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This TOP supersedes TOP 8-2-509A, dated 3 August 2016.

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**14. ABSTRACT**
This Test Operations Procedure (TOP) provides basic information to facilitate planning, conducting, and reporting of large item interiors testing such as tactical vehicles, fixed and rotor wing tactical aircraft, vans, shelters, building interiors, shipboard interiors, and cargo aircraft interiors. This TOP provides standard methods for chemical and biological contamination survivability (CBCS) testing of interior surfaces of military materiel. It is designed to provide results to determine if large items of mission-essential (ME) equipment have met applicable chemical, biological contamination survivability (CBCS) requirements. This TOP describes typical facilities, equipment, and procedures used to contaminate and decontaminate equipment, samples for contamination density, and samples for residual vapor or liquid contamination, to determine degradation of mission essential (ME) functions resulting from the contamination/decontamination (C/D) procedures.

**15. SUBJECT TERMS**
CB; chemical; biological; NBC; biological, chemical; contamination; decontamination; survivability; hardness; decontaminability; compatibility; simulant; material effects; chemical and biological materials effects (CBME) database

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

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# CHEMICAL, BIOLOGICAL, AND RADIOLOGICAL CONTAMINATION SURVIVABILITY, LARGE-ITEM INTERIORS



*This TOP supersedes TOP 8-2-509A, dated 3 August 2016.

1. SCOPE.

1.1 Purpose.

a The purpose of this Test Operations Procedure (TOP) is to address chemical and biological (CB) contamination survivability (CBCS) testing of the interiors of large items of mission-critical systems. TOP 08-2-510B[1**] separately addresses the exteriors of large items of mission-critical systems. Large item interiors are defined as tactical land vehicles, fixed and rotor-wing tactical aircraft, vans, shelters, building interiors, shipboard interiors, and cargo aircraft interiors.

b. The hierarchy or logic for testing/selection of tests (most desirable because of the information gained through least desirable) is:

(1) Full system agent or simulant interior testing gives full information on the ability of a system to be survivable. The use of the actual system under test (SUT) is the most reliable and realistic method for assessing all aspects of the item's survivability. These aspects include assessing for agent trapped in cracks, crevices, between components, in angles, and in odd shapes not easily decontaminable, and evaluating the item's textures and geometry. If it is not feasible and/or cost effective to use the actual item to determine survivability, then based on coordination between the tester, the customer, and the evaluator, testing alternatives will be considered and a choice for testing made.

(2) Scaled-down testing will use a smaller version (e.g., one-quarter scale, etc.) in place of the full-size version of the SUT. The test methods described in this document will still be used.

(3) Component agent testing gives information on the ability of a component or components to meet the criteria. Detailed planning must be conducted to determine if the data from component testing can be extrapolated to full system interior testing. If the component method is selected for testing to represent a large item, the procedures in TOP 08-2-111B[2] will be followed.

(4) Mock-ups may be specially fabricated to simulate the SUT interior, or the actual SUT with expensive optical, electronic, or other internal components removed. Mock-ups must be fabricated of the same materials, have the same coatings, and have similar design features as the intended developmental SUT. The mock-ups must be furnished and/or approved by the materiel developer. The similarities and differences between the mock-up and the SUT it simulates will be carefully analyzed and documented.

(5) A chemical, biological, and radiological (CBR) contamination survivability assessment (CBRCSA) is an assessment of the expected ability of the system interior to be survivable with the possibility of little or no agent data available for consideration. No actual testing is conducted.

** Superscript numbers and letters correspond to those in Appendix B.

c. CBCS is the capability of a system and its operators to withstand a CB-contaminated environment, including decontamination, without losing the ability to accomplish the assigned mission. Characteristics of CBCS are decontaminability, hardness, and compatibility. These characteristics are defined in paragraphs 1.3.1 through 1.3.3. Agent must be used to measure decontaminability and hardness for the full cycle (contamination, decontamination, and re-issue to the Warfighter). Simulants may be used to measure hardness against decontamination methods, solutions, and/or mixtures. CBCS should be monitored throughout the materiel acquisition cycle and is to be evaluated and assessed during developmental and operational testing.

d. This TOP provides basic information to standardize and facilitate planning, conducting, reporting, and standardizing CBCS testing of military materiel and infrastructure interiors. It is designed to provide results to demonstrate that the interiors of large items of mission-critical systems or infrastructures have met the policies of Army Regulation (AR) 70-75[3] as implemented by the Department of the Army (DA)-Approved Nuclear, Biological, and Chemical (NBC) Contamination Survivability (NBCCS) Criteria for Army Materiel[4]. This TOP describes typical facilities, equipment, and procedures used to contaminate equipment, sample for contamination density and residual contamination, decontaminate; determine the degradation of mission-essential (ME) functions resulting from the contamination/decontamination (C/D) procedures; and analyze crew/test-item compatibility.

e. The acronyms, CB and CBR, are used in this document, rather than NBC, to reflect current terminology in use within the Department of Defense.

1.2 Limitations.

a. For many systems or infrastructure, the use of actual chemical agents may be limited because of the complexity and cost of testing actual interiors. Where size, complexity, personal safety, or cost prohibits the testing of actual interiors, testing panels and/or components may be required. Therefore, tests on representative panels and/or subcomponents may be conducted as described in TOP 08-2-111B[2]. It is imperative that the assigned evaluator be involved early in the test design to confirm that the proposed data collected from these alternative tests are acceptable.

b. When testing is conducted using simulants for chemical warfare agents (CWAs) or agents of biological origin (ABOs) without a corresponding agent/simulant correlation or relationship, the test data must not be used without the establishment of the agent/stimulant relationship. Information on the physical parameters that are being simulated must be included in test reports. Overall, it must be noted that simulants do not represent CWAs/biological warfare agents (BWAs) in many properties.

c. This TOP does not, nor does it intend to, identify or predict all scenarios and conditions that may be applicable to CBCS testing. Therefore, coordination with the combat and material developers and the use of appropriate threat documents is imperative in developing an operationally realistic environment and a comprehensive test. The evaluator will participate in determining the number of test events necessary for each CB mission-critical system, ensuring

statistical significance. This allows for successful extrapolation and assessment of CBCS test results for the interiors of CB mission-critical systems.

d. Testing of interiors may require a static environment to gain reproducible results, which may not reflect operational scenarios.

e. Measurement of hardness against actual CWAs/ABOs is not always possible for system-level interiors. Materials of mission-critical components/systems within the infrastructure that are deemed accessible to CWA/ABO contamination should be tested at the coupon level to assess material changes. The observed material changes would then require an evaluation by the system developer and/or evaluator as to the potential system-level implications. These materials would be tested in accordance with (IAW) TOP 08-2-061[5].

f. The only criteria for CBCS as listed in this TOP are for the Department of the Army[4]. Although AR 70-75[3] covers chemical, biological, and radiological contamination survivability (CBRCS) policy, there are no additional criteria. For acquisition programs that have CBRCS requirements, the default is to use the DA criteria.

g. There are many factors that can affect the performance and/or survivability of a system interior before and after the conduct of decontamination operations. Many of these factors cannot be evaluated for their effects. An example would be the age of the paint on the surface (aged, new, etc).

h. The only current mechanism for converting agent mass from solid sorbent tubes (SSTs) or bubblers is to use a downwind hazard prediction model[6]. After a decontamination system performance model is developed with the necessary toolset, then that model may replace the current model.

i. The compatibility portion of CBCS will not be addressed in this TOP. Compatibility of operation while wearing personal protective ensemble, is more efficiently addressed during operational testing.

j. Radiological testing is not covered in this version of the TOP.

1.3 General Criteria Evaluations.

The following procedures must be used to quantitatively assess the ability of an item tested to meet the criteria for decontaminability and hardness.

1.3.1 Decontaminability.

a. Chemical.

(1) Vapor Hazard.

(a) The effective concentration of agent vapor desorbed is $C_e$. The mission time provided by the user is t. Then $C_et$ = dosage, which must be compared with the appropriate criteria[4].

(b) As the SUTs become larger, the ability to collect vapors from the entire system becomes extremely complicated. A sampling method must be developed and validated for collecting vapor samples from interior surfaces. The sampling method must be described in any test report. The sampling method may not provide entire interior surface samples, but may define representative areas to be sampled for extrapolation to the total surface area of the system being tested.

