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14. ABSTRACT
This TOP provides basic information to facilitate test planning, conducting, and reporting, in achieving standardized chemical and biological (CB) contamination survivability testing of small items of mission-essential (ME) military materiel. This TOP is to be used for the testing of small items of equipment that are decontaminated by the individual warfighter or by two-person or three-person teams operating portable and handheld decontaminating devices.

15. SUBJECT TERMS
CB; chemical; biological; decontamination; survivability; hardness; decontaminability; compatibility; agent; simulant; mission-oriented protective posture, level IV, MOPP IV; mission-essential; ME; small items

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

*Test Operations Procedure 08-2-111C 22 June 2021
DTIC AD No.

CHEMICAL AND BIOLOGICAL (CB) CONTAMINATION SURVIVABILITY, SMALL ITEMS OF EQUIPMENT

* This TOP supersedes TOP 08-2-111B, dated 25 August 2015.
Approved for public release; distribution unlimited.

1. SCOPE.

1.1 Purpose.

a. The purpose of this Test Operations Procedure (TOP) is to standardize chemical and biological (CB) contamination survivability (CBCS) testing of small items of equipment.

b. This TOP provides basic information to facilitate planning, conducting, reporting, and standardizing CB survivability testing of military materiel small items. It is designed to demonstrate that small items of mission-essential (ME) equipment have met the provisions of Army Regulation (AR) 70-75[1**] as implemented by the Department of the Army (DA)-Approved Nuclear, Biological, and Chemical (NBC) Contamination Survivability (NBCCS) Criteria for Army Materiel[2] and Military Standard (MIL-STD) 3056[3]. To survive CB contamination, materiel must meet criteria for decontaminability, hardness, and compatibility[2]. This TOP describes typical facilities, equipment, and procedures used to contaminate test items, sample for contamination density, decontaminate test items, sample for residual contamination, determine degradation of selected ME functions resulting from the contamination/decontamination (C/D) procedures, and analyze individuals in protective personal equipment/test-item compatibility.

c. Testing on the actual items is most desirable because of the information that can be gained. Testing may be performed on representative materials of small items of equipment. Testing representative materials reduces realism in testing and the data must be extrapolated to the system. 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, this testing alternative will be considered and a choice for testing made.

(1) Coupons/Panels Testing. This testing provides information on the ability of a set of materials to meet the criteria[2]. This is more difficult to extrapolate to the full system because the impact of crevices, small spaces, etc., must be estimated or ignored. If coupon or panel testing is selected, the panels must be made from the same materials with the same coatings as the item being evaluated. The procedures in TOP 08-2-061B[4] for coupon testing must be followed.

(2) Assessment. An assessment of the expected ability of the system to meet the criteria[2] will be made by analyzing current literature and databases to extrapolate the possibility of contamination and survivability. This analysis is conducted with little or no agent data available for consideration. There is no actual testing conducted on the test item.

d. 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 4.2 through 4.3. Chemical and biological agent should be used in testing when possible to measure decontaminability and hardness for the full cycle (contamination, decontamination, and re-issue to the Warfighter). Simulants may be used

** Superscript numbers correspond to Appendix C, References.

in testing. When simulants are used, hardness can only be determined based on effects from decontamination methods, solutions, and/or mixtures.

e. The acronym, CB, is used in this document, rather than NBC, to reflect current terminology in use within the Department of Defense (DOD).

1.2 Limitations.

a. This TOP only provides standard procedures for testing the contamination survivability of small items of equipment, such as equipment carried by an individual Warfighter and removable sensitive equipment.

b. The only criteria for CBCS as listed in this TOP are for the Department of the Army[3]. There are no additional criteria from other DOD components. For acquisition programs that have CBCS requirements, the default is to use the DA criteria[2]. These criteria are for use in determining contamination survivability of the system under test.

c. There are many factors that can affect the performance and/or survivability of a system before and after the conduct of decontamination operations. Many of these factors cannot be evaluated for their effects without an exponential expansion of a trial matrix. An example would be the age of the paint on the surface (aged, new, etc.).

d. The only current mechanism for converting vapor concentrations of chemical agent into dosages is to use a downwind hazard prediction model[5]. Once a decontamination system performance model is developed with the necessary toolset, then that model may replace the current model.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

This section lists all required test facilities, with the specific characteristics, sizes, and features needed for each item.

Item	Requirement
Chemical surety laboratory and chemical agent storage facility.	Constructed to ensure safe and secure storage, handling, analysis, and decontamination of chemical agents.
Chemical agent test facility or chamber.	Constructed to allow C/D and extended residual hazard sampling of small items of equipment deliberately contaminated with chemical agent/simulant in a temperature-controlled environment. The chamber must have sufficient volume to allow free air circulation around the test item. Ability to control temperature and wind speed is required.

Item	Requirement
Biological analytical laboratories.	Required to store and prepare test quantities of biological agent/simulant materials, to charge disseminating devices, to prepare samplers, and to analyze the 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 test item. Biological surety regulations will be followed if biological surety material is used. Ability to set and maintain temperature and relative humidity (RH) is highly desirable. Constructed to allow decontamination of the test item as part of the test procedure. Must not increase the hazard or degrade safety protocols when used in a laboratory.

2.2 Instrumentation.

These values are minimum requirements. Actual instrumentation may have greater precision, and actual values must be reported.

Parameter	Measuring Device	Permissible Error of Measurement
Air temperature (-20° to 50 °Celsius (°C).	Thermocouple with digital recording capability.	±0.5 °C.
RH (0 to 90 percent).	Humidity probe with digital recording capability.	±2 percent.
Airflow (0 to 5 meters per second (m/sec)).	Anemometer or similar device with digital recording capability.	±0.1 m/sec.
Photographs.	Digital still color camera.	Adequate resolution to document typical test procedures, details of contamination techniques, and any discrepancies from planned procedures necessitated by operational conditions.
Video.	Digital video camera.	Adequate resolution and frames/second speed to document typical test

Parameter	Measuring Device	Permissible Error of Measurement
		procedures, details of contamination techniques, and any discrepancies from planned procedures necessitated by operational conditions.

