the chamber for 1 hour to reduce chamber contamination. The 1-hour air-wash will also serve as the 1-hour weathering time.

c. Immediately after air-wash, swab sample the second 25-cm^2 area in each set to determine the test item simulant contamination density.

4.2.5.6 Decontamination of the Test Item.

a. Because biological spores can be reaerosolized easily, be careful to avoid unwanted BG contamination of test samples. Instrumentation and other nontest item surfaces may be decontaminated immediately after test item contamination density sampling has been completed. If practicable, the test item may be removed from the test chamber or room for decontamination and residual contamination sampling.

b. Start decontamination immediately after contamination density sampling. Use standard decontamination procedures, solutions, and equipment as described in Reference 8, and any test item-specific procedures furnished as part of the test documentation package.

c. Perform decontamination procedures as if the entire surface of the test item were uniformly contaminated. The sampling areas should receive no more or no less attention, time,

or effort than the areas not sampled. Appropriate time should be spent on rough surfaces, joints, angles, and hard-to work areas. The decontamination process should last no longer than 75 minutes.

d. Record all decontamination procedures, equipment, tools, and time used in the decontamination process, including item-specific procedures. Chlorine containing compounds such as supertropical bleach, calcium hypochlorite, or sodium hypochlorite are the decontaminating solutions of choice for biological agents. However, chemical agent decontaminating solution number 2 (DS-2) is effective against biological agents and may be specified in the test documentation as the decontaminating solution to use for some biological testing.

4.2.5.7 Residual Hazard Sampling After Biological Contamination/Decontamination. When the test item surface is dry following decontamination, swab sample the third 25-cm^2 area in each set to determine the residual contamination remaining on the test item. For porous materials such as ropes, tarpaulins, harness, cable, etc., extract the item with saline solution which should then be filtered, cultured, and counted. When sampling data are available, calculate the contamination reduction values for each material/location sampled. If the contamination reduction values do not meet the NBC contamination survivability criteria, decontaminate the test item again and sample for residual contamination. Repeat the decontamination and residual contamination sampling a second time if required to meet the contamination reduction criteria.

4.2.6 Hardness Determination.

a. If the review of the probable modes for hardness failure of the test item (Paragraph 3.1.d) indicate that biological contamination/decontamination could affect mission-essential performance significantly, the hardness determination should include one or more contamination/decontamination cycles with biological simulants.

b. After biological simulant decontamination is complete and the final set of swab samples have been taken, visually inspect the test item for evidence of corrosion caused by the biological test procedures. Operate the item, measure, and record all mission-essential functional performance characteristics. Measure each parameter at least twice, depending on the inherent difficulty in reproducing a specific value, and compare with pretest values. These data must be compatible with receipt inspection data (Paragraph 4.1.5.3.c). Interview operators and record any indication of operational degradation attributable to the biological contamination/decontamination cycles. Measurement of hardness degradation should be for five nuclear, biological, or chemical contamination/decontamination cycles on one test item, scheduled over a 30-day period.

4.2.7 Data Reduction, Presentation, and Evaluation.

a. Describe each sampling area, including the location, material of construction, surface geometry, and surface texture. Cite the decontaminant, decontamination time, and decontaminating procedures used, including item-specific procedures furnished by the materiel developer.

b. Summarize and describe the chamber conditions during the test period. Record the simulant batch or lot number, simulant physical property data, and aerosol disseminator operating data. Identify and explain any deviations from target values.

c. For each material/location, summarize and describe the CFU recovered from the control samples, the chamber air contamination level, the test item contamination level, and the residual sample level after decontamination, including any residual sample values obtained after the second and third decontaminations.

d. Calculate the biological spore decontamination reduction ratio achieved by the decontamination process (the item challenge contamination level divided by the residual contamination level) for each material/location sampled. Present the spore reduction ratio and the raw challenge and hazard data. Compare the calculated decontamination ratio values with the NBC contamination survivability criterion for biological spores. The item will be considered decontaminable for biological agent if the contamination is reduced to levels at or below the established criterion. If alternative methods of decontamination appear likely to improve decontamination effectiveness, recommend them for consideration.

e. The biological hardness determination will be the same and may be performed jointly with those described in Paragraph 4.1.6.3.

4.2.8 Adapting to Pathogenic Agents.

a. Most of the facilities, instrumentation, and procedures required for pathogenic agent testing are essentially the same as described for simulant testing. The safety procedures, environmental controls, and test chamber certification would be much more stringent when testing with pathogens. There is no known chamber that will accommodate large pieces of army equipment (tanks, vans, and vehicles) that is approved (or approval expected) for work with pathogenic biological agents.

b. If pathogenic biological contamination survivability data are required, they may be obtained from swatches, components, and panels of test item material small enough to be tested inside laboratories equipped with state-of-the-art biological safety hoods and devices; these data may then be extrapolated to larger pieces of equipment.

4.3 Nuclear Contamination Survivability.

4.3.1 Objectives

a. Decontaminability. Determine the hazards associated with troop use of equipment that has been contaminated with radioactive fallout debris and then decontaminated using standard and/or test item-specific procedures.

b. Hardness. Determine performance degradation in mission-essential functions of military materiel after nuclear contamination and decontamination using standard and/or test item-specific procedures.

4.3.2 Criteria/Conditions.

4.3.2.1 Criteria

a. Mission-essential equipment shall be hardened to ensure that exposure to five contamination/decontamination cycles does not degrade the mission-essential functional performance of the equipment more than 20 percent, or that specified by the combat developer, measured over a 30-day period. The five-cycle requirement refers to a cumulative total of five exposures to one or more contaminants (nuclear, biological, or chemical) and the associated decontamination processes.

b. Following decontamination of the test item to remove nuclear fallout debris, the residual radiation activity on/in the test item will result in no more than negligible risk to unprotected users of the item. In the determination of the risk level, the following conditions (Paragraph 4.3.2.2) apply.

4.3.2.2 Conditions.

a. General Conditions.

(1) One-half of the activity could be induced activity resulting from the initial blast effects and nontest item-related sources and would not be measured in this test. The other half of the activity (which would be determined in this test) would result from radioactive debris remaining on the item after radioactive fallout decontamination.

(2) The unprotected users of the item would arrive H+2 hours and remain inside, on, or 1 meter from the item for a period of time based on the item MP, not to exceed 12 hours.

(3) Decontamination begins 1 hour after contamination and lasts no longer than 75 minutes. Only standard field decontaminants, equipment, and procedures and/or item-specific procedures provided by the combat developer will be used to decontaminate the equipment.

(4) The item surface temperature is 30°C and wind speed is less than 1 m/sec.

b. Detailed Conditions. The detailed conditions for simulant nuclear fallout contamination survivability testing are given below:

(1) Test chamber: temperature 30±5°C, ambient RH, wind speed (air circulation over the test item) <1 m/sec, and chamber sealed.

(2) Nuclear fallout simulant: fluorescent particles (FP).

(3) Exterior target contamination density: $2.5\pm0.5 \times 10^5$ particles/cm^2.

(4) Fallout simulant particle size: 1 to 5 μm.

(5) Sampling and counting controls: test item background control, laboratory control, and particle counting control.

(6) Surface areas selected for sampling must be representative of the test item materials, surface texture, paint, and areas where the user will have contact with the item.

(7) Contamination weathering time before start of decontamination will be 1 hour ±2 minutes after completion of contamination. The decontamination process should last no longer than 75 minutes.