(c) Traditional vapor samplers (bubblers and SSTs) sample vapor streams for discrete periods of time defined by a sampling plan. The bubbler solvent containing agent or the SSTs with agent residing on the sorbent are analyzed and the mass of residual agent quantified. The volume of agent-containing air is determined by using critical orifices to restrict the airflow through the sampler and flow rating the critical orifice on the upwind side before and after the sampling period. The two flow rates allow a determination of whether or not the airflow through the sampler changed over time. The mass of agent is used to calculate the average concentration during the sampling period by multiplying the mass times the volume of air that passes through the sampler. The dosage is calculated by multiplying the concentration by the time of sampling and then accumulating the dosage for all sample periods for a total dose.

(d) The MINICAMS® is being used to replace the traditional vapor samplers as a near real-time analytical method. The MINICAMS reports concentrations. The air-sampling rate is controlled by a mass flow controller at 0.5 meters per second (m/s). The sampling times (sample, analyze, and then purge) range from 3 to 15 minutes. The concentration can be multiplied by the total sample time for a total dose.

(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 must be compared with the appropriate mass value in Table 1 of the criteria for Army materiel[4].

b. Biological. The colony-forming units [(CFUs), spores that have become viable cells] that are sampled after decontamination are divided by the number of CFUs sampled after contamination of the SUT. This ratio is then expressed as the log reduction and is compared with the appropriate criteria[4]. The criteria are based on a spore count, and because it is impossible to realistically count individual spores, a CFU reduction of 6 logs (i.e., reduced by a factor of one million) is used instead. If the system CFU reduction is greater than or equal to 6 logs, then the system has successfully met the criterion for biological decontaminability.

1.3.2 Hardness.

CB hardness[4] is “the capability of materiel to withstand the material-damaging effects of CB contamination and relevant decontaminations”. Changes in critical physical/performance parameters will provide insight as to how the system interior may function following C/D. At times, the system will not be tested against CWA or BWA but against a simulant. Under these conditions, the only meaningful data will be the hardness of the material/system to the decontamination process.

a. The ME function characteristics will be obtained from the material developer (i.e., voltage output, airflow, pressure, etc).

b. The ME function characteristics will be measured on the as-received item for baseline functional performance.

c. The C/D cycles will be performed. The same parameters will be measured after each cycle.

d. Pre- and post-C/D measurements will be compared to obtain the percent degradation (if any).

e. Long-term effects (30 days or greater), as outlined in test documentation (such as air worthiness considerations), will include additional measurements of the selected function parameters at scheduled time intervals.

f. Multiple cycles of C/D (more than the usual five cycles) also need to be considered in cases related to biological contamination not related to BWAs and regular transits from the U.S. to outside the U.S. (usually aircraft). This consideration is intended for military materiel in a civilian environment.

1.3.3 Compatibility.

The ability to obtain operationally relevant data during development or laboratory testing is extremely limited and may have to be obtained during operational testing. Functions relating to the operation of the SUT are measured while individuals and/or crew members are wearing normal uniforms and while wearing mission-oriented protective posture, level IV (MOPP IV). The percent difference in times is calculated, and if it is less than 15 percent, the SUT has successfully met the criterion for compatibility[4].

a. The ME Warfighter tasks, applicable to the system interior, will be obtained from the user for the equipment under evaluation.

b. Tasks (timed) will be performed in the operator's standard garment.

c. Tasks (timed) will be performed in the protective ensemble.

d. Times and effectiveness of the operator(s) will be compared.

## 2. FACILITIES AND INSTRUMENTATION.

Facilities, instrumentation, and safety procedures used for CBCS CWA testing are strictly controlled. Testing with simulants has fewer restrictions.

2.1 Facilities.

| Item | Requirement |
|---|---|
| Chemical surety laboratory and chemical agent storage facility. | Constructed to ensure safe and secure storage, handling, analysis, and decontamination of chemical agents and/or simulants used for surety materiel. |
| Chemical agent test facility (chamber). | Constructed to house the SUT during agent or simulant C/D and sampling. The chamber must have sufficient volume to allow free air circulation around the SUT. Ability to control temperature, relative humidity (RH), and wind speed is required. |
| Biological decontamination facility [Joint Biological Agent Decontamination System (JBADS)]. | Built to perform hot, humid air decontamination of tactical, cargo, and rotor wing aircraft. |
| Fielded decontaminating apparatus as specified in the concept of operations (CONOPS). | Constructed to decontaminate the SUT as part of the test procedure. |
| Biological analytical laboratories. | Required to store and prepare test quantities of biological contamination simulant materials, to charge disseminating devices, to prepare samplers, and to analyze all biological agent/simulant materials. |
| Chambers for biological simulant testing. | The chamber must be equipped with an air intake and an exhaust system, and must have sufficient volume to allow free air circulation around the SUT. Biological surety regulations will be followed if biological surety material is used at any time. Ability to set and maintain temperature and RH is highly desirable. |
| Test range or appropriate operational test facility. | Required to allow the SUT to be operated and to perform all ME functions and tasks required to accomplish specific CONOPS as outlined in the capabilities documents. This includes tasks such as communications, aiming and tracking targets, firing weapons, using optical instruments, operating controls and switches, reading instruments, resupply, and decontamination. Observation and measurement of any degradation of the ME functions attributable to the C/D procedures or CB protective equipment that the test-item operators are required to wear must be recorded. |

2.2 Instrumentation.

The instrumentation choices are test and test location dependent. Permissible error-measurement values are minimum requirements. Actual instrumentation may have greater precision; actual values must be reported.

| Parameter | Measuring Device | Permissible Error of Measurement |
|---|---|---|
| Air temperature (-20 to 50 °Celsius (°C)). | Thermocouple or other. | ±0.5 °C. |
| Relative humidity (0 to 90 percent). | Hygrometer or other. | ±2 percent. |
| Wind speed (0 to 5 m/s). | Anemometer or other. | ±0.1 m/s. |
| Video. | Video camera. | Adequate to document typical test procedures, details of contamination techniques, and any discrepancies from planned procedures necessitated by operational conditions. |
| Photographs. | Still color camera. | Adequate to document typical test procedures, details of contamination techniques, and any discrepancies from planned procedures necessitated by operational conditions. |

2.2.1 Chemical Test Instrumentation.

The instrumentation choices are test and test location dependent. Permissible error measurement values are minimum requirements. Actual instrumentation may have greater precision; actual values must be reported.

| Parameter | Measuring Device | Permissible Error of Measurement |
|---|---|---|
| Chemical agent mass from liquid samples (microgram (µg)). | Gas chromatograph (GC), high-performance liquid chromatograph (HPLC), liquid chromatograph (LC), spectrophotometer, or equivalent. | ±15 percent of calibration standard. |

| Parameter | Measuring Device | Permissible Error of Measurement |
|---|---|---|
| Contamination density or challenge level in grams per meter squared ($g/m^2$). | GC, HPLC, LC, spectrophotometer, or equivalent. | ±15 percent of calibration standard. |
| Contamination density drop size in millimeters (mm). | Digital imaging software for measuring or "reading" the diameter of the drops. | ±10 percent. |
| Chemical agent mass from vapor samples. | GC, HPLC, LC, spectrophotometer, MINICAMS® or equivalent. | ±15 percent of calibration standard. |

2.2.2 Biological Test Instrumentation.

| Parameter | Measuring Device | Permissible Error of Measurement |
|---|---|---|
| Background contamination | Microscopes, swabs, or wipes plated on growth media, automatic colony counters, or equivalent. | ±10 percent CFU/sample. |
| Post-contamination verification. | Microscopes, swabs, or wipes plated on growth media, automatic colony counters, or equivalent. | ±10 percent CFU/sample. |
| Post-decontamination residual. | Microscopes, swabs, or wipes plated on growth media, automatic colony counters, or equivalent. | ±10 percent CFU/sample. |

2.2.3 CB Hardness Test Instrumentation.

| Parameter | Measuring Device | Permissible Error of Measurement |
|---|---|---|
| ME functions as described in specific CONOPS. | As necessary (optical haze, transmittance, durometer, tensile strength, etc.). | Precision and accuracy requirements must be compatible with the nature of the SUT and type of function but must allow for the detection of 20 percent degradation in the ME performance characteristic after completion of each of the required C/D cycles. |

3. REQUIRED TEST CONDITIONS.

a. CBCS testing requires the handling and use of chemical and biological agents. Throughout testing, primary emphasis must be on operator and test safety. The importance of technical quality, completeness of test data, and conformance with specified test and operating procedures must be emphasized.

b. The required test parameters[4] are temperature (30±2.0 °C) and airflow across the SUT (<1.0 m/s). There is no requirement for controlling RH.