2.3 Chemical Test Instrumentation.

Parameter	Measuring Device	Permissible Error of Measurement
Contamination density or challenge level (grams per meter squared (g/m^2)).	A control coupon will be used for the measurement of the actual contamination density applied.	±15 percent of challenge target.
Chemical agent mass from vapor samples (microgram (µg)).	MINICAMS® (OI Analytical, division of OI Corporation, College Station, Texas), gas chromatograph (GC), high-performance liquid chromatography (HPLC), liquid chromatograph (LC), spectrophotometer, or equivalent.	Sample must be ±15 percent of calibration standard.
Chemical agent mass from liquid samples (µg).	GC, HPLC, LC, spectrophotometer, or equivalent.	Sample must be ±15 percent of calibration standard.

2.4 Biological Test Instrumentation.

These values are minimum requirements. Actual instrumentation may have greater precision; actual values must be reported.

Parameter	Measuring Device	Permissible Error of Measurement
Background contamination.	Microscopes, swabs, or wipes placed on growth medium, automatic colony counters, or equivalent.	±10 percent colony forming unit (CFU)/sample.

Post-contamination verification.	Microscopes, swabs, or wipes placed on growth medium, automatic colony counters, or equivalent.	±10 percent CFU/sample.
Post-decontamination.	Microscopes, swabs, or wipes placed on growth medium, automatic colony counters, or equivalent.	±10 percent CFU/sample.

2.5 CB Hardness Test Instrumentation.

Parameter	Measuring Device	Permissible Error of Measurement
ME functions as described in system specific Concept of Operations (CONOPS).	As necessary (optical haze, transmittance, durometer, tensile strength, etc.).	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 ME performance characteristic after completion of required C/D cycles.

2.6 CB Compatibility Test Instrumentation.

Parameter	Measuring Device	Permissible Error of Measurement
Operator performance tests.	Stop watches or equivalent. Operator/crew ME functions are timed and/or accuracy-based functions.	Precision and accuracy requirements must be compatible with the nature of the test item and type of function being studied, but must allow for the detection of 15 percent degradation in the item/operator ME function performance.

3. REQUIRED TEST CONDITIONS.

The required test parameters are temperature of 30±2.0 °C and airflow across the test item less than 1.0 m/sec. There is no requirement for RH; however, RH will be monitored and recorded.

3.1 Test Planning.

a. Each test plan must be reviewed for technical accuracy. In addition, the test plan must accurately reflect the requirements outlined in the system capability documents. Published test

records, procedures, and the case files of similar test items must be reviewed to identify potential problem areas that may be difficult to decontaminate.

b. The ME functions, performance characteristics measured during hardness testing, and the ME Warfighter tasks, measured during compatibility testing, specified by the materiel developer and the combat developer, respectively, will be listed. These will be used to measure degradation in performance caused by contamination and decontamination processes and by the need for the operator to wear a protective ensemble. Units of measurement and the accuracy and precision required for each measurable parameter will be identified. All issues concerning measurable performance and degradation will be identified and reviewed.

c. A realistic test item sample size will be determined through coordination with the customer and the system evaluator using factors such as test item availability and item cost. A minimum sample size of three test items is recommended. This determination of sample size may be less than optimum. If the sample size is less than optimum, a testing scheme will be devised to optimize test item use and required data output.

d. Representative areas of the test item to be sampled for residual contamination will be selected and identified. Selection of the sample locations will depend on consideration of overall test item size, geometry of the test item, materials of construction, surface texture, presence of joints and crevices, areas handled/touched by system operators, and the likelihood to contribute to producing a vapor or contact hazard. Because of the nature of contact sampling devices, sample locations need to be flat or nearly flat. An appropriate number of such areas will be selected to help assure the statistical validity of the resulting number of samples. The test plan will identify and explain the rationale for the areas selected and the statistical-analysis methodology used. Each sample location selected must be described and photographed. No additional marks must be placed within the marked boundaries of the locations to be sampled.

e. Existing system-specific decontamination procedures using fielded decontaminants or developmental decontaminants must be reviewed and incorporated into the planned test as much as possible.

3.2 Safety.

Test site specific standing operating procedures (SOPs) and/or other safety documents applicable to the specific item and tests being conducted must be reviewed.

3.3 Environmental.

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

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

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 CB 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 test item at the time of testing is an important test variable. The test item must be inspected. Inspection data, certificates of compliance, or similar documentation, must be reviewed to ensure that exterior surfaces, finishes, and packaging meet specifications. 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.

3.5 Test Conditions.

a. The amount of time between contamination and the start of decontamination operations (often called weathering or age time) will depend on requirements in the capability documents. The default weathering time is 60 minutes. Given changes in battlefield doctrine, the default weathering time may not be representative of the actual travel time from a contamination site to a decontamination site. Weathering time must be coordinated with the test sponsors and combat developers. Standard field and/or item-specific decontaminants, equipment, and procedures will be used if they exist and are available. The decontamination procedure conducted and time between C/D cycles will be included in the test plan for each system or equipment item. The decontamination process time (excluding point detector monitoring during operational testing) will be recorded.

b. When CBRCS testing is conducted in a chamber housing the test item, the chamber and item surface temperature will be 30 °C, and wind speed over the test item will be no greater than 1 m/sec.