4.3.3 Controls and Limitations.

a. Paint type, specifications, and application must comply with combat developer specifications for the test item.

b. Before each trial, sample the surfaces to be tested for background contamination and foreign substances that could interfere with sample analysis.

c. Use qualified and trained operators, standard equipment, and standard procedures (the same type of equipment and procedures that troops would use in the field with that test item).

4.3.4 Data Required. Report the following data in the units indicated:

a. Description of the test item exterior materials of construction, paint type, and surface condition, including cleanliness (mud, grease). Photographs of joints, crevices, textures, or other subjects that may prove difficult to decontaminate.

b. Photograph and written description of each area selected for sampling.

c. Chamber: temperature -- °C, RH -- percent, and wind speed (airflow) -- m/sec.

d. FP lot number, particle count/g, color, and particle size range -- μm.

e. FP disseminator used, operating air pressure -- psi, dissemination time -- seconds, mass of FP disseminated -- grams, and chamber air contamination density -- FP particles/L of air.

f. Test item FP background control counts, test item FP surface contamination density counts, test item FP residual contamination counts -- particle/cm^2, and FP counting control values.

g. All pertinent test event times and sample times -- minutes.

h. A description of decontamination methods, equipment, solutions (if used), and any item-specific decontamination procedures and special devices used.

i. Results of the receipt inspection and visual inspection of the test item surfaces after each contamination/decontamination cycle.

j. Receipt inspection results and pretest (baseline) and posttest mission-essential functional performance data used to determine test item hardness (degradation).

k. A system safety risk assessment of test findings IAW guidance in Reference g (also see Reference h).

4.3.5 Methods and Procedures.

4.3.5.1 Nuclear Fallout Simulant. The nuclear fallout simulant to be used is zinc sulfide FP in the 1 to 5 μm size range. Before the start of testing, the FP to be used should be tested for fluorescent color.

4.3.5.2 Receipt Inspection and Functional Performance. Perform receipt inspection and a pretest mission-essential functional performance test as described in Paragraph 4.1.5.3.c, if not previously performed as part of another test phase.

4.3.5.3 Test Preparation.

a. Perform an analysis of the test item as discussed in Paragraph 4.1.5.4.b to help identify locations and materials to be sampled. Selection of the number and location of the areas to be sampled will depend on the OMS/MP and the test item size, geometry, materials of construction, paint, surface texture, cracks, crevices, and the accessibility for decontamination. Consider crew assignments, the locations most likely to contribute to crew hazard, and any areas that might allow decontaminating solutions to seep into and degrade delicate equipment. Identify three 4-cm^2 sampling areas from each material/location to be sampled. Duplicate areas for each material/location are desirable. Make special note of any material or surface selected that requires the sampling areas to be less than 4-cm^2. If any areas or components of the test item have been identified by the combat developer for item-specific decontamination procedures, identify such areas and components.

b. Calibrate a dry FP-disseminating apparatus to disperse FP particles in the 1- to 5-μm size range. Determine a precalculated time, air pressure, and FP quantity to contaminate the test item to the target level.

c. Before FP tests begin, rehearsals may be required to familiarize test crews with all test procedures and data requirements. Allow crews to practice until the operation of dispensing equipment, decontamination procedures, and sampling become reproducible and routine. Do not use the test item to be used during hardness and decontaminability tests during rehearsals; do not disseminate the FP.

d. To reduce FP contamination of instruments and equipment, templates and protective covers may be useful. Do not use plastic sheeting or other materials capable of carrying a high static charge in the chamber because the static charge can influence FP behavior; Velostat® or equivalent sheeting can be used.

4.3.5.4 Contamination and Sampling.

a. Select, describe, and photograph representative areas of the test item for FP sampling. Each of these areas should also be subdivided so as to contain a set of three smaller areas, each containing a minimum of 4 cm^2. Identify at least three such sets.

b. Before the start of a trial, use a 4-cm^2 patch of Microtiter® plate-sealing tape and sample the first area in each set. This patch sample will be used to measure pretest (background) contamination.

c. Contaminate the air inside the chamber to a level of approximately $1x10^6$ FP particles/L of air by aerosolizing dry FP, using a laboratory FP dissemination apparatus. The desired contamination level on exterior surfaces is $2.5x10^5$ particle/cm^2. The exact weight of dry FP material and the length of time the disseminator is operated to meet that value will be determined by the senior operator and reported as required data.

d. Immediately after completion of FP aerosol dissemination, sample the chamber air for FP concentration at two locations, one on each end of the chamber. Sample for 30 to 60 seconds, using two 6-L/min membrane filters oriented face-downward. Allow 1 hour for fallout contamination of the test item. Air-wash the chamber for 1 hour to reduce chamber air contamination.

e. After the 1-hour air-wash and before decontamination of the test item, use a second 4-cm^2 patch of Microtiter® tape and sample the second area from each set of three to measure the surface FP contamination density.

4.3.5.5 Decontamination of the Test Item.

a. Because FP can be re-aerosolized easily, exercise appropriate care to avoid unwanted FP contamination of test samples. Instrumentation and other nontest item surfaces may be vacuumed immediately after contamination sampling has been completed. If practicable, the test item may be removed from the test chamber or room for decontamination and residual contamination sampling.

b. Start decontamination immediately after FP contamination density sampling. Use standard decontamination procedures, solutions, and equipment as described in Reference 8, and any item-specific procedures furnished by the combat developer.

c. Decontamination procedures should be performed on all exposed surfaces of the test item. The sampling areas should receive no more or no less attention, time, or effort than the areas not sampled. Appropriate time should be spent on rough surfaces, joints, angles, and hard-to-work areas. Make detailed records of any area that falls into this category. The decontamination process should last no longer than 75 minutes.

d. Record all decontamination procedures, equipment, tools, and time used in the decontamination process, including item-specific procedures.

4.3.5.6 Post-decontamination Sampling.

a. After decontamination and when the test item surface is dry, use a patch of Microtiter® plate-sealing tape and sample for residual FP contamination remaining on each material/location selected for sampling. Calculate the contamination reduction values for each material/location sampled. If the contamination reduction values do not meet the NBC contamination survivability criteria, decontaminate the test item again and sample for residual contamination. Repeat the decontamination and residual contamination sampling a second time, if required, to meet the contamination reduction criteria. Record the time and procedures used for each additional decontamination and sampling cycle.

b. After each contamination/decontamination cycle, inspect all exterior surfaces of the test item for evidence of deterioration or buildup of deposits or sludge that could affect test item performance. Give special attention to any area that might allow contaminants or decontaminants to penetrate below the surface.

4.3.6 Hardness Determination.

a. If the review of the probable modes for hardness failure of the test item (Paragraph 3.1.d) indicate that nuclear contamination/decontamination could affect mission-essential performance significantly, the hardness determination should include one or more contamination/decontamination cycles with nuclear simulant FP.

b. After each contamination/decontamination cycle is complete, visually inspect the test item external surfaces and interior spaces for evidence of corrosion and degradation caused by the nuclear test procedures. Operate the item and measure and record all mission-essential functional performance parameters. Measure each task at least twice, depending on the inherent difficulty in reproducing a specific value; compare with the pretest values. These data must be compatible with receipt inspection data (Paragraph 4.3.5.2). Interview test item operators and record any indications of operational degradation attributable to the nuclear contamination/decontamination cycles. Measurement of hardness degradation should be for five nuclear, biological, or chemical contamination/decontamination cycles on one test item, scheduled over a 30-day period.