3.1 Test Planning.

a. Each CBCS test plan must be reviewed for technical accuracy, conformance to regulations, and standing operating procedures (SOPs) applicable to the specific item and tests being conducted. In addition, the test plan must accurately reflect the requirements outlined in capabilities documents. Published test records, procedures, and the case files of tests of similar items to identify potential areas that are difficult to decontaminate must be reviewed. All SOPs and procedures for current, adequate, and complete information must be reviewed.

b. The Capability Development Document (CDD), the CONOPS, and Failure Definition/Scoring Criteria (FD/SC) must be reviewed. The Operational Test Agency (OTA) Evaluation Plan (OEP) and the Test and Evaluation Master Plan (TEMP) will be used to determine the overall test structure, data required, criteria, and analysis to be used. The ME function performance characteristics specified by the Materiel Developer and the Combat Developer will be listed. These will be used to measure the degradation in performance caused by CB C/D. Units of measurement and the accuracy and precision required for each parameter measured will be identified. All issues concerning measurable performance and degradation will be reviewed.

c. Based on the information collected from the requirements documents and in coordination with the customer, the number of SUTs and the number of C/D cycles that need to be conducted on the SUT will be determined.

d. A realistic test-item sample size (based on test cost, as well as test-item size, value, and availability) will be determined through review and coordination with the assigned operational test-activity evaluator. The sample size may be determined by test-item availability, cost, or other factors that may cause it to be less than optimum. If sample size is less than optimum, a testing scheme will be devised to optimize test-item use and required-data output. The use of the design-of-experiment will be considered in developing the test matrix.

e. Representative areas of the SUT or infrastructure interior under test to be sampled for residual contamination will be selected and identified. The number, location, and shape of the areas selected to be tested will depend on consideration of test-item size, geometry, materials of construction, surface texture, presence of joints and crevices, areas handled/touched by system operators, and the likelihood to contribute to crew vapor and contact hazard. Because of the nature of sampling devices, sample locations need to be flat or nearly flat. Coupons of the same material as the sample location (including any paint, anodizing, etc.) can be used by attaching the coupons on the sample location and removing them for liquid extraction of residual contaminant.

Additional consideration must be given to any areas that might allow contaminating agents and/or simulants and decontaminating solutions to seep into and degrade delicate or vulnerable equipment. An appropriate number of such areas will be selected to help assure the statistical validity of the resulting sample size. The test plan will identify and explain the rationale for the areas selected and the statistical analysis methodology used. The test report will identify any changes from the test plan. Each sample location selected must be described and photographed. No additional marks should be placed within the marked boundaries of the locations to be sampled.

f. C/D cycles will be conducted using agents and/or simulants and fielded decontamination systems and procedures. Actual survivability can only be confirmed by using actual agents. The default chemical agents[4] are persistent nerve agent (VX), distilled mustard (HD), and thickened soman (TGD). A biological simulant is used in place of an ABO. Decontamination systems and decontaminants include, but are not limited to: the reactive skin decontaminant lotion (RSDL) skin decontamination kit; the M295 decontamination kit individual equipment; the M100 sorbent decontamination system; hot soapy water (HSW); supertropical bleach (STB), and Joint Sensitive Equipment Wipe (JSEW). Field expedient decontaminants include, but are not limited to: high-test hypochlorite (HTH, a STB substitute); household bleach solutions (usually a ratio of one part bleach to ten parts water); alcohol-wetted cloth (for sensitive equipment); and low-pressure, high-volume water.

g. If the system being tested is a tactical, cargo, or rotor wing aircraft for biological contamination, then the JBADS hot, humid air decontamination should be used. In the case of JBADS, control of the humidity is required for the biological decontamination process.

h. If the system consists of materials similar to other systems already tested (e.g., both system's chassis are chemical agent-resistant coating-painted steel, or both systems are bulldozers with one being larger than the other), then consideration may be given to conducting a CBRCSA as a cost-saving measure. Before implementing this option, coordination must occur with the test sponsor and the OTA conducting the system evaluation. The basic steps of a CBRCSA are:

(1) The test-item design and the materials of construction will be examined. The materials of construction will be reviewed to see if any data pertaining to those materials can be found in the chemical and biological materials effects (CBME) database[7]. An analysis will be performed based on previous test experience and technical information concerning the material's ability to survive exposure to contamination, decontaminants, and the decontamination process. If there are material effects data in the CBME, then the data can be reviewed for applicability to the current system.

(2) Any areas where agent could pool or seep, such as cracks, crevices, hinges, joints, countersunk screw heads, or other difficult to decontaminate features, will be noted. The manufacturer's operation manual or preliminary instructions, if available, will be reviewed for any cleaning/decontamination instructions.

(3) It is recommended that any identifiable vulnerabilities or questionable design or materials should be adequately tested. If any aspect of design or identification of a material

appears to make test failure probable, testing of the suspect design or material should be performed early in the test cycle.

(4) Preliminary results can often be determined from a pilot study and analysis of the collected information. The report of the survivability assessment will detail the expected ability of the system to meet the CBRCS criteria[4].

i. Qualified and trained operators and standard equipment (decontamination, maintenance, and calibration, etc.), that Warfighters would use with the system will be scheduled for tests involving the use of simulants. These operators may be used for hardness testing. If Soldiers are desired, ensure a Test Schedule and Review Committee request is submitted within one year from the start of testing or as early as possible. Standard decontamination procedures will be developed for the SUT, if required. Before testing begins, rehearsals must be held to familiarize the test team with the functioning of the SUT, test procedures, and data requirements. The team must practice using simulants until agent-dispensing, decontamination, and sampling become reproducible and routine. The SUTs used during the actual test must not be used for rehearsals with simulants unless it is the only SUT available and testing will be conducted outdoors. It is recommended that one or more dry-runs be performed to give operators an opportunity to demonstrate, standardize, and confirm operational procedures.

j. For tests involving threat agents, the appropriate laboratory will be scheduled to conduct the test, and laboratory technicians will receive appropriate system-operating training before testing begins.

k. Existing system-specific decontamination procedures, using fielded decontaminants or developmental decontaminants, must be reviewed and incorporated into the planned test as much as possible. Any deviations from existing procedures in the test plan must be documented in the test report.

3.2 Safety.

Applicable safety and surety regulations will be reviewed to ensure compliance of all test procedures.

3.3 Environmental.

All test site specific environmental requirements for local, state, and federal approvals for the use of simulants will be met and documented.

3.4 Quality Assurance (QA) and Quality Control (QC).

a. A QA plan, as required by the test site, must be prepared for each test program to ensure that all variables that can be controlled are controlled and that appropriate records are kept throughout the duration of testing. Variables that cannot be controlled must be identified in the test plan. Test variables include, but are not limited to: purity and stability of CBR agents and simulants used, purity and stability of decontaminants, calibration and maintenance of instrumentation and disseminators, accuracy and precision of the laboratory instruments, and quality and uniformity of all test samples.

b. The condition of the SUT at the time of testing is an important test variable. Unless receipt inspection was accomplished as part of a subtest completed before CBCS testing, the SUT should be receipt inspected. Inspection data, certificates of compliance, or similar documentation must be reviewed to ensure the interior surfaces, finishes, and packaging meet specifications. Generally, the item must be tested in as-received condition, matching its condition when issued to Warfighters in the theater of operations as closely as possible. CBRCS testing may be required periodically throughout the equipment life cycle if the effect of normal wear is a major factor in survivability.

c. Testing must always be conducted IAW approved test documentation, such as technical manuals, field manuals, equipment operating instructions, SOPs, this TOP, the approved test-planning directive, OEP, TEMP, and the test plan. Deviations from test documentation will be put in writing and approved by the appropriate authority as part of the test plan and report production.

d. All QC measures will be described in the test plan.

e. Instrumentation calibration will be recorded as part of the test record, and will include the calibration requirement (yearly, semi-annual, etc.).