3.6 Controls and Limitations.

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

b. Before testing, the surfaces of the test item must be inspected for background contamination. Any foreign substances on the test item surface that could interfere with sampling the surface or with analytical instrumentation must be removed before testing.

c. Analysis control data include standard analytical controls. The instrument calibration need not be composed of standards at equal concentration intervals. Rather, the standards must be spaced closer together near the low-concentration end of the calibration curve.

d. Instrument calibration will be recorded as part of the test record and will include the calibration requirement (yearly, semiannual, etc.).

4. TEST PROCEDURES.

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.

b. Surfaces will be inspected for foreign materials normally not present on the item (e.g., dust, mud, grease, or marking). Foreign materials may be removed by brushing, vacuum cleaning, or washing with soapy water and sponge. The removal of foreign materials will minimize any bias that could create an over/under estimate of the true contamination survivability of the system being tested. The surface condition, surface cleanliness, corrosion, materials of construction, variance from standard painting, and paint condition will be recorded.

c. The test item will be operated in accordance with (IAW) the operator's manual. ME functional performance characteristics (e.g., electronic functions, shelter setup) identified by the combat developer (e.g., in the failure definition/scoring criteria) must be measured and recorded. Based on the selected functional performance characteristics, each functional performance characteristic must be designated as either a functional performance attribute (go or no-go) or as a functional performance variable measured over a continuous range of values. Each parameter must be measured at least twice and must be recorded to the smallest significant unit of measure. If any damage, surface condition, or ME functional performance characteristic falls outside developer specifications, then testing will not proceed without customer approval.

4.2 Chemical Contamination Survivability.

4.2.1 General.

a. Selected exterior areas will be initially contaminated (random drop pattern over the selected area) to a uniform contamination density as specified in the system threat assessment and capability documents (default of 10 g/m^2) with 5 to 10 microliter (µL) sized drops of thickened soman (tGD) and 2 to 5 µL sized drops of distilled mustard (HD), or persistent nerve agent (VX). The chemical agents VX, HD, and tGD, are required for testing by the DA-Approved NBCCS Criteria for Army Materiel[2]. The selection of areas to be contaminated is based upon the concept that there will be a "rain" of airborne contamination onto the item. The "rain" is usually considered to come at a 30-degree angle from the vertical. Therefore, there is an expectation that only the top and two adjacent sides of the test item will become contaminated.

b. The purity of the chemical agents must be known and verified (preferably 85 percent or greater) and recorded as test data. A purity certification must be provided with the chemical agent used for testing. 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 relationship must be fully documented through coordination with the customer and system evaluator before testing begins.

4.2.2 Test Method Outline.

a. Test item will be prepared for testing, to include sample location, identification and documentation, marking of sample areas; etc.

b. The contaminants will be prepared for application.

c. Laboratory hood or test chamber operation will be verified and environmental conditions for the test stabilized. Environmental conditions are monitored, the test item is allowed to equilibrate with the ambient conditions, and any required background samples are taken before contamination.

d. The contaminants are applied to the item under test.

e. Weathering proceeds.

f. Decontamination operations will be conducted on the item under test.

g. Post-decontamination vapor and liquid (contact) sampling and sample analysis will be conducted.

h. Sample analysis will be performed.

i. Hardness determination, including post-decontamination functional performance measurements.

4.2.3 Objectives.

a. Decontaminability. Determine the ability of a system to be rapidly (less than 75 minutes) and effectively decontaminated following chemical agent exposure. Measure the vapor and percutaneous or contact residuals, 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. Use the vapor and contact residuals to determine if a hazard exists.

b. Hardness. Determine the capability of a system to withstand the material damaging effects of chemical agent and relevant decontamination processes. Measure the degree of performance degradation in ME functions of military ME materiel after each C/D cycle by standard and/or item-specific procedures.

c. Compatibility. Determine the degree of degradation in ME Warfighter tasks as a result of operating a piece of equipment while wearing the CB protective ensemble.

NOTE: ME functions are those functions that define the successful completion of a mission for the system or equipment being tested as defined by the test sponsor and/or combat developer in the failure definition/scoring criteria.

4.2.4 Criteria.

a. Decontaminability.

(1) The exterior and interior surfaces of materiel developed to perform ME functions shall be designed such that contamination remaining on, or desorbed, or re-areosolized from the surface following decontamination shall not result in more than a negligible risk (defined in Table 1 of the criteria for Army materiel[2]) 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 soman (GD) having a mass median diameter of 2-5 millimeter (mm).
10 g/m^2 of unthickened VX.
10 g/m^2 of HD.
10^5 spores/m^2 of biological agent 1-5 micrometers in size.

(2) 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.

(3) Decontamination begins one hour after contamination using standard field decontaminants, equipment and procedures; and the decontamination process, excluding monitoring, lasts no longer than 75 minutes. The time to complete decontamination will be recorded.

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

(5) Surface temperature is 30°C and exterior wind speed no greater than 1 m/sec.

b. Hardness. Mission-critical equipment shall be sufficiently hardened to ensure that exposure to the specified C/D cycle does not degrade the operational ME performance of the equipment more than 20 percent (or that specified by the combat developer) measured over a 30-day period, or as defined by the capabilities documents.

NOTE: As an example, if the faceplate of a protective mask had a transmittance of 99 percent and after five cycles of decontamination the transmittance is measured as 97 percent, then the degradation is calculated as [(99 - 97)/99] × 100 = 2 percent.

c. Compatibility. The combination of equipment and protection shall permit performance of ME operations, communications, maintenance, resupply, and decontamination tasks by trained and acclimatized troops over a typical mission profile in a contaminated environment not to exceed 12 hours within the following conditions:

(1) In meteorological conditions of areas of intended use.

(2) With no degradation, excluding heat stress, of crew performance of ME tasks greater than 15 percent (or other value designated by the combat developer based on approved rationale) below levels specified for these tasks when accomplished in a non-contaminated environment.

d. Data Required. The following data will be reported in the units indicated:

(1) Test Chamber/Fume Hood.