4.3.7 Data Reduction, Presentation, and Evaluation.

a. Describe each sampling area and give the location, material of construction, surface geometry, and surface texture. Cite the decontaminant and the decontaminating procedures used, including references to field manuals and/or item-specific decontamination procedures.

b. Summarize and present the chamber conditions during the test period, including air movement, temperature, and RH. Compare the contamination densities achieved with the target values. Present FP contamination density and the residual contamination remaining for each sampling area. Identify and explain any deviations from established criteria.

c. Calculate the FP decontamination reduction ratio achieved by the decontamination process (the item challenge contamination level divided by the residual contamination level) for each location sampled. Compare the calculated decontamination ratio values with the NBC contamination survivability criteria for nuclear debris.

d. Data reduction and presentation for nuclear simulant contamination survivability will be the same as for biological contamination survivability (Paragraph 4.2.7).

4.4 NBC Compatibility.

4.4.1 Objective. Determine if mission-essential equipment can be operated, maintained, and resupplied by troops wearing the full NBC protective ensemble (MOPP4).

4.4.2 Criterion/Conditions.

4.4.2.1 Criterion. Excluding heat stress, degradation of crew performance of mission-essential tasks will be no greater than 15 percent below the levels specified for these tasks when accomplished in a non-NBC environment.

4.4.2.2 Controls and Limitations.

a. Meteorological conditions during testing must match those of areas of intended use. Paired comparisons should be planned, thus eliminating meteorological conditions as a source of variation in comparing test item performance with and without the wearing of NBC protective clothing.

b. NBC compatibility tests should be based on a test design that considers all variables, such as the level of operator NBC training, degree of acclimatization, familiarity and experience with the equipment, and test environmental variables.

c. All operators of the equipment will be properly trained and certified to operate the test equipment.

d. SOMTE personnel will be used in NBC compatibility tests to the maximum extent possible.

e. Any crews who have been in MOPP4 clothing for more than 75 minutes should be given an overnight rest period before they participate in another trial.

4.4.3 Data Required.

a. A listing of mission-essential tasks identified by the combat developer for the equipment undergoing the NBC compatibility test. The listing should indicate how each task is to be measured and whether the function is to be classified as an attribute (go, no-go) or a variable measured over a continuous range of variables.

b. Determination of baseline mission-essential performance characteristics for the equipment.

c. Measurement of mission-essential soldier tasks/equipment performance with operators in standard battledress and in NBC protective clothing.

d. Temperature, wind speed, relative humidity, light conditions, cloud cover, and heat stress level recorded throughout the testing procedure.

e. A training record, military occupation specialty (MOS) qualification score, experience with the equipment, medical or physical profile, and anthropomorphic data for each operator-participant.

f. Copies of operator, supervisor, and "umpire" questionnaires.

g. A test incident report to document out-of-tolerance performance, breakdown, or other anomalous performance occurring during compatibility tests.

4.4.4 Methods and Procedures.

4.4.4.1 Equipment Operation. Equipment to be tested will be operated and maintained in strict compliance with operating manuals, instructions, and SOPs. In performing maintenance tasks, only tools and repair procedures specified for the equipment will be used.

4.4.4.2 Test Site Operations. Configure the decontamination test site to match the deliberate decontamination site described in Reference 8. Although the simulants used in decontamination test are generally common industrial chemicals of low toxicity and negligible environmental impact, many decontaminants are highly reactive compounds or may contain hazardous components and must be recovered for disposal IAW hazardous waste guidelines.

4.4.4.3 Test Planning and Preparation.

a. Prepare a test scenario specifying functions and operations to be evaluated during a typical mission profile. Include which test items will be used, the type and number of SOMTE personnel, and the sequence of tasks to be measured. Clearly specify the exact measurement to be taken, the sequence in which it is to be taken, and the instrument or measuring device. Maximum use of videotapes should be considered. Clearly explain the role of umpires or field observers. The scenario must ensure that all functions or tasks identified as essential are executed and evaluated.

b. Request a minimum of two SOMTE test crews to allow battledress trials and NBC protective gear trials to be conducted simultaneously, partially eliminating environmental conditions and heat stress levels as variables. Perform a sufficient number of rehearsals to ensure that equipment familiarization is not a factor in the compatibility determination.

4.4.4.4 Test Conduct.

a. Perform the scenario once in battledress and another time in NBC protective clothing, with both crews operating simultaneously. Switch crews and repeat. Repeat the scenario until the decision point specified in the DTP or IAP/IEP has been reached. To avoid bias on the final trial, do not inform SOMTE personnel of the number of replicate trials to be conducted.

b. Complete any questionnaires used at the completion of each pair of trials. Whenever possible, review videotapes between trials to ensure that the test is meeting objectives.

c. Degradation of crew performance caused by heat stress while wearing NBC protective clothing will be observed and recorded. To help avoid heat stress, schedule trials at the time of day and seasons when heat stress will be at a minimum. The factors outlined in Technical Bulletin-Medical (MED) 507[9], together with the use of a stress meter, will serve as guides in identifying and controlling heat stress whenever meteorological conditions and level of exertion indicate that a potential heat-stress problem exists.

4.4.5 Data Reduction, Presentation and Evaluation.

a. Summarize and present crew/test item performance data in tabular form as paired comparisons. Highlight differences in performance attributable to type of clothing worn.

b. If questionnaires are used, tabulate and summarize questionnaire data, highlighting any operational difficulties attributed to the wearing of NBC protective clothing by crew members or observers. Contrast questionnaire data for the two sets of trials and interpret results (also see Paragraph 1.3 c).

c. Summarize and present meteorological data and heat-stress meter data.

d. Identify data gaps and discuss instances where data were inconclusive.

5. DATA REQUIRED.

Separate data sets are required for the three test procedures, Chemical Contamination Survivability, Biological Contamination Survivability, and Nuclear Contamination Survivability.

5.1 Chemical Contamination Survivability.

Requirements are specified in paragraphs 4.1.4a through 4.1.4q.

5.2 Biological Contamination Survivability.

Requirements are specified in paragraphs 4.2.4a through 4.2.4o.

5.3 Nuclear Contamination Survivability.

Requirements are specified in paragraphs 4.3.4a through 4.3.4j.

6. PRESENTATION OF DATA.

6.1 Chemical Contamination Survivability.

6.1.1 Decontaminability data should include a description of the as received test item or "mock-up", identifying any damage and specific conditions of the surface to be exposed to agents. Receipt inspection photographs are important. Differences between the mock-up and test item are described. Levels of contamination agent and decontaminant should be presented for each test, along with residual levels. Video of the decontamination process should be made and reviewed to identify any unique techniques or cautions. Compile a tabulation of results (residual contamination) along with the Approved NBC contamination survivability criteria (Table 1, Appendix B). Prepare a narrative analysis of the decontamination procedure and a separate analysis of effects, considering test item mission, operator position, and possible remedial measures to counter hazardous conditions where present. Refer to paragraph 4.1.6 for further detail on processing of data.

6.1.2 Hardness data will be presented in a format to show direct comparison of pre-exposure and post-exposure mission essential performance of the test item.

6.2 Biological Contamination Survivability.

6.2.1 Decontaminability data should include a description of the as received test item or "mock-up", identifying any damage and specific conditions of the surface to be exposed to biological spores. Receipt inspection photographs are important. Differences between the mock-up and test item are described. For each agent used, identify the contamination density (spores per square meter), area to which applied, surface material, texture and temperature, and chamber temperature, humidity and wind conditions. Also tabulate decontamination solutions, equipment, procedures, and decontamintion time. Video of the decontamination process should be made and reviewed to identify any unique techniques or cautions. Compile a tabulation of results (residual contamination) along with the Approved NBC contamination survivability criteria of 500 spores/square meter.