## 4. TEST PROCEDURES.

Paragraphs 4.1 through 4.3 address CB contamination survivability testing separately. Although the test methods are similar, subtle but important differences exist. Long-term CB hardness is discussed in paragraph 4.6.

### 4.1 Receipt Inspection.

a. Test items must be inspected for shipping damage, completeness of assembly, required accessories, and necessary manuals, logbooks, etc. Any missing components, damage, or other discrepancies noted will be documented. There should be no visible damage to the systems.

b. Before testing the test items should be assigned unique test item control numbers (TICNs). The TICNs can be generated during receipt inspection as sequential alphanumeric codes that identify the specific test item. The component or the manufacturer's serial numbers may be used as the identifier. The TICNs must be permanently marked or attached to the test items.

c. Sample locations will be marked to ensure samples are taken from the same area. The area markings must outline the total area. Sample location identifiers must be outside the marked area. The sample location identifiers, descriptions, materials of construction, and surface geometry and texture, will be recorded by photograph for the test report.

### 4.2 Test Method Outline.

a. SUT will be prepared for testing, to include sample location, identification and documentation; marking of sample areas; etc. as described in paragraph 4.1.

b. The agents/simulants will be prepared for application as described in paragraph 4.3.7.

c. Test chamber operation will be verified and environmental conditions for the test stabilized (if test is conducted in a chamber). If an item is too large to fit properly in a chamber, testing may be conducted outdoors. Environmental conditions will be monitored, the SUT will be allowed to equilibrate with the ambient conditions, and any required background samples will be taken before contamination IAW paragraph 4.3.8.

d. Agents/simulants are applied to the SUT. Paragraph 4.3.9 describes the details of this step.

e. Decontamination operations will be conducted on the SUT as described in paragraph 4.3.10.

f. Post-decontamination vapor and liquid (contact) sampling and sample analysis will be conducted as described in paragraph 4.3.11.

g. Hardness determination, including post-decontamination functional performance measurements, will be performed IAW paragraph 4.3.12.

4.3 Chemical Contamination Survivability Testing.

4.3.1 Objectives.

a. Decontaminability. The ability of a system or infrastructure to be rapidly and effectively decontaminated (less than 75 minutes[4]) following chemical-agent exposure will be determined. Vapor and percutaneous hazards, including eye effects, associated with Warfighter use of equipment that has been contaminated with chemical agent and decontaminated using standard and/or item-specific decontamination procedures will be measured.

b. Hardness. The capability of a system or infrastructure interior to withstand the material damaging effects of chemical agent and relevant decontaminations will be determined. The degree of performance degradation in ME functions of military mission-critical materiel after chemical agent C/D by standard and/or item-specific procedures will be measured.

4.3.2 Criteria and Conditions.

a. Criteria.

(1) Decontaminability. The interior surfaces of systems developed to perform ME functions shall be designed so that chemical contamination remaining on, or desorbed from, the surface following decontamination shall not result in more than a negligible risk (5 percent mild incapacitation) to unprotected individuals working inside, on, or 1 meter from the system after chemical agent C/D, as stated in the criteria[4].

(2) Hardness. Mission-critical systems shall be hardened to ensure that exposure to the specified C/D cycles does not degrade the operational ME functions of the system more than

20 percent (or that specified by the Combat Developer) over a 30-day period[4] or as defined by the capabilities documents.

**NOTE**: As an example, if the hydraulics of a cargo aircraft loading ramp are consistently able to lift the ramp in 10 minutes before decontamination, and can only lift the ramp in 15 minutes after five cycles of decontamination, then the degradation is measured as [(15-10)/10]×100 = 50 percent.

b. Conditions.

(1) Selected interior areas will be initially contaminated in a random drop pattern (if a syringe or pipettor is used) or by an aerosol generated over the selected surface, to a contamination density as specified in the system threat assessment and capability documents. If no operationally relevant drop size has been determined, the default size will be 5- to 10-microliter (µL) drops of TGD, or 2- to 5-µL drops of unthickened HD or VX. If the system threat assessment does not specify contamination density, 10 percent of exterior contamination, or 1 g/m² (IAW the NBC criteria[4]) will be used.

(2) The purity of the chemical agent and/or simulant used must be known and recorded as test data. A purity certification must be provided with the agent used for testing, and the certificate will have been issued within the last 12 months. The quantity applied may be adjusted to achieve the required pure agent contamination density. If weapons-grade agent is used, the purity must be measured and recorded as test data. If simulant testing is necessary, a simulant/agent correlation must be fully documented.

(3) The amount of time between contamination and the start of decontamination operations (often called weather time) will depend on requirements in the capability documents. The default weather time is 60 minutes[4]. Given changes in battlefield doctrine, the default weather time may not be representative of the actual travel time from a contamination site to a decontamination site. Weather time must be coordinated with the test sponsors and Combat Developers. Standard field and/or item-specific decontaminants, equipment, and procedures will be used as much as possible. The decontamination procedure conducted and time between C/D will be included in the test plan for each system or equipment item. The decontamination process time (excluding point detector monitoring) must be recorded.

(4) The chamber and item surface temperature will be 30°C (86 °Fahrenheit (°F) and chamber wind speed no greater than 1 m/s[4].

4.3.3 Controls and Limitations.

a. System Interior Surfaces. Testing may be done with simulants on system-level interiors, or CWA testing may be done on representative panels, components, mock-ups, or scale models.

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

c. Before each trial, the interior surfaces (vapor and contact) will be inspected and sampled for background contamination. All residual background decontaminant and other foreign substances that could interfere with sample analysis must be removed before trials are conducted.

d. Analysis control data includes standard analytical controls. The standards need not be at equal concentration intervals across the expected range; rather, they should be spaced closer together near the low-concentration end of the calibration curve and then across the expected concentration range.

e. Test controls should include:

(1) Vapor only: Non-operated sampler control (a sampler taken into the area surrounding the SUT but not used, opened, or aspirated).

(2) Vapor only: Operated sampler control (a sampler taken into the area surrounding the SUT and used, opened, or aspirated, but not exposed to agent or simulant).

(3) Positive control, which is a SUT or panel that is contaminated but not decontaminated.

(4) Negative control, which is a SUT or panel that is not contaminated but is decontaminated.

f. Actual system testing is the preferred method and should be used when feasible and cost effective. The use of the actual SUT is the most reliable and realistic method for assessing all aspects of the system's decontaminability. These aspects include assessing for agent trapped in cracks, crevices, between components, in angles, and in odd shapes not easily decontaminable, and evaluating the item's textures and geometry. A mock-up (some actual-sized configuration that will fit into a test chamber) is most likely to be tested because of cost and size considerations. The test methods and procedures that follow are for the actual system or mock-up of a system.

g. If it is not 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. In coordination between the tester, the customer, and the evaluator, the following will be considered:

(1) The data requirements.

(2) Scaled-down Testing. A smaller version (e.g., one-quarter scale, etc.) will be used in place of the full-size version of the SUT. The test methods described in this document will still be used.

(3) Small Section or Component Testing. If the small section or component method is selected for testing to represent a large item, the procedures in TOP 08-2-111B[2] will be followed.

(4) Panel Testing. If panel testing is selected, the panels must be made from the same materials as the large item being evaluated. The procedures in TOP 08-2-061B[5] must be followed.

(5) Mock-ups. The mock-ups may be specially fabricated to simulate the SUT or may be the actual SUT with expensive optical, electronic, or other internal components removed. Mock-ups must be fabricated of the same materials, have the same coatings, and have similar design features as the intended developmental SUT. The mock-ups must be furnished and/or approved by the Materiel Developer. The similarities and differences between the mock-up and the SUT it simulates will be carefully analyzed and documented.

h. Data analysis for the SUT and component testing are the same. The resulting data for component testing may or may not be applicable to the whole system.