(a) Temperature in °C.

(b) RH in percent.

(c) Wind speed (airflow) in m/sec.

(2) Agent or Simulant.

(a) Name and control number or lot number.

(b) Purity analysis in percent and scan in the certificate of analysis.

(c) Viscosity after adding thickener in centistokes (cSt).

(d) Age since thickened, if thickened.

(e) Volume of agent/simulant dispensed in µL.

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

(g) Number of drops applied to the test item

(3) Results of each post-decontamination agent/simulant vapor sample (collected during the 12-hour sampling period) $\mu g/m^3$

(4) Contact sample results in µg/sample.

(5) Results of the sampling and analysis controls and standards in µg/sample.

(6) Sample history with elapsed time to analysis in days.

(7) Complete description of the contact sampler used (material type, manufacturer, 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.

(8) Contamination, weathering, decontamination, and sampling times in minutes.

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

(10) Description and photographs of the test-item exterior surface condition (pretest), including construction materials, paint type, paint thickness (number of coats), paint condition, and surface cleanliness (e.g., mud, grease, and other).

(11) 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 commensurate with the parameter being measured.

(12) Descriptions and photographs of test-item cracks, crevices, and other features that could allow contaminants or decontaminants to penetrate below the surface and may be difficult to decontaminate.

(13) A description of the required contact-sampling times specified.

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

(15) Identification of the C/D cycle event.

(16) Relevant safety findings as a result of testing.

(17) Test-item description.

(18) Locations of contaminated surfaces, the contamination area, and total surface area contaminated.

(19) Interior volume of vapor sampling boxes.

4.2.5 Test Procedures.

a. Test controls must include:

(1) When using a solid sorbent tube (SST), bubbler, or similar sampler for vapor samples, a non-operated sampler control (a sampler taken into the area surrounding the test item but not used, opened, or aspirated).

(2) An operated vapor sampler control (a sampler taken into the area surrounding the test item and used, opened, or aspirated, but not exposed to CB agent or simulant) or a background sample.

(3) A positive control which consists of a test item or coupon contaminated but not decontaminated for vapor or liquid sampling.

(4) A negative control which consists of a test item or coupon that is not contaminated, but is decontaminated for vapor or liquid sampling.

b. Agents:

(1) Neat VX with a purity greater than 85 percent, unless weapons-grade is desired. The agent purity must be verified before testing.

(2) Neat 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 (Philadelphia, Pennsylvania) poly(methyl methacrylate). This should provide thickened agent with a viscosity of roughly 1,000 cSt at 20 °C. 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 varies less than 10 percent. The agent purity must be verified before testing.

(3) Neat HD with a purity greater than 85 percent, unless weapons-grade is desired. The agent purity must be verified before testing.

(4) Other approved contaminants (e.g., toxic industrial materials (TIMs)) as specified in requirements documents and the Test and Evaluation Master Plan (TEMP).

(5) Simulants to be used must be specified in the test plan. Simulants may be prepared with a suitable thickener.

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.

d. The test item will be placed in the chamber and the chamber stabilized at the environmental conditions specified for the test. The test item will be permitted to reach equilibrium with the chamber. Temperature and RH will be recorded throughout the test.

e. The selected areas of the test item will be contaminated with agent. The contaminant 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. The dose confirmation sampler (e.g., a Teflon™ swatch) will be contaminated at the same time as the test item and the sampler will be immediately placed into a container with the appropriate type and quantity of solvent, sealed tightly, labeled, and transported to a chemical laboratory for analysis.

f. The test item will be allowed to weather or age for the amount of time outlined in the test plan before performing decontamination procedures.

g. The thorough decontamination process as outlined in the Army Technical Publication (ATP) 3-11.32[6] and listed below will be followed, unless test item specific procedures are required by the test sponsor. There are no standard decontamination procedures for sensitive equipment materiel such as: night vision goggles, radios, etc.

(1) Equipment preparation consisting of a hot, soapy water (HSW) wash-down.

(2) Application of the decontaminant. Application of all currently fielded decontaminants requires brushing or scrubbing.

(3) Decontaminant contact time (default is 30 minutes, but varies by decontaminant; some decontaminants may require continual application to remain wet throughout the contact time).

(4) Post-decontamination clean water rinse to remove residual decontaminant and contaminant. Allow the test item to dry off before conducting post-decontamination sampling.

(5) Point detector monitoring for residual contamination.

h. All times for each phase of the procedure must be recorded, except the time to monitor for residual contamination.

i. Decontamination procedures must be performed as if the entire surface of the test item has been contaminated. The contaminated sampling areas will receive no more or no less attention, time, or effort than uncontaminated areas. Appropriate time will be spent on angles and areas that are difficult to decontaminate.

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

k. Post-decontamination sampling consists of residual vapor off-gas sampling and residual liquid contact sampling.

l. Residual liquid contact sampling is conducted as follows:

(1) 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 centimeter $(cm)^2$. Any material used for a contact sampler must be free of powder. The contact sampler must be backed by aluminum foil (Figure 1) to prevent contamination of the weight. When the sampling area is not even or contains irregularities, a material such as sponge rubber is inserted between the aluminum foil and the weight to force contact with all surface irregularities. The assembled sampler will be placed on the selected area creating a pressure of 0.05 to 0.07 kilogram (kg)/cm^2 [or 0.7 to 1.0 pounds per square inch (psi)] evenly applied for 15 minutes. For the 2-inch diameter sampler, this is equivalent to a 2-inch diameter cylindrical mass of 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.