6.2.2 Hardness data will be presented in a format to show direct comparison of pre-exposure and post-exposure mission essential performance of the test item.

6.3 Nuclear Contamination Survivability.

6.3.1 Decontaminability data should include a description of the as received test item or "mock-up", identifying any damage and specific conditions of the surface to be exposed to nuclear fallout simulant. Receipt inspection photographs are required of exterior materials, construction, paint, cleanliness, joints and crevices. Record the contamination level on exterior surfaces (as close to 2.5×10^5 particles/cm^2 as possible). Also tabulate decontamination solutions, equipment, procedures, and decontamination time. Video of the decontamination process should be made and reviewed to identify any unique techniques or cautions. Compile a tabulation of results (residual contamination) along with the Approved NBC contamination survivability criteria of 25cGy rad/mission.

6.3.2 Hardness data will be presented in a format to show direct comparison of pre-exposure and post-exposure mission essential performance of the test item.

6.4 NBC Compatibility.

6.4.1 Present crew performance data (time to perform function) in tabular form comparing regular battledress and MOPP IV clothing.

6.4.2 Summarize questionnaire data in narrative form highlighting crew difficulties.

6.4.3 Tabulate meteorological and heat-stress meter data.

APPENDIX A. CHECKLISTS.
CHECKLIST A.1. CHEMICAL AGENT TEST

TEST PLAN PREPARATION	COMPLETED
1. Literature search.	_____
a. Case files reviewed.	_____
b. Item specific decontamination procedures identified and summarized.	_____
c. Surety and safety regulations reviewed, and safety assessment report (SAR) available.	_____
d. SOP review completed.	_____
2. Essential operating characteristics identified.	_____
a. Specific operating characteristics to be measured.	_____
b. Measuring equipment on hand.	_____
3. Test item examination and analysis.	_____
a. Areas handled or touched identified; sampling and decontamination techniques for those areas established.	_____
b. Materials of construction reviewed.	_____
c. Cracks, joints, and crevices identified.	_____
d. Use of live agent and simulant approved.	_____
e. System support package available.	_____
4. Proper safety and environmental documents on file.	_____
5. Quality assurance (QA) plan requirements outlined.	_____
6. Receipt inspection requirements reviewed.	_____

CHECKLIST A.1. CHEMICAL AGENT TEST

TEST PLAN PREPARATION (cont'd)	COMPLETED
7. Test item condition before testing determined.	_____
8. The number of test items determined.	_____
9. Pretest sampling requirements established.	_____
10. Use of robotics considered.	_____
11. Training requirements prepared.	_____
12. Approved test plan documentation assembled.	_____

PRETEST PREPARATION

1. Current certification of storage, laboratory, and test areas confirmed.	_____
2. All assigned people enrolled in chemical surety program.	_____
3. Chemical agent physical data obtained.	_____
4. Receipt inspection.	_____
a. Test item(s) received.	_____
b. Test item(s) inventoried and test item identification number (TIIN) assigned, if not assigned previously.	_____
c. Test item damage documented.	_____
d. Surfaces of test item(s) inspected and described.	_____
e. System support package received, inventoried, and determined to be complete.	_____

CHECKLIST A.1. CHEMICAL AGENT TEST

PRETEST PREPARATION (cont'd)	COMPLETED
5. Test item analysis.	_____
a. Drawings, specifications, and photographs of test item on hand.	_____
b. OMS/MP available and category of material to which test item belongs (FM 3-5) identified.	_____
c. Areas likely to present vapor or contact hazard identified.	_____
d. Crevices, angles, cracks, or any area that might be difficult to decontaminate identified.	_____
e. Areas where control samples, contamination density, droplet size samplers, and residual samples are to be located are identified.	_____
f. Items 5.c through 5.e identified on sketch of test item.	_____
6. Standard decontaminants and procedures from FM 3-5 and item-specific procedures identified and ready.	_____
7. Rehearsals completed.	_____
8. Chamber environmental controls operating and test item temperature-conditioned.	_____
9. Pretest control samples taken.	_____
10. Number of samplers identified and prepared.	_____

CHECKLIST A.1. CHEMICAL AGENT TEST

DATA REQUIRED	COMPLETED
1. Record of chamber environmental and operating conditions.	_____
2. Test participant data.	_____
a. Technicians' names and qualifications recorded.	_____
b. Name, rank, MOS, NBC training, length of service, and familiarity with procedures.	_____
3. Test item description.	
a. Condition of surface.	_____
b. Photographs of cracks, crevices, or other areas difficult to decontaminate.	_____
4. Agent contamination.	_____
a. Agent name, purity, and viscosity.	_____
b. Agent contamination densities.	_____
c. Average agent droplet size.	_____
d. Agent application and sample time.	_____
e. Test control and laboratory standard data.	_____
f. Description of agent application techniques, and quantity dispensed.	_____
g. Identification of sampling techniques used.	_____
h. The average area of the surface wetted by individual drops, if safety procedures permit the measurement and if the area is desired.	_____

CHECKLIST A.1. CHEMICAL AGENT TEST

DATA REQUIRED (cont'd) COMPLETED

5. Decontamination. _____

   a. Decontaminant name, chemical composition, and age recorded. _____

   b. Methods, equipment, tools, or special devices used recorded. _____

   c. Standard and item-specific procedures recorded. _____

   d. Video documentation showing elapsed times for the decontamination process. _____

6. Posttest performance data. _____

   a. Pretest performance data recorded. _____

   b. Posttest performance data recorded. _____

   c. Notes or comments from operators. _____

   d. Visual inspection of test item with documentary photographs completed. _____

TEST PROCEDURES

1. Safety procedures, chamber certification confirmed, safety samplers in place and operating. _____

2. Agent disseminating equipment calibrated and performance confirmed. _____

3. Test item temperature-conditioned. Chamber operating and test conditions recording. _____

4. Test rehearsals conducted and test participants ready. _____

5. Control samples taken; contamination density and droplet size samplers ready. _____

CHECKLIST A.1. CHEMICAL AGENT TEST

TEST PROCEDURES (cont'd)	COMPLETED
6. Decontamination equipment checked and ready.	_____
7. Agent applied to the test item within droplet size range and contamination density specified.	_____
8. Droplet size samples and contamination density samples taken.	_____
9. One-hour agent weathering time and chamber ventilation complete.	_____
10. Test item decontamination completed.	_____
a. Start time.	_____
b. DS-2 dwell time.	_____
c. Stop time.	_____
d. Standard and item-specific procedures recorded.	_____
11. Residual hazard sampling.	_____
a. Vapor sampling initiated.	_____
b. Contact hazard areas sampled.	_____
c. Sequential vapor samples completed and time recorded.	_____
12. Chamber and equipment decontamination completed.	_____
13. Mission-essential performance characteristics measurements and visual inspection completed.	_____

CHECKLIST A.2. BIOLOGICAL SIMULANT TEST

PRETEST PROCEDURES	COMPLETED
1. Current certification of storage, laboratory, and test chamber for BG aerosols verified.	_____
2. Biological simulant physical property data recorded.	_____
3. Test item analysis and sketch of sampling areas completed.	_____
4. Number of samplers determined and prepared.	_____
5. Surface of the test item inspected; damage and surface condition recorded.	_____
6. Decontamination procedures from FM 3-5 and item-specific procedures identified.	_____
7. BG nebulizer calibrated and operating conditions determined.	_____
8. Test item temperature-conditioned.	_____
9. Rehearsals completed and test crews ready.	_____
10. Test chamber operating and environmental conditions within specifications.	_____

