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14. ABSTRACT
This TOP provides the standard process for preparation, planning, conduct, and reporting for field testing of ColPro systems. The process is designed to evaluate the effectiveness of mobile and stationary ColPro systems under operational field conditions during exposure to an agent by using a simulant vapor cloud.

15. SUBJECT TERMS
solid sorbent tube (SST); challenge concentration; breakthrough concentration; real-time monitor (RTM); near real-time monitor (NRTM); simulant exposure area (SEA); total exposure dosage (TED); protection factor (PF); concentration × time (Ct).

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 08-2-198A 19 October 2021
DTIC AD No.

COLLECTIVE PROTECTION (COLPRO) FIELD TESTING

Page

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1. SCOPE.

1.1 Background.

a. Collective protection (ColPro) systems are designed to provide protection of enclosed personnel and equipment from chemical warfare agent (CWA) and biological and/or radiological contaminants.

b. Stationary ColPro systems allow personnel to proceed with their primary military functions without impeding the operator's mission in a modular ColPro shelter. Mobile reconnaissance ColPro vehicles are capable of locating CWA threat areas using onboard detectors and can function as an advanced warning system.

c. ColPro systems provide a toxic-free area (TFA) where personnel can function without the need of individual protection equipment during CWA threats. The TFA is over-pressurized with filtered air to significantly reduce the potential for direct CWA intrusion. Additionally, the systems have an environmental control unit and a blower equipped with a chemical, biological, and radiological (CBR) filter, which supplies clean air inside the system while maintaining positive pressure.

d. Entry/exit to and from the TFA under threat conditions may require the use of an airlock or a protective entrance. The airlock functions as a staging area that permits toxic vapors from contaminated items to be purged before entering the TFA, thus allowing personnel to move from a contaminated area into the TFA with minimal contamination carryover.

e. The protection efficiency of a ColPro system relies heavily on the ability of personnel to follow correct operational procedures in order to maintain a toxic-free environment within the TFA. Over-pressure systems can only reduce the risk of CWA intrusion.

1.2 Purpose.

a. This Test Operations Procedure (TOP) provides the standard process for preparation, planning, conduct, and reporting for field testing of ColPro systems. The process is designed to evaluate the effectiveness of mobile and stationary ColPro systems under operational field conditions during exposure to an agent by using a simulant vapor cloud.

b. For the purpose of this TOP, tents and other similar stationary ColPro shelters will be referred to as ColPro systems. Vehicles and other similar mobile ColPro shelters will be referred to as mobile ColPro platforms. When discussing both the ColPro systems and platforms, the term ColPro system under test (SUT) will be used. Also, those individuals responsible for setting up and running the test will be referred to as test team (TT). Those who actually participate in the test, such as enacting the entry/exit procedures, will be referred to as test participants (TPs).

c. Field testing is conducted by challenging ColPro SUTs with simulant vapor clouds. The simulant challenge concentration is compared to any breakthrough simulant concentration inside the TFAs of the ColPro SUTs.

d. This TOP describes testing methods currently in use along with the parameters required for each method. However, test parameters may change depending on objectives for a particular test program. The objectives for test programs can be found in the Capability Development Document (CDD), System Performance Specification, and other program documentation.

e. This TOP is to be used as a guide in preparing test plans.

1.3 Limitations.

a. The procedures in this TOP are not sufficient alone to assess the ability of ColPro items to protect the user. These procedures are designed to be used as part of an overall assessment program evaluating the material performance, manufacturing, and system integration with other pieces of protective equipment.

b. The results obtained by using these test procedures cannot be correlated to the full range of battlefield conditions; therefore, an absolute protection value cannot be determined.

c. This TOP is limited to currently approved standards and procedures. Developments in practices, equipment, and analysis may necessitate modifications or additions to these testing procedures.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

List all required test facilities, with the specific characteristics, sizes, and features needed for each item. Standard equipment or facilities common to most technical organizations, which have little effect on the validity or reproducibility of a test, need not be listed.

Item	Requirement
Chemical laboratory.	Must provide the general analytical laboratory support needed for work with CWA simulants, including calibration solutions, sample analysis, and hazardous waste disposal.
Outdoor testing locations.	Required for conducting field trials on ColPro SUTs.
Simulant exposure area (SEA).	Area in which simulant [liquid or vapor, as specified in the detailed test plan (DTP)] may be disseminated on TPs and where the desired concentration may be maintained. Structure may be composed of fabric or solid materials.

2.2 Equipment.

Item	Requirement
Stationary vapor generator.	Must be capable of releasing and maintaining target simulant concentrations in the test grid for the required time period as specified by the test plan.
Portable vapor generator.	Must be portable and have the capability of releasing and maintaining target simulant concentrations in the test grid for specific time periods as specified by the test plan.
Standoff detectors.	Used to map the vapor cloud as it is released from the disseminator to obtain information, such as average length, width, and uniformity of the cloud in real-time.

2.3 Instrumentation.

Parameter	Measuring Device	Permissible Error of Measurement
Challenge concentration.	Real-time monitors (RTMs), or near RTMs (NRTMs), for monitoring outdoor challenge concentrations of simulant vapor.	± 10 to 25 percent over the range of 10 to 1000 milligram per cubic meter (mg/m^3) for each instrument. The limit of detection (LOD) for the concentration monitors should be sufficiently low to meet specific test requirements for the challenge of interest (± 5 percent of target concentration).
Breakthrough concentration.	RTMs, or NRTMs, for monitoring breakthrough concentration of simulant vapor.	±10 to 25 percent over the range for each instrument.