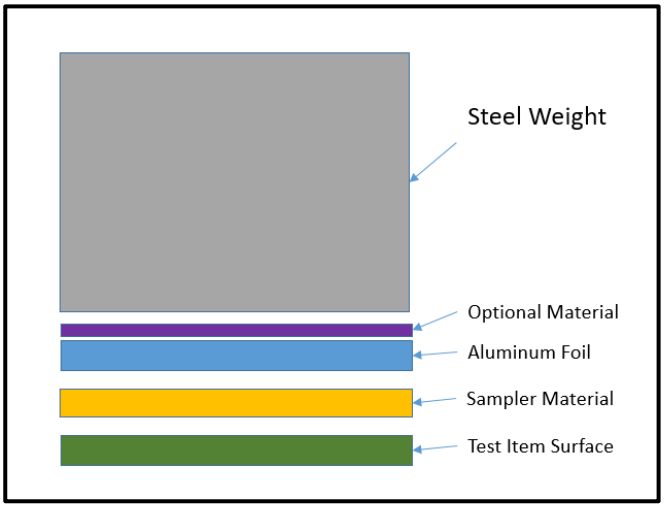

Figure 1. Diagram showing arrangement of test surface, sampler, and steel weight for residual chemical agent liquid sampling.

(2) After reaching the appropriate time interval established by the test plan, the contact sampler will be immediately removed. The sampler and aluminum foil 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.

(3) If possible, two contact samples will be taken from each area selected for contact sampling. The 0-hour sample shall be taken immediately after the decontamination rinse has dried. Samples shall be taken at intervals determined in the test plan as necessary for the specific CONOPS of the test item (e.g., how long a human might be expected to lean on, touch, or hold the area sampled).

m. Residual vapor sampling is conducted as follows. When the surfaces of the sampling areas are no longer visibly wet after the clean water rinse, vapor sampling can begin. To determine residual vapor hazard, the decontaminated item must be placed in a temperature-controlled sampling box, or other enclosure of appropriate size to fit the item. For reproducible results, the box must have the following characteristics or features:

(1) It must have interior surfaces made of stainless steel or other material that is nonsorptive for agent/simulant.

(2) The box must generally fit the item with unobstructed airflow around the item but without excessive free air space that will allow pockets of agent/simulant vapor to remain for long periods of time.

(3) The box must be vented to allow it to be initially flushed, on command, with clean outside air (approximately one air exchange per minute for 4 minutes), and constructed to provide air (agent/simulant vapor) sampling ports.

(4) The interior of the box will be sampled for residual agent/simulant vapor before being used.

(5) A minimum of two vapor samples (three samples are desirable) must be obtained for any sampling time interval unless a near-real time (NRT) sampler is used. A vapor-sampling sequence must be specified in the test plan.

(6) Contaminated air will be aspirated through the sampling equipment at the appropriate rate and for the desired length of time (typically up to 12 hours). Typically, MINICAMS® are aspirated at a rate of 0.5 liters per minute (L/min); SSTs may be aspirated from 0.5 to 1.2 L/min; and glass impingers (bubblers) are aspirated at a rate of 1.0 L/min.

(7) Samples will be taken at appropriate intervals (as coordinated in the test plan) that total the duration of the mission time described in the CONOPS. Generally, more agent vapor will be given off during the first few hours of sampling and slowly decrease over time. Thus, sampling intervals must be short in the beginning and longer later, when using cumulative sampling devices (e.g., bubblers or SSTs). This will avoid saturating any sampling device. A minimum of two SSTs must 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 NRT samplers, and the sample time setting selected will be determined to avoid saturating the detector.

n. Sample analysis must use test instruments and methods that give precise and accurate values for the primary data parameters outlined in this TOP. Data from military chemical alarms, detectors, detector papers, and kits (provide only qualitative yes/no answers) may be used to complement data obtained from more precise analytical instruments.

o. After completion of all decontamination and sampling procedures, all surfaces of the test item will be inspected for visible evidence of leakage and degradation caused by the agents, decontaminants, and decontaminating procedures. 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.

p. The test item must be operated IAW the appropriate manual. ME functional performance characteristics must be measured and recorded. Each parameter must be measured at least twice. Any visible evidence of operational degradation will be recorded. The hardness and ME performance data collected must be comparable with the pretest values recorded.

q. 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.

4.3 Biological Contamination Survivability.

4.3.1 Objectives.

a. Decontaminability. Determine the ability of a system to be rapidly (less than 75 minutes) and effectively decontaminated following exposure to an agent of biological origin (ABO) or simulant. Measure the associated hazards with warfighter use of equipment that has been contaminated with biological agent and decontaminated using standard and/or item-specific decontamination procedures.

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

4.3.2 Criteria.

a. Materiel developed to perform ME functions shall be hardened to ensure that exposure to the specified CBR 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. The number of C/D cycles for biological survivability must consider pandemic events and the requirements imposed by the affected countries.

b. After decontamination, residual contamination levels for the equipment must constitute a negligible risk to unprotected users of the equipment.

4.3.3 Controls.

a. Analyzed swab control (unused swab).

b. Swab of a non-contaminated surface.

c. Diluent control.

d. Plate control.

e. A maximum of 18 hours between sample collection and culturing.

4.3.4 Data Required.

a. Test chamber temperature in °C.

b. RH in percent.

c. Wind speed of airflow around the test item in m/sec.

d. Contaminant name, control or lot number, and manufacturer.

e. Diluent used.

f. Percent solids in spore preparation.

g. Spore preparation date.

h. Spore preparation use date.

i. CFU per mL of spore preparation.

j. Dissemination equipment used and parameter settings used.

k. Quantity of contaminant suspension disseminated in milliliters (mL).

l. Dissemination time in seconds.

m. Photographs taken during testing documenting test item surface conditions, surface cleanliness, joints, cracks, crevices and any other areas that would be difficult to decontaminate.

n. Contamination results for each background sample area, each contamination density sample area, and each post-decontamination sample area in CFU per sample area.

o. Description of decontaminating solutions (i.e., formulation, active ingredients, and age), application methods, equipment, lot number, and item-specific procedures used.

p. Pretest and posttest ME functional performance characteristics used as the measure of the test item's mission performance before and after exposure to contaminants, decontaminants, and decontamination procedures.