DATA REQUIRED

1. Chamber environmental and operating conditions. _____
2. Test participants' qualifications and training. _____
3. Description of test item material and surfaces. _____
4. Description and photographs of crack, crevices, and other areas difficult to decontaminate. _____

CHECKLIST A.2. BIOLOGICAL SIMULANT TEST

DATA REQUIRED (cont'd) — COMPLETED

5. Biological simulant data. _____
   a. Simulant count and physical properties. _____
   b. Control/background sample data. _____
   c. Chamber air contamination density. _____
   d. Test item surface contamination density. _____
   e. Test item residual contamination density. _____
6. Nebulizer description and operating and time data. _____
7. Decontaminant name and chemical composition. _____
8. Decontamination equipment, tools, procedures, and item-specific procedures. _____
9. Test item data. _____
   a. Pretest mission-essential performance. _____
   b. Posttest mission-essential performance. _____
   c. Visual inspection for test item degradation with documentary photographs. _____
   d. Operator interview, notes, or comments. _____

TEST PROCEDURES

1. BG nebulizer calibrated and performance verified. _____
2. Receipt inspection completed and mission-essential tasks measured. _____
3. Test rehearsals completed and test crews ready. _____

CHECKLIST A.2. BIOLOGICAL SIMULANT TEST

TEST PROCEDURES (cont'd) COMPLETED

4. Test item temperature-conditioned and test chamber conditions within specifications. _____
5. Control/background samples taken. _____
6. Templates and disposable covers in place (if used). _____
7. Simulant physical property data recorded. _____
8. Decontamination equipment checked and ready. _____
9. Simulant aerosolized. Nebulizer operating data recorded. _____
10. Chamber air contamination level sampled. _____
11. One-hour simulant settling time completed. _____
12. One-hour chamber ventilation/weathering completed. _____
13. Test item contamination density sampling completed. _____

DATA REQUIRED

1. Decontamination time, FM 3-5 procedures used, and item-specific procedures documented. _____
2. Test item residual contamination density sampling completed. _____
3. Chamber and equipment decontamination completed. _____
4. Mission-essential performance measurements and visual inspection completed. _____

CHECKLIST A.3. NUCLEAR SIMULANT TEST

PRETEST PROCEDURES	COMPLETED
1. Test chamber certified for FP aerosols and laboratory procedures verified.	_____
2. Simulant FP physical properties data recorded.	_____
3. Test item mission evaluation completed, surface materials identified, and sketch of sampling areas completed.	_____
4. Test item inspected; damage and surface condition recorded.	_____
5. The number of samplers determined and prepared.	_____
6. The decontamination procedures from FM 3-5 and item-specific procedures determined.	_____
7. FP disseminator calibrated; operating parameters determined.	_____
8. Rehearsals completed and test crews ready.	_____
9. Test item temperature-conditioned.	_____
10. Test chamber operational and environmental conditions within specifications.	_____

DATA REQUIRED

1. Chamber environmental conditions and operational data.	_____
2. Test crew qualifications and training.	_____
3. Description of the test item materials and surfaces.	_____
4. Description and photographs of test item cracks, crevices, and other areas difficult to decontaminate.	_____

CHECKLIST A.3. NUCLEAR SIMULANT TEST

DATA REQUIRED (cont'd) — COMPLETED

5. Nuclear simulant data. _____
   a. FP count and physical properties. _____
   b. Control/background sample data. _____
   c. Chamber air contamination density. _____
   d. Test item surface contamination density. _____
   e. Test item residual contamination density. _____
6. FP generator description, operating, and time data. _____
7. Decontamination equipment, tools, procedures, solutions, and item-specific procedures. _____
8. Hardness. _____
   a. Pretest mission-essential performance and receipt inspection data. _____
   b. Posttest mission-essential performance data. _____
   c. Posttest visual inspection data with photographs of degradation. _____
   d. Operator interviews, notes, and comments. _____

TEST PROCEDURES

1. FP generator calibrated and performance verified. _____
2. Receipt inspection complete and mission-essential tasks measured. _____
3. Test rehearsals completed and test crews ready. _____

CHECKLIST A.3. NUCLEAR SIMULANT TEST

TEST PROCEDURES (cont'd)	COMPLETED
4. Test item temperature conditioned, and test chamber operating conditions within specifications.	_____
5. Templates and disposable covers in place (if used).	_____
6. Control/background samples taken.	_____
7. Decontamination equipment checked and ready.	_____
8. FP simulant aerosolized. Disseminator operating data recorded.	_____
9. Chamber air FP contamination level sampled.	_____
10. One-hour FP settling time completed.	_____
11. One-hour chamber ventilation/weathering completed.	_____
12. Test item contamination density sampling completed.	_____
13. Decontamination time, FM 3-5 procedures, and item-specific procedures documented.	_____
14. Test item residual contamination density sampling complete.	_____
15. Chamber and equipment decontamination complete.	_____
16. Test item mission-essential performance measurements and visual inspection complete.	_____

CHECKLIST A.4. NBC COMPATIBILITY TEST

PRETEST PREPARATION	COMPLETED
1. Test item mission profile and task requirements obtained from the combat developer.	_____
2. Compatibility test scenario(s) specifying mission-essential tasks and operations to be evaluated during a typical mission profile prepared and approved.	_____
3. The test scenario mission-essential task measurements defined in detail, including instrumentation required, accuracy and precision of measurement, the number of measurement replications, type of documentation, and the role of field observers.	_____
4. Questionnaires and interview sheets for SOMTE personnel and field observers prepared.	_____
5. Test controls and limitations defined, including meteorological conditions.	_____
6. SOMTE requirements defined. Test crews assembled and certified.	_____

DATA REQUIRED

1. Test meteorological conditions recorded throughout testing. _____
2. A list of test item mission-essential tasks. _____
3. The following test item mission-essential task data:
   a. Baseline mission-essential task data (design criteria) provided by the combat developer. _____
   b. Receipt inspection mission-essential task performance data. _____
   c. Test crew mission-essential task performance data while in battledress uniform. _____

CHECKLIST A.4. NBC COMPATIBILITY TEST

DATA REQUIRED (cont'd) COMPLETED

d. Test crew mission-essential task performance data while dressed in NBC protective ensemble (MOPP4). _____

e. Test item operating crew (SOMTE) MOS, qualifications, and training data. _____

4. Test item operating crew and field observer questionnaires, interview sheets, and comments. _____

5. A list of instrumentation used; accuracy and calibration data. _____

6. Test incident reports or other documentation of test item failure, out-of-tolerance performance, or other anomalous performance. _____

TEST PROCEDURES

1. Test crews fully trained and rehearsals complete. _____

2. Test item operational. All mission-essential systems performing within specifications. _____

3. Test item operators dressed (battledress or MOPP4), inspected, and ready. _____

4. Meteorological conditions within specified limits. _____

5. Test crews and field observers briefed and ready. Test scenario and checklist provided and understood. _____

6. Test data instrumentation operational, including video and photography. _____

7. Test item operator heat stress monitoring procedures ready. _____

CHECKLIST A.4. NBC COMPATIBILITY TEST

TEST PROCEDURES (cont'd) COMPLETED

8. Mission-essential task sequence complete. _____

   a. Mission-essential task number 1 complete. _____

      Battledress _____ Time: _____

      MOPP4 _____ Time: _____

   b. Mission-essential task number 2 complete.

      Battledress _____ Time: _____

      MOPP4 _____ Time: _____

   c. Mission essential task number 3 complete.