4.3.4 Data Required.

The following data in the units indicated will be reported:

a. Test chamber or interior space:

b. Temperature in °C.

c. RH in percent (especially if the decontaminant requires a specific relative humidity).

d. Agent or Simulant:

(1) Name and control number.

(2) Purity in percent.

(3) Name, product identity, and manufacturer of thickener (if thickened).

(4) Viscosity after adding thickener (if thickened) in centistokes (cSt).

(5) Time since thickening, if thickened.

(6) Name, product identity, and manufacturer of dye (if used).

(7) Quantity of dye and/or thickener (if thickened) in grams per liter (g/L).

(8) Quantity of agent/simulant dispensed in grams (g).

(9) Agent/simulant contamination density in $g/m^2$.

(10) Agent/simulant drop diameter in mm (drop size distribution and mean).

e. Results of each post-decontamination agent/simulant vapor and contact sample (collected during the sampling period) in µg/sample.

f. Complete description of the contact sampler used (material type, lot number, diameter, thickness, and any other pertinent information). Description of any contact sampler efficacy and/or solvent extraction efficacy studies conducted on the contact sampler and solvent used for extraction.

g. Total number and location of contact samplers.

h. A description of the required contact-sampling times specified.

i. Results of sampling and analysis controls and standards in µg/sample.

j. Sample history with elapsed time to analysis in days.

k. Contamination, weathering, decontamination, and sampling elapsed times in minutes.

l. Description of decontamination solutions (i.e., formulation, active ingredients, lot number, and age).

m. Methods, equipment, and system-specific procedures used during decontamination.

n. Description and photographs of the system interior surface condition (pretest), including construction materials, paint type, paint thickness (number of coats), paint condition, and surface cleanliness (mud, grease, etc).

o. Description and photographs of system joints, cracks, crevices, and other features that could allow contaminants or decontaminants to penetrate the surface and may be difficult to decontaminate.

p. Pretest (baseline) and posttest (30 days after the first contamination and/or other defined long-term time interval) ME functional performance data, recorded to the highest level of accuracy and precision that is commensurate with the parameter being measured.

q. Description and photographs of any materials degradation (e.g., corrosion).

r. Identification of the C/D cycle event.

s. Any relevant safety findings as a result of testing.

4.3.5 Significance and Use.

a. The sample data collected from chemical contamination survivability testing allows a determination of contact and vapor hazards to unprotected personnel from decontaminated military materiel.

b. The functional performance and/or material effects data collected allows a determination of the amount of physical or functional degradation of the system resulting from CB C/D procedures and materials to determine if there is a hardness issue.

4.3.6 Interferences.

a. There are no interferences when the test method is conducted under laboratory-controlled conditions.

b. Outdoor testing has inherently uncontrolled or extreme variances in temperature or humidity. The extreme variances are constituents or properties that will create test conduct interferences. Exact repeatability is lost with outdoor testing because of the variable natural environmental conditions.

4.3.7 Agent/Simulant Preparation.

a. The agents to be used are as follows:

(1) Neat VX with a purity greater than 85 percent, unless weapons-grade is desired.

(2) Neat soman (GD) with a purity greater than 85 percent unless weapons-grade is desired, and thickened with 5 percent (weight/volume) of Rohm and Haas Acryloid K125 poly(methyl methacrylate). This should provide thickened agent with a viscosity of 1,000 cSt at 20 °C (68 °F). During preparation, batch-to-batch variability in viscosity may be greater than 10 percent. This large variability can be reduced by slowly adding the thickener over long periods of time. Complete solution of the polymer in GD is slow; therefore, mixing must continue until the measured viscosity is constant.

(3) Neat HD with a purity greater than 85 percent (unless weapons-grade is desired). The agent may be prepared with approximately 0.5 percent (weight/volume) of a suitable dye.

(4) The minimum quantification level for HD is 50 µg, for GD is 2.5 µg, and for VX is 250 nanograms (ng).

(5) Other approved contaminants [e.g., non-traditional agents (NTAs), toxic industrial chemicals (TICs), toxic industrial materials (TIMs)] as specified in the TEMP.

b. Simulants to be used are specified in the test plan.

4.3.8 Test Chamber Operation.

When a test chamber is required for use, the test chamber will be operated using the procedures, controls, and SOPs approved for the agent in use. If an item is too large to fit properly in a chamber, testing may be conducted outdoors. Environmental conditions will be monitored, the SUT will be allowed to equilibrate with the ambient chamber or outdoor conditions, and any required background samples will be taken before contamination. Some general technical data requirements for the test chamber are as follows:

a. The test chamber environmental conditions should be computer-monitored, and data should be recorded at least every 15 minutes. The environmental conditions will include air temperature, RH, and wind speed or air speed.

b. The SUT will be placed in the chamber and the chamber stabilized at the environmental conditions specified for the test. The SUT will be conditioned until it has stabilized at 30 ± 5 °C (86 ± 9 °F). Temperature and RH must be recorded continuously throughout the test.

c. Before proceeding to agent application or contamination, background liquid 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.

4.3.9 Agent/Simulant Application.

a. The mechanism for determining the actual amount of agent or simulant used to contaminate the SUT is called baseline contamination samples or baseline confirmation samples. The data collected from these samples will provide confidence that the agent/simulant dissemination method performed well and also provide the actual value for initial contamination. The selection of the appropriate baseline contamination density samplers is dependent on a test site's capability for providing and analyzing the samplers. The samplers will be placed adjacent to the sampling locations. The samplers will be contaminated at the same time as the sampling location of the interior surface.

b. The selected areas of the interior surface will be contaminated with the agent/simulant. Agent/simulant will be applied with a suitable dissemination device that has been calibrated and operated at the flow rate and pressure to achieve the drop size and contamination density specified in the test plan. Precision dissemination device (e.g., pipette) calibration must be current and compliant with the required performance specifications listed in the most current versions of the International Organization for Standardization (ISO) 8655 Parts 1 and 2[8] or American Society for Testing and Materials (ASTM) International E1154-89[9] for the volumes being delivered. If possible, photographs will be taken of drops on the contaminated test surface to record the deposition effects.

c. Immediately after contamination, the contamination density samplers will be removed and placed into sample jars with the appropriate solvent for analytical processing.

4.3.10 Decontamination of Interiors.

a. Army Technical Publication (ATP) 3-11.32 Multi-Service Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Passive Defense[10] is a good source for information on decontamination procedures, decontaminants, and decontamination systems.

b. Decontamination must begin within the time interval specified in the test plan (based on the CONOPS) after completion of contamination and any required aging time. Standard procedures or any system-specific procedures, decontaminants, and equipment will be used. If the decontamination process degrades the material or functionality, the effects must be documented.

c. Decontamination will begin with areas contaminated first and end with areas contaminated last. The decontamination process includes the following steps:

(1) Interior preparation consisting of specific procedures included in the test plan.

(2) Application of the decontaminant.

(3) Decontaminant contact time specific procedures identified in the test documentation package.

d. The time duration for each phase of the procedure must be documented.

e. 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.

f. Decontamination procedures must be documented. Video documentation is recommended, but still photographs can be used.

4.3.11 Post-Decontamination Sampling.

a. Vapor Sampling.

(1) When a determination is made that the decontamination procedure is completed, vapor sampling can begin. The determination that the decontamination procedure is complete will be based on the technology being used (e.g., surface is dry from a liquid, samplers or time elapsed indicate the vapor is no longer present, etc.). Because it is difficult to sample the vapor from the entire surface within a large item, vapor samples can be taken at representative locations for extrapolation to the total surface area of the system. Attention must be paid to locations where personnel exposure is expected.

(2) The sampling methods and/or methodology must be detailed in the test plans and reports. Sampling methodology should consider the following items (this list is not exhaustive):

(a) Area of vapor sampling.

(b) Distance from the surface being sampled.

(c) Sampling frequency.

(d) Collection material (i.e., proper sorbent for collection).

(e) Sampler enclosure.

(3) Contaminated air will be aspirated through the SST (or other apparatus) at the appropriate rate and for the desired length of time (determined to minimize contaminant breakthrough) to trap contaminant vapor. Typically, MINICAMS are aspirated at a rate of 0.5 liters per minute (L/min), SSTs may be aspirated from 0.5 to 1.0 L/min, and glass impingers (bubblers) are aspirated at a rate of 1.0 L/min.