4.3.5 Test Procedures.

a. Test chamber operation will be verified and environmental conditions for the test stabilized. Environmental conditions are monitored, the test item allowed to equilibrate (minimum of 2 hours) with the ambient conditions, and background samples (see Figure 2) are taken before contamination.

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

b. The compressed air, dry powder disseminator must be prepared to disperse the test organism containing particles in the 1 to 5 μm size range. The appropriate operating time, air pressure, and concentration for the disseminator must be determined. The project biologist will determine exact disseminator air pressure, the duration of disseminator operation, and the number of CFUs required to meet the test-item contamination target of 1×10^7 CFU/sample area.

c. The dry powder disseminator will be used to apply the contaminant to the test item. One hour must be allotted for contamination to settle on the test item. After the settling, the chamber will be air-washed for 1 hour to reduce chamber contamination.

d. Immediately after the air-wash, the second sample area in each sampling location will be swab sampled to determine the contamination density at that location.

e. Decontamination will begin immediately after contamination density sampling. Standard decontamination procedures, solutions, and equipment, or any test item-specific procedures furnished as part of the test documentation package will be used. Typically, a diluted sodium hypochlorite/water solution (1 L sodium hypochlorite mixed into 9 L water, which gives a 10 percent dilute solution) is used.

f. All decontamination procedures, equipment, tools, and time used in the decontamination process, including item-specific procedures, must be recorded.

g. When the test-item surface is dry following the post-decontamination rinse, the third sample area in each sampling location will be swab sampled to determine the residual contamination remaining on the test item.

h. Analysis of biological samples will be conducted IAW test site SOP.

i. After biological decontamination is complete and the final set of swab samples has been taken, the test item will be visually inspected for evidence of degradation (e.g., corrosion, paint peeling, yellowing of plastics, etc.) caused by the test procedures. The test item 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. Post-C/D values will be compared with pretest values.

j. Any visible indication of operational degradation attributable to the biological C/D cycle(s) will be recorded.

5. DATA REQUIRED.

a. The data requirements for each of the specific subtests are identified along with each of the subtests described in Section 4.

b. Any deviations from existing procedures in the test plan must be documented in the test report.

6. PRESENTATION OF DATA.

6.1 Decontaminability.

a. Chemical.

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

(2) Vapor Hazard. The effective concentration of chemical agent vapor desorbed from the test item is C_e. The mission time, the time during which the warfighter will be exposed or near the test item, is t. Then C_et = dosage, which must be compared with the appropriate criteria[3].

(a) Traditional vapor samplers (bubblers and SSTs) sample vapor streams for discrete periods of time usually of 2, 4,or 6 hours (or longer) defined by a sampling plan. The bubbler solvent containing chemical agent or the SSTs with chemical agent residing on the sorbent bed are analyzed and the mass of residual chemical agent vapors collected is quantified. The volume of agent-laden air is determined by using restriction orifices or mass flow controllers to restrict the airflow through the sample chamber. The average vapor concentration during the sampling period is calculated by multiplying the mass of the chemical agent collected by the vapor sampler times the volume of air that passes through the sample chamber. The dosage is calculated by multiplying the agent vapor concentration by the time of sampling. The total dose is calculated by adding the dosage for all sample periods.

(b) The MINICAMS® is a NRT analytical instrument that can report vapor concentrations in less than 15 minutes. The air-sampling rate is controlled by an internal mass flow controller to 0.5 L/min. The sampling times (sample, analysis, and purge) range from 3 to 15 minutes. The total dose is calculated by multiplying each vapor concentration by the total sample time.

(c) The size of the enclosure or vapor off-gas box used on test items can significantly affect the vapor data collected and must be given consideration when designing the test. If a small test item is placed in a large off-gas box, then the chemical agent vapor can be diluted by the large volume of air in the box resulting in an underestimation in the calculation of the total dose. Likewise, if a small test item is placed in an off-gas box only slightly larger than the item, then the chemical agent vapor has a large presence in the smaller volume of air, which can result in an overestimation in the calculation of the total dose. The recommended maximum air displacement is 75 percent.

(d) In order to deal with the issue of the results being influenced by the volume of the off-gas box, new methodology has been developed that normalizes the volume of the off-gas

box used. Instead of reporting only a concentration or total dose, the toxic load of the airflow is calculated and used to characterize the test item emission rate. The emission rate can then be used to develop multiple scenarios with the test item and determine if any of the scenarios represent a vapor hazard. This methodology can be found in the Baseline Source Document Chemical Decontaminant Performance Evaluation Testing[7] and TOP 08-2-060 Post-Decontamination Vapor Sampling and Analytical Test Methods[8].

(3) Contact Hazard.

(a) The contact hazard is measured by analyzing a sampler for the mass of chemical agent that is absorbed from the contaminated surface. The mass of chemical agent per unit area of the sampler must be adjusted to the entire area of the test item that may be contacted by the warfighter to determine if a hazard exists.

(b) This value must be compared with the appropriate mass value in Table 1 of the criteria for Army materiel[3]. This methodology does not take into account skin uptake rates and other toxicity factors.

b. Biological.