      Battledress _____ Time: _____

      MOPP4 _____ Time: _____

   d. Mission-essential resupply task complete.

      Battledress _____ Time: _____

      MOPP4 _____ Time: _____

   e. Mission-essential test item maintenance tasks complete.

      Battledress _____ Time: _____

      MOPP4 _____ Time: _____

9. Questionnaires and interviews of test item operators complete. _____

10. Data sheets, questionnaires, and interviews of field observers complete. _____

APPENDIX B. QUADRIPARTITE STANDARDIZATION AGREEMENT 747 EDITION 1

DECLARATION OF ACCORD

1. SCOPE OF AGREEMENT.

This agreement has been approved for use by the Armies of the United States, United Kingdom, Australia, and Canada as the standard NBC Contamination Survivability Criteria to be applied to all mission-essential military equipment.

The United States, United Kingdom, Canada, and Australia agree that they will, in the course of designing and testing mission-essential military equipment, use the NBC Contamination Survivability Criteria detailed in this agreement. The subscribing Armies also agree that, once applied to a developmental piece of equipment, the criteria will be modified only if they cannot be met for proven economic, technical, or operational reasons.

The subscribing Armies further accept that they will consult and in every possible case reach mutual agreement on all changes of modifications affecting the agreed degree of standardization before the introduction of such changes or modifications. This agreement may be reviewed or canceled by agreement of the subscribing Armies.

2. CONTINUITY AND RELATED AGREEMENTS.

a. Continuity: QSTAG 747 was prepared as a result of recommendations made, and is based on a concept paper agreed at the Third Meeting of the Quadripartite Working Group on Nuclear-Biological-Chemical Defense held in May 81. A final draft of QSTAG 747 was accepted at 9 QWG/NBCD held in May 90. The United States is the Custodian Army.

b. Related Agreements: QSTAG 244, QSTAG 260.

3. RELEASE TO NATO.

This QSTAG will be released to the North Atlantic Treaty Organization by the Primary Standardization Office.

4. National Ratifying References - Details of Implementation.

Nation	Ratifying Reference	National Implementing Document	Date of Implementation Services				
			Forecast	Actual	A	N	A F
US	AMCICP-AA(34-1d) dated 6 Feb 91	Quantitative NBC Contam. Surviv'ty Criteria & Prog Mang't Directive for CW Defense		Feb 89	X	-	R
UK	LSOR4/8333	TBA	On Promulgation		X	-	X
CA	2510-5-747 (DNBCC) dated 26 Oct 90	CFB 316, Vol 12		Jan 91	X	X	X
AS	A90 31986 dated 25 July 1991	TBA	On Promulgation		X	X	X
NZ							

5. Reservations.

US: The US Air Force reserves the right to reduce contamination levels for liquid agents VX and HD based on standards expected to be developed by NATO.

BY THE WASHINGTON STANDARDIZATION OFFICERS:

//signed//
WILLIAM H. FORSTER
Major General
United States Army

//signed//
EDMUND F.G. BURTON
Brigadier
British Army

//signed//
IAN C. DOUGLAS
Brigadier General
Canadian Forces

//signed//
JOHN H. ROBBINS
Brigadier
Australian Army

12 Aug 1991
(Date Signed)

NBC CONTAMINATION SURVIVABILITY CRITERIA FOR MILITARY EQUIPMENT

DETAILS OF AGREEMENT

1. INTRODUCTION.

1.1 PURPOSE.

The purpose of this agreement is to standardize quantitative criteria for all mission-essential military equipment to survive the effects of nuclear, biological, and chemical (NBC) contamination and the resulting decontamination process.

1.2 SCOPE AND USE.

1.2.1 Standard criteria, expressed in terms of decontaminability, hardness, and compatibility, are provided to ensure that the mission-essential military equipment survives the effect of:

-- contamination by chemical and biological agents.
-- radioactive contaminants and neutron induced activity.
-- decontamination processes.

(Criteria for surviving the initial effects of nuclear weapons are excluded from the scope of this agreement and are covered separately in QSTAGS 244 and 620.)

1.2.2 These NBC Contamination Survivability Criteria will be stated as essential characteristics in appropriate requirements documents and used to design and test the survivability of mission-essential equipment under development. Once applied to a developmental piece of equipment, these criteria will be modified only upon consideration of proven economic, technical, and/or operational reasons.

1.2.3 These criteria are engineering design criteria intended for use only in a developmental setting. They do not define doctrine or operational criteria for decontamination, establish protection criteria, provide guidelines on how to achieve the required survivability, establish test protocols, or specify survivability in training environments.

1.3 DEFINITIONS.

1.3.1 NBC Contamination Survivability - capability of a system and its crew to withstand an NBC-contaminated environment, including decontamination, without losing the ability to accomplish the assigned mission. Characteristics of NBC Contamination Survivability are decontaminability, hardness, and compatibility.

1.3.2 Mission-Essential Equipment - equipment necessary to accomplish primary or secondary missions of a unit or organization.

1.3.3 Mission-Essential Functions - minimum operational tasks that a system is required to perform in order to accomplish its mission profile.

1.3.4 Mission Profile - a time-phased description of the operational events and environments an item experiences from beginning to end of a specific mission. It identifies the tasks, events, durations, operating conditions, and environment of the system for each phase of a mission. A mission profile should be based on a typical scenario for the item/system.

1.3.5 Decontaminability - ability of a system to be rapidly and effectively decontaminated to reduce the hazard to personnel operating, maintaining, and resupplying it.

1.3.6 Hardness - ability of a system to withstand the damaging effects of NBC contamination and any decontamination agents and procedures required to decontaminate it.

1.3.7 Compatibility - ability of a system to be operated, maintained, and resupplied by personnel wearing the full NBC protective ensemble.

2. BACKGROUND.

2.1 The nuclear, biological, and chemical threat to ABCA nations is well documented. It follows that ABCA armies must be trained, organized, and equipped to operate effectively on a battlefield that includes nuclear, biological, and chemical environments. Accordingly, mission-essential items of materiel must survive these environments.

2.2 The Quadripartite Working Group on NBC Defense approved in May 1981 a concept for survivability of materiel contaminated by chemical or biological agents or residual nuclear radiation. This QSTAG is based on that concept.

3. PHILOSOPHY.

3.1 Criteria standardized herein are based on the following philosophy:

A soldier or crew surviving an NBC attack should be able to continue using mission-essential systems and equipment in a full protective ensemble if necessary. When the mission permits, the systems and equipment should be capable of rapid restoration to such a condition that all essential operations can be continued in the lowest protective posture consistent with the mission and threat, and without long-term degradation of the materiel.

3.2 NBC contamination is pervasive and can be widespread, but does not generally damage equipment immediately. Thus, equipment would be available for continued use in the mission and could be employed if the soldier can perform his tasks while protected from the toxic effects. Likewise, since equipment is not immediately damaged by NBC contaminants, it should be capable of being decontaminated and restored to conditions such that the soldier can operate in clothing consistent with the threat and such that the equipment does not experience long-term degradation. This philosophy is consistent with the needs of both user and materiel developer because it centers on the essential needs of the soldier.

4. CHARACTERISTICS OF NBC CONTAMINATION SURVIVABILITY.

NBC contamination survivability is comprised of the three elements of decontaminability, hardness, and compatibility. To survive NBC contamination, equipment must meet criteria of all three.

4.1 Decontaminability.

4.1.1 The ability of a system to be decontaminated to reduce the hazard to personnel operating, maintaining, and resupplying it is termed "decontaminability." Key words in this definition are the necessity to reduce the hazard to personnel. Thus, decontaminability criteria are related to personnel response to chemical and biological agents and to residual nuclear radiation.