(4) Samples will be taken at appropriate intervals that total the duration of the mission time described in the CONOPS. Generally, more agent/simulant vapor will be given off during the first few hours of sampling and slowly decrease over time. Thus, sampling intervals may need to be short in the beginning and longer intervals later, when using cumulative sampling devices (bubblers or SSTs). This will avoid saturating cumulative sampling devices. A minimum of two SSTs should be obtained for any time interval (three samples are desirable), with the second sampler serving as a backup to the first sampler. A vapor-sampling sequence must be specified in the test plan. MINICAMS are near real-time (NRT) samplers, and the sample time setting selected will be determined to avoid saturating the detector.

(5) Fielded vapor point detectors may be used to represent this step in the thorough decontamination process. Data collected using point detectors are used for qualitative data purposes.

b. Liquid (Contact) Sampling.

(1) Locations on the system will be sampled where direct contact with the operator's skin or hands or prolonged contact with other clothed body parts is expected.

(2) Contact samplers [a thin disk of latex dental dam (1 mm thick) or other suitable material] will be prepared with a nominal size of 10 to 25 centimeters squared ($cm^2$). Any material used for a contact sampler must be free of powder. The contact sampler should be backed by aluminum foil (see Figure 1) to prevent contamination of the weight and then by a material such as sponge rubber to force contact with all surface irregularities. The assembled sampler will be placed on the selected area creating a pressure evenly applied of 0.05-0.07 kilograms per centimeter squared ($kg/cm^2$) (or 0.7-1.0pounds per square inch (psi)) for 15 minutes. For the 2-inch diameter sampler, this is equivalent to a 2-inch diameter cylindrical mass weighing 1 kg. Additional contact samplers can be sequentially placed on the same area, for selected intervals of time up to a total of 60 minutes. Contact sampling is most appropriate for horizontal surfaces.

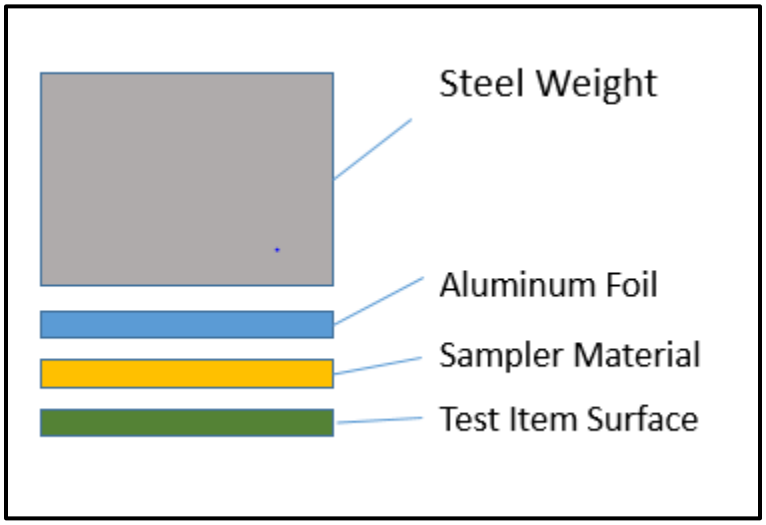


Figure 1. Diagram showing arrangement of test surface, sampling material, and steel weight for residual chemical agent liquid sampling.

(3) After reaching the appropriate time interval, the contact sampler will be immediately removed. The sampler will be placed in a sample jar filled with the appropriate type and quantity of solvent; the jar will then be sealed and transported to a chemical laboratory for analysis.

(4) The 0-hour sample will be taken immediately after the decontamination rinse has dried. Samples will be taken at intervals determined in the test plan as necessary for the specific CONDA OPS of the SUT (e.g., how long a human might be expected to lean on, touch, hold, etc., the area sampled).

(5) Sample Analysis. Sample analysis should use analytical instruments and methods that give precise and accurate values for the primary data parameters. Data from military chemical alarms, detectors, detector papers, and kits (which provide only qualitative yes/no answers) should be used to complement data obtained from more precise analytical instruments.

4.3.12 Hardness Determination.

a. After completion of all decontamination and sampling procedures, all interior surfaces of the system will be inspected for visible evidence of degradation caused by the agents, decontaminants, and decontaminating procedures. Other signs of material degradation may include corrosion, peeling paint, discoloration, brittleness of rubber components, hazing or yellowing of plastic components, etc. Any degradation must be described and documented with photographs.

b. ME functions are those functions that define the successful completion of a mission for the system or infrastructure being tested as defined by the test sponsor and/or Combat Developer in the FD/SC. The SUT will be operated IAW the instruction manual, and all ME functional performance characteristics will be measured and recorded. Each parameter will be measured at

least twice, depending on the inherent difficulty in reproducing a specific value, and compared with pretest values.

c. Hardness data collection must be performed after each C/D cycle and 30 days (or the specified time interval in the test plan) after the first contamination. Hardness data must be sufficiently accurate and precise to define any degradation after each C/D cycle and the specified time period.

d. The hardness and ME performance data collected will be compared with the pretest values recorded.

4.4 Adapting to CWA Simulant Testing.

a. Generally, 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 required safety and environmental protection restrictions, as well as the reduced approval requirements for test chamber work using simulant rather than those required for toxic agent work. Simulants must be used when a test is performed by Certified Military Tester 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 with simulants will only determine the effects of the decontaminant and the decontamination procedures. Any adverse effects that could be caused by chemical agents would not be determined or subject to evaluation.

b. Many SUTs that fail hardness testing fail not because of the agent contamination, but because of the wetting and/or corrosive action of the decontamination solutions and/or decontamination procedures on delicate optical, electronic, and mechanical components. Coordination with the test sponsor and the OTAs must be conducted for the specific combination of SUT, simulant, and decontamination procedure to determine if simulant testing adequately demonstrates survivability.

c. Proper selection of a simulant may effectively test certain aspects of survivability, but no single simulant test is likely to encompass all of the same aspects of survivability as well as CWA testing.

4.4.1 Agent/Simulant Selection.

a. The selection of chemical compounds to simulate chemical agents is a critical step in testing with simulants. The test-item materials of construction and candidate simulant will be examined and compared with the CBME database[7] to ensure compatibility, i.e., that no degradation will be caused by the simulant that would not be caused by agent. 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.

b. Simulants selected for decontaminability testing must closely match the properties of the chemical agent. Selected simulants must have similar chemical interactions with the decontaminants used, solubility in the decontamination solution, and 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.

c. The procedures used during decontamination will be the same as those used for agent testing; however, the chemical reaction between the simulant and the decontaminating solution will not be the same or may not proceed at the same rate as with the actual chemical agent.

d. The sampling devices used to sample the simulant should be selected to be as sensitive as those used in chemical-agent testing. The analytical procedure must be able to identify and measure the simulant to the same sensitivity as the chemical agent for which the simulant is a surrogate.

4.5 Biological Contamination Survivability Testing.

4.5.1 Objectives.

a. Decontaminability. The ability of a system to be rapidly (less than 75 minutes[4]) and effectively decontaminated will be determined following exposure to an ABO or simulant. The associated hazard will be measured on equipment that has been contaminated with biological contaminant and decontaminated using standard and/or item-specific decontamination procedures.

b. Hardness. The capability of a system to withstand the material-damaging effects of biological agent and/or relevant decontaminations will be determined. The degree of performance degradation will be measured for ME functions of military mission-critical materiel after biological agent C/D by standard and/or item-specific procedures.

4.5.2 Criteria and Conditions.

a. Criteria.

(1) Decontaminability. After rapid decontamination[4], residual contamination levels for the equipment must constitute a negligible risk to unprotected users of the equipment.

(2) Hardness. Materiel developed to perform ME functions shall be hardened to ensure that exposure to the specified CB C/D cycles does not degrade the ME performance of the equipment more than 20 percent or that specified by the Combat Developer measured over a specified time or mission duration[4]. The number of C/D cycles for biological survivability must consider pandemic events and the requirements imposed by the affected countries.

b. Conditions. If not already specified in the capabilities document, the detailed conditions for biological contamination survivability testing will be as follows:

(1) Chamber temperature: 30±5 °C.