(1) CFUs are viable spores/cells that form colonies when plated on microbial growth agar. Biological decontaminability is determined by forming a ratio of the CFUs sampled after decontamination to the initial number of CFUs sampled when the test item was contaminated with the CFUs. This ratio is then expressed as the log reduction and compared with the appropriate criteria[3]. The ratio is calculated in Equation 1.

$$Log\ Reduction = \log_{10}(CFU_{final} - CFU_{initial}) \qquad \textit{(Equation 1)}$$

where:
CFU_{final} = CFUs sampled after decontamination operations
CFU_{inital} = CFUs sampled after contamination of the tested system

(2) The criteria are based on spore count. It is impossible to realistically count individual spores, therefore, a CFU reduction of 6 logs (i.e., reduced by a factor of one million) is used as the pass/fail criteria. If the CFU reduction is greater than or equal to 6 logs, then the test item has successfully met the criterion for biological decontaminability.

c. Hardness.

(1) The functional performance and/or material effects data collected allow 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.

(2) All ME function performance data, identified by test-cycle number, agent, and decontaminant, will be summarized and tabulated.

(3) ME function performance data for each C/D cycle will be compared with the receipt inspection performance data or the pre-test baseline data. The ME performance data and operator interview data will be used to determine whether more than 20 percent degradation in item performance (or that specified by the combat developer) has occurred. Significant results will be highlighted and discussed.

d. Long-Term CB Hardness. Hardness data will be presented in a format to show direct comparison of pretest and posttest exposure ME function performance of the test item. Any visible effects will be recorded. The long-term hardness determination will be performed in the same manner as the same as chemical hardness.

e. CB Compatibility. When compatibility data are collected, test item performance data will be summarized and presented in tabular form. The time taken to perform the operation with protective clothing will be subtracted from the time taken to perform the operation without the same protective clothing. The differences in performance attributable to type of clothing worn will be highlighted.

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

(2) The functional performance and/or material effects data collected allow 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.

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APPENDIX A. EXPLANATION OF TERMS.

Capability Document. A document that captures the capabilities specific to the initial concept, development, or production of a program.

Capability Development Document (CDD). A document that captures the information necessary to develop a proposed program(s), normally using an evolutionary acquisition strategy. The CDD outlines an affordable increment of militarily useful, logistically supportable, and technically mature capability.

Capability Production Document (CPD). A document that addresses the production elements specific to a single increment of an acquisition program.

Chemical, Biological, and Radiological (CBR) Compatibility. The capability of a system to be operated, maintained, and re-supplied by persons wearing a full complement of individual protective equipment, in all climates for which the system is designed and for the period specified in the CDD.

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

CBR Decontamination. The process of making material safe by absorbing, destroying, neutralizing, rendering harmless, or removing chemical or biological agents and radiological contamination.

CBR Environment. The environment created by chemical, biological, or radiological contamination.

CBR Hardness. The capability of material to withstand the material-damaging effects of CB contamination and relevant decontaminations.

CBR Contamination Survivability (CBRCS). The capability of a system to withstand CBR contaminated environments, decontaminants, and decontamination processes, without losing the ability to accomplish the assigned mission. A CBR-contaminated survivable system is hardened against CB agent(s) or radiological contamination and decontaminants. It can be decontaminated, and is compatible with individual protective equipment. CBRCS may be accomplished by hardening, timely re-supply, redundancy, mitigation techniques (to include operational techniques), or a combination thereof. The elements of CBRCS covered by this TOP are compatibility, decontaminability, and hardness.

Chemical, Biological, and Radiological (CBR) Survivability. The capability of a system to avoid, withstand, or operate during and/or after exposure to a CBR environment (and relevant decontamination), without losing the ability to accomplish the assigned mission.

APPENDIX A. EXPLANATION OF TERMS.

Combat Developer. A category of sponsor responsible for drafting, staffing, and revising capabilities documents.

Initial Capabilities Document (ICD). Documents the need for a materiel approach or an approach that is a combination of materiel and non-materiel to satisfy a specific capability gap(s). It defines the capability gap(s) in terms of the functional area, the relevant range of military operations, desired effects, time, and doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF) and policy implications and constraints. The ICD summarizes the results of the DOTMLPF analysis and approaches (materiel and non-materiel) that may deliver the required capability. The outcome of an ICD could be one or more joint DOTMLPF change recommendations or CDDs.

Material Developer. The organization responsible for research, development, and acquisition of material systems in response to capabilities documents.

Mission-Critical System. A system whose operational effectiveness and operational suitability are essential to successful mission completion or to aggregate residual combat capability. If this system fails, the mission will not likely be completed. Such a system can be an auxiliary or supporting system, as well as a primary mission system.

Neutron-Induced Gamma Activity. The radioactivity of elements, typically in soil, induced by neutrons produced by a nuclear burst. The induced radioactivity produces gamma and beta radiation.

Sponsor. The organization responsible for drafting, staffing, and revising capabilities documents. For this document, sponsors include combat developers.

System Threat Assessment. A predecessor document that is used to summarize in a CDD the projected threat environment and the specific threat capabilities to be countered. The summary includes the nature of the threat, threat tactics, and projected threat capabilities (both lethal and nonlethal) over time.

APPENDIX B. ABBREVIATIONS.

ABO	agent of biological origin
AD No.	accession number
AR	Army Regulation
ATEC	US Army Test and Evaluation Command
ATP	Army Tactical Publication
°C	degrees Celsius
CB	chemical and biological
CBCS	chemical and biological contamination survivability
CBR	chemical, biological, and radiological
CBRCS	chemical, biological, and radiological contamination survivability
C/D	contamination/decontamination cycle
CDD	Capability Development Document
CFU	colony forming unit
cm	centimeter
CONOPS	concept of operations
CPD	Capability Production Document
cSt	centiStoke
DA	Department of Army
DOD	Department of Defense
DOTMLPF	doctrine, organization, training, materiel, leadership and education, personnel and facilities
DTIC	Defense Technical Information Center
g/m^2	grams per meter squared
GC	gas chromatograph(y)
GD	soman
HD	distilled mustard
HPLC	high-performance liquid chromatography

APPENDIX B. ABBREVIATIONS.