4.1.2 Even under a "fight dirty" concept of operations where partial decontamination is the rule rather than the exception, decontaminatility is required. NBC contaminants could eventually breach the shield of the protective ensemble and, when operations permit, should be removed where they present a hazard. Further, decontamination reduces the soldier's vulnerability when the shield is dropped to satisfy basic physiological needs or to replace components of the NBC protective ensemble. Thus, decontaminability criteria are related to the response of unprotected personnel.

4.1.3 Decontaminability is enhanced by considering:

4.1.3.1 Materials. Maximize use of materials that do not absorb NBC contaminants and that facilitate their rapid and efficient removal with decontaminants readily available on the battlefield.

4.1.3.2 Design. Incorporate designs that reduce or prevent accumulation of NBC contamination and make those areas that are exposed readily accessible for decontamination.

4.1.3.3 Contamination Control. Employ devices and means that reduce the amount of contamination to be removed, such as positive overpressure systems for combat vehicles, packaging for supplies, and protective covers.

4.1.3.4 NBC Equipment. Provide for integration of NBC detection, measurement, decontamination, and contamination control devices. Consideration for integration of such devices at the earliest stage of the materiel acquisition process promotes maximum achievement of effective contamination avoidance, control, removal, and decontamination verification.

4.1.4 Criteria for decontaminability were developed by analyzing toxicity data, determining agent concentration levels corresponding to a negligible risk to unprotected personnel (or a "best substantiated combat ineffectiveness threshold estimate" in the absence of sufficient data to calculate a negligible risk value); and relating agent concentration to time, temperature, windspeed, and threat parameters.

4.2 Hardness.

4.2.1 The ability of a system to withstand the damaging effects of NBC contamination and decontamination agents and procedures require to carry out the decontamination process is termed "hardness." Although strongly related to decontaminability, hardness is a distinct characteristic; decontaminability is concerned with reducing the hazard to personnel as a result of decontamination efforts, while hardness is concerned with condition of the equipment after it has been subjected to an agent and decontamination.

4.2.2 Criteria for hardness were developed by analyzing vulnerabilities of construction materials to agents and decontaminants, considering mission profiles of classes of materiel designed to perform mission-essential functions; and determining allowable percentage degradations of quantifiable essential performance characteristics such as reliability, availability, and maintainability (RAM) standards.

4.3 Compatibility.

4.3.1 The ability of a system to be operated, maintained, and resupplied by personnel wearing the full NBC protective ensemble is termed "compatibility." Even if a piece of equipment is completely hardened against NBC contamination and decontaminants and can also be easily decontaminated, it still must have the capability of being operated effectively while in an NBC contaminated environment. Thus, in the development of equipment designed to perform mission-essential functions one must consider the combination of the equipment and personnel in anticipated NBC protection.

4.3.2 Collective protection enhances compatibility because it provides crew members a clean environment until they must exit to perform some essential task outside the enclosure. Unless individual protective gear is decontaminated or discarded, reentering crewmen will enter dirty. In some cases, agents may enter collective protection enclosures before the equipment is buttoned up. Thus, although collective protection may provide a "shirt sleeve" environment most of the time during a battle, it does not provide compatibility. However, for those systems for which collective protection does provide a continuous clean environment, the combat developer may elect to fulfill the compatibility requirement by utilizing collective protection. In doing so, he accepts the possibility of crew degradation should contamination enter and the crew be forced to don the individual protection ensemble.

4.3.3 Criteria for compatibility were developed by considering mission profiles of classes of equipment designed to perform mission-essential function, analyzing performance degradation of crew member operating the equipment while in protective ensemble, determining allowable percentage degradations of mission-essential functions, and relating those degradations to time and temperature parameters.

5. STANDARDIZED CRITERIA.

5.1 Decontaminability Criteria. (See explanatory notes in paragraph 5.4.)

DECONTAMINABILITY CRITERION

(CONTAMINANTS)

The exterior and interior surfaces of materiel developed to perform mission-essential functions shall be designed such that NBC contamination remaining on, or desorbed or reaerosolized from, the surface following decontamination shall not result in more than a negligible risk (as defined in table 1) to unprotected personnel working inside, on or 1 meter from the item. The following (worst case) conditions apply:

Exterior surfaces initially are uniformly and separately contaminated with 10 g/m^2 of thickened droplets of GD having a mass median diameter (MMD) of 2-5mm.

10 g/m^2 of unthickened VX.

10 g/m^2 of unthickened HD.

10^5 spores/m^2 of biological agent 1-5 micrometers in size.

4 g/m^2 of insoluble radioactive contaminants 37-200 micrometers in size and 185 GBq/m^2 gamma activity.

Initial contamination levels on interior surfaces subject to contamination are a factor of 10 lower than on exterior surfaces in the absence of evidence to the contrary.

Decontamination begins 1 hour after contamination using standard field decontaminants or simulants, equipment and procedures; and the decontamination process, excluding monitoring, lasts no longer than 75 minutes.

Suitable simulants may be used in lieu of the stated threat agents.

Exposure of unprotected personnel to the decontaminated materiel is not to exceed 12 hours based on the mission profile determined by the combat developer.

Surface temperature is 30°C and exterior wind speed no greater than 1 m/s (3.6 km/h).

(INDUCED ACTIVITY)

Materiel developed to perform mission-essential functions shall be designed such that, when exposed to a neutron fluence from a nuclear detonation that results in a total dose of 3,000 cGy (rad) to the crew of the equipment, the neutron induced activity in the item will result in no more than a negligible risk (as defined in table 1) to unprotected personnel arriving at H+2 and remaining inside, on, or 1 meter from the item for a period of time based on the mission profile, not to exceed 12 hours.

5.2 Hardness Criterion. (See explanatory notes in paragraph 5.4.)

HARDNESS CRITERION

Materiel developed to perform mission-essential functions shall be hardened to ensure that degradation over a 30-day period of no more than 20 percent in selected quantifiable mission-essential performance characteristics is caused by 5 exposures to NBC contaminants, decontaminants, and decontaminating procedures encountered in the field.

5.3 Compatibility Criterion. (See explanatory notes in paragraph 5.4.)

COMPATIBILITY CRITERION

The design of materiel developed to perform mission-essential functions shall take into consideration the combination of equipment and personnel in anticipated NBC protection.

The combination of equipment and NBC protection shall permit performance of mission-essential operations, communications, maintenance, re-supply, and decontamination tasks by trained and acclimatized troops over a typical mission profile in a contaminated environment not to exceed 12 hours:

In meteorological conditions of areas of intended use.

With no degradation, excluding heat stress, of crew performance of mission-essential tasks greater than 15 percent below levels specified for these tasks when accomplished in a non-NBC environment.

5.4 Explanatory Notes.

5.4.1 Selected negligible risk values are in table 1.

5.4.2 A 1-hour delay prior to beginning decontamination allows time for agent sorption, yet is generally not too long enough to allow elimination of surface hazard by weathering.

5.4.3 Initial contamination levels for interiors are a factor of 10 lower to account for the protection provided by the enclosure. Interior surface contamination will be limited to the exposed areas that could reasonably be expected to result from a successful surprise attack on the materiel item postured in its most vulnerable configuration, and to those exposed surfaces normally susceptible to agent transfer from a contaminated crew.

5.4.4 Seventy-five minutes is a typical time for decontaminating items with present decontamination procedures.

5.4.5 Although surface temperatures of equipment in the field will frequently exceed 30°C, this temperature is optimum for assessing decontaminability because it allows sufficient contamination to remain after the 1-hour sorption/weathering process, yet, causes sufficient outgassing of residual agent following decontamination to adequately evaluate the decontaminability process.