(2) RH: ambient ±1 percent.

(3) Test chamber air circulation: ≤1 m/s.

(4) Contamination density: $1 \pm 0.5 \times 10^8$ CFU/$m^2$.

(5) Particle size: 1 to 5 µm.

4.5.3 Controls.

a. Surface areas selected for sampling must be representative of the interior surface paint, materials, and texture, including the areas where the user will have direct contact.

b. Swab control (unused swab).

c. Swab of an uncontaminated surface.

d. Diluent control.

e. Plate control.

f. A maximum of 18 hours between sample collection and analysis.

4.5.4 Data Required.

a. Test Chamber or the System Interior.

(1) Temperature in °C.

(2) RH in percent.

(3) Airflow through the interior in m/s.

b. Agent or Simulant.

(1) Name, control number, and spore manufacturer.

(2) Diluent used.

(3) Percent solids.

(4) Date prepared and/or reconstituted.

(5) Quality of spore preparation (greater than 90 percent desired).

(6) Date used.

(7) CFU per mL.

(8) Disseminator used.

(9) Quantity of agent/simulant suspension disseminated in mL.

(10) Air pressure in psi.

(11) When testing using JBADS:

(a) The contaminant on the spore strips.

(b) The level of contamination.

c. Color photographs and written description of each area contaminated.

d. Contamination density for each sampling area before and after decontamination, expressed in CFU/sample.

e. Sample history with elapsed time to analysis in hours.

f. Elapsed time required to complete contamination, weathering time before decontamination, and decontamination time.

g. Description of the decontaminant (i.e., formulation, active ingredients, and age), methods and/or methodology, equipment, lot number, and item-specific procedures used.

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

i. Pretest and posttest ME functional performance characteristics (when measured) used as the measure of the SUT's mission performance before and after exposure to contaminants, decontaminants, and decontaminating procedures.

j. When testing with the JBADS, a description of the aircraft enclosure.

4.5.5 Hazards.

a. Follow all site specific safety protocols to address any hazards in working with the selected biological simulants.

b. There are safety issues that need to be addressed when testing with decontaminant chemicals that are hazardous (e.g., chlorine, hydrogen peroxide, etc).

4.5.6 Biological Agent/Simulant Preparation.

The biological organism (agent or simulant) used for testing will be characterized for proper particulate size profile (1 to 5 μm) and quality of spore preparation (greater than 95 percent spores).

4.5.7 System Interior Preparation.

a. All resources will be in place before testing. Locations will be marked to ensure samples are taken from the same area. For biological contamination survivability (CS), three closely-located 25-$cm^2$ sample areas will be marked for each location selected (see Figure 2). Only the boundary of the area must be marked; no markings must be made within the boundary. Sample location numbering or other designation must be marked outside the boundary.

b. When testing with the JBADS, the location of spore strips used for determining decontamination efficacy will be laid out IAW the test plan.


Figure 2. Example of three closely located sampling areas with sampling sequence indicated.

4.5.8 Disseminator Preparation.

A disseminator (air driven or liquid slurry) will be calibrated to disperse the test organism containing particles in the 1-to 5-µm size range. The appropriate operating time, air pressure, and slurry concentration will be determined for the disseminator. The exact slurry count, the generator air pressure, the duration of generator operation, and the number of CFU/L of chamber air to meet the SUT-contamination target of $1 \times 10^8$ CFU/$m^2$ will be determined by the project biologist.

4.5.9 Test Conduct.

a. The chamber or system acting as a chamber will be brought to the environmental conditions specified for the test, and stabilized for a minimum of four hours. Temperature, RH, and airflow will be recorded at a minimum of every 5 minutes for the duration of the test.

b. Before contamination, the first of the three collocated 25 $cm^2$ sampling areas will be swab-sampled to determine the background contamination level and residual substances (decontaminant) that could interfere with sample analysis.

c. When testing with the JBADS and using spore strips, the background contamination level sample does not need to be taken. A confirmation sample may be analyzed as required.

d. The air inside the chamber will be contaminated to a level of approximately $1 \times 10^6$ CFU/L of air.

e. One hour will be given for contamination to settle on the SUT (when an air-driven disseminator is used). After the settling, the chamber will be air-washed for 1 hour to reduce chamber contamination. The 1-hour air-wash can also serve as the 1-hour weathering time.

f. After the air wash/weathering time period, the second sample will be taken for determining the actual contamination level of the SUT. In the case of the JBADS samples will be taken as designated in the operations manual or test plan as required.

g. Decontamination will begin immediately after post-contamination sampling. Standard decontamination procedures, solutions, and equipment; or any SUT-specific procedures furnished will be documented. The JBADS decontamination procedures will be initiated when that system is being used. The JBADS process may involve multiple days (up to 4) to fully decontaminate a SUT. The JBADS process decontaminates both interior and exterior surfaces.

g. Following decontamination, the third 25 $cm^2$ area will be swab sampled in each sample location to determine the residual contamination remaining on the SUT. In the case of the JBADS, samples will be taken as designated in the operations manual as required.

h. For porous materials such as upholstery, ceiling tiles, etc., a coupon of the material will be extracted with saline solution, which must then be filtered, cultured, and counted.

i. Analysis of biological samples will be conducted IAW test site SOPs.

4.5.10 Hardness Determination.

a. After biological decontamination is complete and the final set of samples have been taken, all interior surfaces of the item will be inspected for visible evidence of degradation caused by the contaminants or decontaminants. Degradation will be described and documented with photographs.

b. ME functions are those functions that define the successful completion of a mission for the system or infrastructure being tested as defined by the test sponsor and/or Combat Developer in the FD/SC. The SUT will be operated and all ME functional performance characteristics will be measured and recorded. Each parameter will be measured at least twice, depending on the inherent difficulty in reproducing a specific value, and compared with pretest values.

4.6 Long Term CBR Hardness.

4.6.1 Objective.

Determine the long-term (as specified in the capabilities documents, but greater than 30 days[4]) effects of CBR contamination and CBR decontamination procedures.

4.6.2 Criterion.

There is no criterion for hardness determination for a time period greater than 30 days.

4.6.3 Hardness Determination.

At the conclusion of the long-term period, the interior of the SUT will be visually inspected for evidence of degradation caused by the test procedures, and any visible effects will be recorded. The item will be operated and measured, and all ME functional performance characteristics will be recorded. Each parameter will be measured at least twice, depending on the inherent difficulty in reproducing a specific value, and compared with pretest values. Procedures (paragraph 4.3.12) and data required (paragraphs 4.3.4.n through q) are the same as those described for chemical hardness

5. DATA REQUIRED.

The data required are listed above in Section 4 under each subtest.

6. PRESENTATION OF DATA.

6.1 Receipt Inspection Data.

a. Receipt inspection photographs of exterior materials, construction, paint, cleanliness, joints and crevices will be reported.

b. Data pertaining to surface materials and their finishes will be reported in a form that can be compared with pretest and posttest hardness functional performance data.

6.2 Chemical Contamination Survivability Data.

a. Chemical decontaminability will be determined by comparing posttest results against established criteria (paragraph 4.1.2.1). The item will be considered decontaminable if residual vapor dosage and liquid mass (contact) sampling results are reduced to levels at or below the established decontaminability criteria[4].

b. Decontamination efficacy (DE) will be calculated (Equation 1) and reported.

$$DE = [(C_i - C_d)/C_i \times 100 \qquad \textit{(Equation 1)}$$

where:

$C_i$ is the initial contamination density.

$C_d$ is the residual contamination after decontamination operations.

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

d. The concentration of agent vapor recovered from each test-item sampling location (component, if used) identified by time should be represented in table format.

e. The agent vapor mass will be run through the downwind hazard prediction model[6] and the calculated dosages will be compared with the DA approved NBCCS criteria for mission-critical materiel[4] and Military Standard (MIL-STD)-3056[11] and tabulated.

**NOTE**: 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 SUT, and selected scenarios that have almost unlimited variables. One approach[12] would be to calculate toxic load from the agent vapor dosages measured from an SUT. This approach allows the toxic load calculations to be transferred to exposure scenarios on a case-by-case basis, depending on the SUT and its expected use in the field.

f. Any statistical analyses conducted on test results will be presented.