HSW	hot, soapy water
IAW	in accordance with
ICD	Initial Capabilities Document
kg	kilogram
L/m	liters per minute
LC	liquid chromatograph
µg	microgram
µL	microliter
m/sec	meters per second
mL	milliliters
ME	mission essential
NBC	nuclear, biological, and chemical
NBCCS	nuclear, biological, and chemical contamination survivability
NRT	near-real time
psi	pounds per square inch
QA	quality assurance
QC	quality control
psi	pounds per square inch
RH	relative humidity

APPENDIX B. ABBREVIATIONS.

SOP	standing operation procedure
SST	solid sorbent tube
TEMP	Test and Evaluation Master Plan
tGD	thickened soman
TIM	toxic industrial materiel
TOP	Test Operations Procedure
VX	persistent nerve agent

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APPENDIX C. REFERENCES.

1. AR 70-75, Survivability of Army Personnel and Materiel, 2 May 2005.

2. US Army Nuclear and Combating Weapons of Mass Destruction Agency (USANCA), Springfield, Virginia, Department of the Army (DA)-Approved Nuclear, Biological, and Chemical (NBC) Contamination Survivability (NBCCS) Criteria for Army Materiel, May 2005.

3. US Army Edgewood Chemical and Biological Center, Military Standard (MIL-STD) 3056 Design Criteria for Chemical, Biological, and Radiological System Contamination Survivability, 23 November 2018.

4. TOP 08-2-061B, Chemical Decontaminant Testing, Draft.

5. L. Salomon, R.K. Dumbauld, and J.F. Bowers, Paper Presented at Test Technology Symposium, The John Hopkins University, Laurel, Maryland, US Army 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.

6. Headquarters, Department of the Army (DA), Washington, DC, Army Technical Publication (ATP) 3-11.32, Multi-Service Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Passive Defense, 13 May 2016

7. Edgewood Chemical Biological Center (ECBC), Aberdeen Proving Ground (APG), Maryland, 2007 Source Document (version 1.0), Chemical Decontaminant Performance Evaluation Testing, 2007.

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

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APPENDIX D. APPROVAL AUTHORITY.

CSTE-CI 22 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 08-2-111C, Chemical and Biological (CB) Contamination Survivability, Small Items of Equipment

1. Test Operations Procedure (TOP) 08-2-111C, Chemical and Biological (CB) Contamination Survivability, Small Items of Equipment, 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 test planning, conducting, and reporting, in achieving standardized chemical and biological contamination survivability testing of small items of mission-essential military materiel. This TOP is to be used for the testing of small items of equipment that are decontaminated by the individual Warfighter or by two-person or three-person teams operating portable and handheld decontaminating devices.

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.

ZWIEBEL.MICHA
EL.J.1229197269

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

APPENDIX D. APPROVAL AUTHORITY.

TECMIPT Test Operations Procedure (TTOP) 08-2-111C Chemical and Biological (CB) Contamination Survivability, Small Items of Equipment

The Contamination Mitigation Capability Area Process Action Team (CAPAT) recommends approval of the TECMIPT Test Operations Procedure (TTOP) 08-2-111C. If a representative non-concurs, a dissenting position paper will be attached.

Organization	Signature	Date
Deputy Under Secretary of the Army Test and Evaluation (DUSA-TE)	OBRIEN.SEAN.P.1230553501 Digitally signed by OBRIEN.SEAN.P.1230553501 Date: 2020.10.27 18:16:53 -04'00' Sean P. O'Brien	
Joint Program Executive Office of Chemical Biological Defense (JPEO-CBD) Test & Evaluation	No response, no dissenting position paper Joseph Rybak	
Joint Requirements Office for Chemical, Biological, Radiological and Nuclear Defense (JRO-CBRND)	 MAJ Matthew S. Giffen	8 NOV 20
Joint Science and Technology Office (JSTO)	HIGH.CHRISTOPHER JOHN.1026027671 Digitally signed by HIGH.CHRISTOPHER.JOHN.1026027671 Date: 2020.11.16 14:03:11 -05'00' Chris High	
US Army Evaluation Center (AEC)	HUGHES.JULIANE.OLSEN.1285055837 Digitally signed by HUGHES.JULIANE.OLSEN.1285055837 Date: 2021.02.23 14:30:12 -05'00' Juliane Hughes	
Operational Test and Evaluation Force (OPTEVFOR)	Philip L Engle Jr. Philip L. Engle Jr.	07 Dec 20
Air Force Operational Test and Evaluation Center (AFOTEC)	MADRIGAL.KEVIN.M.1015386319 Digitally signed by MADRIGAL.KEVIN.M.1015386319 Date: 2020.11.13 11:25:55 -07'00' KEVIN M. MADRIGAL, Col, USAF	
Marine Corps Operational Test & Evaluation Activity (MCOTEA)	WADLEY.MICHAEL.CRAIG.1130810841 Digitally signed by WADLEY.MICHAEL.CRAIG.1130810841 Date: 2021.03.23 15:47:12 -04'00' Michael Wadley	
Contamination Mitigation CAPAT Co-Chair	TIENES.BRYAN.MATTHEW.1469193957 Digitally signed by TIENES.BRYAN.MATTHEW.1469193957 Date: 2020.11.20 09:12:11 -05'00' Bryan Tienes	
Contamination Mitigation CAPAT Co-Chair	BURNS.JAMES.R.III.1276086134 Digitally signed by BURNS.JAMES.R.III.1276086134 Date: 2020.12.04 11:15:33 -05'00' James Burns	

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.