5.4.6 Requiring low airspeeds (less than 3.6 km/hr) results in greater chemical agent concentrations over time.

5.4.7 A radioactive fallout contamination of 185 GBq/m^2 would result in a H+1 dose rate of approximately 5 cGy (rad)/hr at 1 meter from a typical large armored vehicle. Using 50 cGy (rad) as a negligible risk dose which could come from exposure over a mission profile period (maximum of 12-hours), one half from operational exposure (i.e., direct radiation from initial

effects or from fallout on the ground) and the other half from equipment contamination, a decontaminability standard of 25 cGy (rad) dose per mission period is reasonable.

5.4.8 A neutron induced activity dose of 25 cGy (rad) per mission (maximum of 12-hour exposure) should be attainable for all items if reasonable attention is given to problem materials.

5.4.9 The "5 exposure" requirement in the hardness criterion refers to a cumulative total of contamination/decontamination cycles using one or more contaminants and associated decontamination processes.

Table 1. Negligible Risk Values for NBC Contaminants.

CONTAMINANT	VAPOR/AEROSOL	LIQUID[b]
CHEMICAL	($mg \cdot min/m^3$)	(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 ($0.01\ mg/cm^2$)[d]
BIOLOGICAL[c]		
RADIOLOGICAL	(maximum of 12 hour exposure)	
Contaminants	25 cGy (rad)	
Induced Activity	25 cGy (rad)	

[a] Applies to pilots.

[b] Applies to skin dose, not absorption through the eyes.

[c] Negligible risk values for biological agents are not determinable with the present database. Since extremely minute quantities of some biological agents can cause incapacitation, equipment should be designed to allow a residue of no more than 500 spores/m^2 of the specified initial contamination levels

[d] Since the effect of HD is localized, it is not appropriate to consider a threshold dose of liquid HD as applying to the entire 70-kg man. Use of mass/body surface area (mg/cm^2) units to describe the dose for which negligible effects are observed is preferable with the provision that the location and surface area must be specified, since mild incapacitation depends on where the contamination exists and the extent of body surface involved.

ANNEX A. REFERENCES.

1. Final Report SPC 810, "Nuclear, Biological, and Chemical Contamination Survivability Standards Study (U)," System Planning Corporation, August 1982. (SECRET)

2. QWG/NBCD Concept Paper, "Nuclear, Biological, and Chemical (NBC) Contamination Survivability for Army Materiel." (UNCLASSIFIED)

3. QSTAG 244, Edition 3, "Nuclear Survivability Criteria for Military Equipment (U)." (CONFIDENTIAL)

4. QSTAG 620, "Consistent Set of Nuclear Survivability Criteria for Communications-Electronics (C-E) Equipment (U)." (CONFIDENTIAL)

APPENDIX C. ABBREVIATIONS.

ACAMS	-	automatic continuous air monitoring system
AMC	-	Army Materiel Command
AMCR	-	Army Materiel Command Regulation
AR	-	Army Regulation
BG	-	*Bacillus subtilis* var. *niger*
C_e	-	effective average concentration
CGy	-	centigray (rad)
CFU	-	colony forming unit(s)
DA	-	Department of the Army
DS-2	-	decontaminating solution number 2
DTP	-	detailed test plan
EA	-	environmental assessment
FD/SC	-	failure definition/scoring criteria
FM	-	field manual
FP	-	fluorescent particle(s)
GD	-	chemical agent soman
HD	-	chemical agent distilled mustard
IAP	-	independent assessment plan
IAW	-	in accordance with
IEP	-	independent evaluation plan
MED	-	medical
MIL-STD	-	military standard
MINICAMS®	-	miniature automatic continuous air monitoring system
MIRAN®	-	miniature infrared analyzer
MMD	-	mass median diameter
MOPP4	-	mission-oriented protective posture level 4
MOS	-	military occupational specialty
NBC	-	nuclear, biological, and chemical
NEPA	-	National Environmental Policy Act
NIGA	-	neutron-induced gamma activity
OMS/MP	-	operational mode summary/mission profile
ORI	-	operational readiness inspection
PAM	-	pamphlet
psi	-	pounds per square inch
QA	-	quality assurance
QSTAG	-	Quadripartite Standardization Agreement
RDT&E	-	research, development, test, and evaluation
REC	-	record of environmental consideration
RH	-	relative humidity

RTM	-	real-time monitor
SAR	-	safety assessment report
SOMTE	-	soldier, operator, maintainer, tester, and evaluator
SOP	-	standing operating procedure
TGD	-	thickened soman
TIIN	-	test item identification number
TOP	-	test operations procedure
VX	-	a persistent nerve agent

APPENDIX D. REFERENCES.

REQUIRED REFERENCES

1. American, British, Canadian, Australian Armies Standardization Program, Quadripartite Standardization Agreement 747, Edition 1, NBC Contamination Survivability Criteria for Military Equipment, 12 August 1991.

2. Headquarters, Department of the Army, Washington, D.C., Army Regulation (AR) 385-61, The Army Toxic Chemical Agent Safety Program, 28 February 1997.

3. Headquarters, Department of the Army, Washington, D.C., Department of the Army Pamphlet (DA PAM) 385-61, Toxic Chemical Agent Safety Standards, 31 March 1997.

4. Headquarters, Department of the Army, Washington, D.C., Army Regulation (AR) 50-6, Chemical Surety, 1 February 1995.

5. Headquarters, Department of the Army, Washington, D.C., Army Regulation (AR) 190-59, Chemical Agent Security Program, 24 June 1994.

6. U.S. Army Materiel Command, Alexandria, Virginia, Army Materiel Command Regulation (AMCR) 385-100, Safety Manual, 26 September 1995.

7. US TOP 8-2-500, Receipt Inspection of CB Materiel, U.S. Army Test and Evaluation Command, Aberdeen Proving Ground, Maryland, 1 July 1984.

8. Headquarters, Department of the Army, Washington, D.C., Field Manual (FM) 3-5, NBC Decontamination, 17 November 1993.

9. Office of the Surgeon General, U.S. Army, Washington, D.C., Technical Bulletin MED 507, Heat Stress Casualty Control, 25 July 1980.

FOR INFORMATION ONLY

a. Headquarters, Department of the Army, Washington, D.C., Army Regulation (AR) 70-75, Survivability of Army Personnel and Materiel, 10 January 1995.

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i. Chemical Systems Laboratory Notebooks 9823 (Stunkard) and 9283 (Fielder), 1979, Chemical Systems Laboratory, Edgewood Arsenal, Maryland.

j. Salomon, L. L., R. K. Dumbauld, and J. F. Bowers, Dugway Proving Ground Test Procedures for Assessing Compliance with the Chemical Decontaminability Requirements of AR 70-71, Paper presented at the Test Technology Symposium, 26-28 January 1988, The Johns Hopkins University, Laurel, Maryland.

Forward comments, recommended changes, or any pertinent data that may be of use in improving this publication to Commander, U.S. Army Test and Evaluation Command, ATTN: AMSTE-TM-T, Aberdeen Proving Ground, Maryland 21005-5055. Technical information may be obtained from the preparing activity: Commander, U.S. Army Dugway Proving Ground, ATTN: STEDP-WD-C-CT, Dugway, Utah 84022-5000. Additional copies are available from the Defense Technical Information Center, 8725 John J. Kingman Road, Ft. Belvoir, Virginia 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.