6.3 Biological Contamination Survivability Data.

a. The results (residual contamination in CFU) will be compared with the contamination density and tabulated. A 6-log reduction from the contamination density will be the minimum acceptable level[4].

b. For each sample location, the CFU recovered from the control samples, the test-item contamination level, and the residual sample level after decontamination will be tabulated.

c. The decontamination reduction ratio achieved by the decontamination process (the item challenge contamination level divided by the residual contamination level) for each sampling location will be calculated. The CFUs (spores that have become viable cells) that are sampled after decontamination will be divided by the number of CFUs sampled after contamination of the SUT. This reduction ratio will be expressed as the log reduction. The reduction ratio and the raw challenge and residual data will be presented in tabular form. The item will successfully meet the criterion[4] for biological decontaminability and be considered decontaminable for biological agent if the system contamination level has a 6 or greater log reduction.

6.4 Hardness Data.

a. Hardness data will be presented in a format to show direct comparison of pre- and post-exposure ME function performance of the SUT.

b. All ME function performance data, identified by test cycle number, agent, and decontaminant will be summarized and tabulated.

c. The ME function performance data for each C/D cycle will be compared with the receipt inspection performance data. The ME performance data will be used to determine whether more than 20 percent degradation in item performance (or that specified by the Combat Developer) has occurred.

6.5 Long-Term Hardness Data.

Long-term hardness (greater than 30 days) data will be presented in a format to show direct comparison of pre-exposure and long-term post-exposure ME function performance of the SUT.

# APPENDIX A. ABBREVIATIONS.

| | |
|---|---|
| ABO | agent of biological origin |
| AD No. | accession number |
| AR | Army regulation |
| ASTM | American Society for Testing and Materials International |
| ATEC | U.S. Army Test and Evaluation Command |
| ATP | Army Technical Publication |
| BWA | biological warfare agent |
| °C | degrees Celsius |
| C/D | contamination/decontamination |
| CB | chemical and biological |
| CBCS | chemical biological contamination survivability |
| CBME | chemical and biological materials effects (database) |
| CBR | chemical, biological, and radiological |
| CBRCS | chemical, biological, and radiological contamination survivability |
| CBRCSA | chemical, biological, and radiological contamination survivability assessment |
| CDD | Capability Development Document |
| CFU | colony forming unit |
| cm | centimeter |
| CONOPS | concept of operations |
| CS | contamination survivability |
| cSt | centistokes |
| CWA | chemical warfare agent |
| DA | Department of Army |
| DE | decontamination efficacy |
| DTIC | Defense Technical Information Center |

# APPENDIX A. ABBREVIATIONS.

| | |
|---|---|
| °F | degrees Fahrenheit |
| FD/SC | Failure Definition/Scoring Criteria |
| g | gram |
| g/L | grams per liter |
| $g/m^2$ | grams per meter squared |
| GC | gas chromatograph |
| GD | soman |
| HD | distilled mustard |
| HPLC | high-performance liquid chromatograph |
| HSW | hot soapy water |
| HTH | high-test hypochlorite |
| IAW | in accordance with |
| ISO | International Organization for Standardization |
| JBADS | Joint Biological Agent Decontamination System |
| JSEW | Joint Sensitive Equipment Wipe |
| kg | kilogram |
| $kg/cm^2$ | kilogram per centimeter squared |
| L/m | liters per minute |
| LC | liquid chromatograph |
| µg | microgram |
| µL | microliter |
| m/s | meters per second |
| ME | mission essential |

# APPENDIX A. ABBREVIATIONS.

| | |
|---|---|
| mm | millimeter |
| MOPP IV | mission-oriented protective posture, level IV |
| NBC | nuclear, biological, and chemical |
| NBCCS | nuclear, biological, chemical contamination survivability |
| NRT | near real-time |
| NTA | Non-traditional agent |
| OEP | Operational Test Agency Evaluation Plan |
| OTA | Operational Test Agency |
| QA | quality assurance |
| QC | quality control |
| RH | relative humidity |
| RSDL | reactive skin decontaminant lotion |
| SOP | standing operation procedure |
| SST | solid sorbent tube |
| STB | supertropical bleach |
| SUT | system under test |
| TEMP | Test and Evaluation Master Plan |
| TGD | thickened soman |
| TIC | toxic industrial chemical |
| TICN | test item control number |
| TIM | toxic industrial material |
| TOP | Test Operations Procedure |
| VX | persistent nerve agent |

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# APPENDIX B. REFERENCES.

1. TOP 08-2-510B, Chemical and Biological Contamination Survivability (CBCS), Large Item Exteriors, 13 March 2019.

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4. U.S. Army Nuclear and Combating Weapons of Mass Destruction Agency (USANCA), Springfield, Virginia, Department of the Army-Approved Nuclear, Biological, Chemical Contamination Survivability Criteria for Army Materiel, May 2005.

5. TOP 08-2-061B, Chemical and Biological Decontaminant Testing, Draft.

6. L. Salomon, R.K. Dumbauld, and J.F. Bowers, Paper Presented at Test Technology Symposium, The John Hopkins University, Laurel, Maryland, Dugway Proving Ground (DPG) Test Procedures for Assessing Compliance With the Chemical Decontamination Requirement of Army Regulation (AR) 70-71, 26 to 28 January 1988.

7. Chemical, Biological, Radiological, and Nuclear Information Analysis Center (CBRNIAC), Aberdeen Proving Ground (APG), Maryland, Chemical and Biological Material Effects (CBME) Database, https://cbme.cbrniac.apgea.army.mil, 2006.

8. ISO 8655, Laboratory Equipment: Piston-Operated Volumetric Apparatus, 10 October 2002 (Corrigenda, 9 December 2008).

9. ASTM E1154-89, Laboratory Testing Standards: Standard Specification for Piston or Plunger Operated Volumetric Apparatus, 2008.

10. ATP 3-11.32, Multi-Service Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Passive Defense, 13 May 2016.

11. MIL-STD-3056, Design Criteria for Chemical, Biological, and Radiological System Contamination Survivability, 23 November 2016.

12. TOP 08-2-060, Post-Decontamination Vapor Sampling and Analytical Test Methods, 12 August 2015.

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# APPENDIX C. APPROVAL AUTHORITY.

CSTE-CI 4 June 2021

MEMORANDUM FOR

Commander, U.S. Army Operational Test Command
Director, U.S. Army Evaluation Center
Commanders, ATEC Test Centers
Technical Directors, ATEC Test Centers

SUBJECT: Test Operations Procedure 08-2-509B, Chemical, Biological, and Radiological Contamination Survivability, Large Item Interiors, Approved for Publication

1. Test Operations Procedure (TOP) 08-2-509B, Chemical, Biological, and Radiological Contamination Survivability, Large Item Interiors, has been reviewed by the U.S. Army Test and Evaluation Command (ATEC) Test Centers, the U.S. Army Operational Test Command, and the U.S. Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency.

2. Scope of the document. This TOP provides basic information to facilitate planning, conducting, and reporting of large item interiors testing such as tactical vehicles, fixed and rotor wing tactical aircraft, vans, shelters, building interiors, shipboard interiors, and cargo aircraft interiors. This document provides standard methods for chemical and biological contamination survivability testing of interior surfaces of military materiel. It is designed to provide results to determine if large items of mission-essential equipment have met applicable chemical, biological contamination survivability requirements.

3. This document is approved for publication and has been posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at https://vdls.atc.army.mil/.

4. Comments, suggestions, or questions on this document should be addressed to U.S. Army Test and Evaluation Command (CSTE-CI), 6617 Aberdeen Boulevard-Third Floor, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to usarmy.apg.atec.mbx.atec-standards@mail.mil.

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MICHAEL J. ZWIEBEL
Director, Directorate for Capabilities Integration (DCI)

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Policy and Standardization Division (CSTE-CI-P), U.S. Army Test and Evaluation Command, 6617 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: Commander, West Desert Test Center, U.S. Army Dugway Proving Ground, ATTN: TEDP-WD, Dugway, UT 84022-5000. Additional copies can be requested through the following website: https://www.atec.army.mil/publications/documents.html, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.