Parameter	Measuring Device	Permissible Error of Measurement
Cumulative dose.	Delayed-analysis samplers for monitoring the total challenge and total breakthrough concentration. May also be calculated from RTM or NRTM data.	Desorption and transferring efficiency of ± 25 percent for vapor analysis.
Air temperature (-20 to 60 °Celsius (°C)).	Thermocouple with digital recording capability.	± 0.5 °C.
Relative humidity (RH) (0 to 90 percent).	Humidity probe with digital recording capability.	± 2 percent.
Wind Speed (0 to 50 meters per second (m/sec)).	Anemometer or similar device with digital recording capability.	± 0.3 m/s.
Wind Direction.	Anemometer or similar device with digital recording capability.	± 3 degrees.
Atmospheric Pressure (600 to 1060 millibar (mbar)).	Barometer.	± 2 mbar at temperature conditions between -20 and 40 °C.

3. REQUIRED TEST CONDITIONS.

3.1 Test Planning.

a. The test will be designed to facilitate data analysis using standard design of experiment techniques to minimize the number of trials needed to obtain statistical validity.

b. Test criteria must be defined before testing so that the program can be designed to obtain the required information. The resulting data must be adequate to support the intended analysis and assessments.

c. Test planning should include determination of the exact-use configuration of each test item (such as command and control tents, rest and relaxation tents, or medical tent configurations), in conjunction with all compatible items to be used with the test item.

d. The use of TPs that will be exposed to simulants in the course of testing must go before a Human Use Committee (HUC) or equivalent. HUC approval or exemption must be received

before testing begins. A safety release may also be required depending on test site requirements. Ensure that all TPs have access to the safety data sheets for any simulants used in testing.

e. Ensure that all SUT specific programmatic documentation is available for test plan development.

3.2 Safety.

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

b. When appropriate, the TT and TPs will wear required personal protective equipment (PPE).

c. Trials that involve the use of mission-oriented protective posture (MOPP) or other heat-inducing PPE, the core body temperatures of the TPs will be closely monitored throughout testing. The TPs will be monitored in accordance with (IAW) the test agency's industrial hygiene or heat stress plan.

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 Control and Quality Assurance (QC/QA).

a. A QA plan, as required by the test site, must be prepared 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. All calibration will be conducted IAW the validated calibration protocol of the test facility. In the absence of a validated protocol, calibration will be conducted as recommended by the instrument manufacturer.

c. The item must be tested in as-received condition, matching the condition it would be in when issued to Warfighters in the theater of operations as closely as possible.

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

e. All personnel working on the test will observe the following procedures:

(1) Samples shall be accompanied by a chain of custody record.

(2) Disposable rubber gloves will be used in handling delayed-analysis samplers (i.e., sorbent tubes) to ensure simulant is not transferred from the hands to the samples. The appropriate techniques (through training) will also be followed to prevent sample contamination.

(3) An air-sampling data sheet will be employed for all tests to ensure all data are collected according to the test plan.

(4) Data sheets will be reviewed for completeness by a designated QC person at the completion of each trial. Once verified as complete, each data sheet will be duplicated and the duplicates will be filed separately from the data sheet used in the analysis.

(5) Air samplers will be cleaned and verified before their use in testing. If sorbent tubes are used, sorbent material should be free of any detectable amount of simulant.

(6) Storage-control samples will be used. A number of air samples that have not been exposed to simulant will be stored with the test samples. Some of the samplers will be blank, and others will be spiked at the concentration range expected to be measured inside the test item.

(7) Quantitative chemical analysis of air samples (solid sorbent tubes (SSTs) only) will be performed with an appropriate number of standards, blanks, and analytical controls.

(8) If samples are to be stored for more than 12 hours before analysis (in the laboratory), it is recommended that they be bagged and stored in a refrigerator at 4 °C. Samples stored for more than 12 hours at greater than 4 °C will be marked as potentially suspect samples..

(9) RTMs and NRTMs will be checked daily at the test site as described in test site SOPs.

(10) RTM data for SEA concentrations will be checked and confirmed by capturing three air-dosage samples (using SSTs) from the challenge concentration during the trial using low-rate sample flow.

(11) NRTMs for the TFA will be checked by injecting standards at known concentrations.

3.5 Test Conditions.

a. Test preparations include selection, examination, anthropometric measurement and characterization (for qualification for the entry/exit trials), and training of TPs (if applicable).

b. Medical examinations of TPs will be required to determine physical ability to perform specified tasks. Medical examinations will be conducted no more than two months before the test begins. If applicable, a medical record will be maintained on each participant.

c. TPs must be trained on the SUTs, mission scenarios, and test conditions including physical activity required.

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 and monitored 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.).

e. Preliminary computational fluid dynamic modeling and atmospheric dispersion modeling will be conducted to determine the optimal placement and location of test instrumentation and the SUT. Modeling should be performed with and without test instruments to determine how the addition of a test instrument will impact the measurement of the performance of the SUT. For example, airflow modeling will identify the potential for stagnant and high airflow zones that could cause localized variations in simulant vapor concentration inside the TFA.

f. During the modeling process, the following assumptions will be made:

(1) It should be assumed that the environmental conditions, including temperature, RH, pressure, wind speed, wind direction, and challenge concentration will remain constant throughout the trial. The model should be constructed to reflect these assumptions.

(2) The environmental conditions (temperature, RH, and pressure) will be determined using historical meteorological conditions of the test site. These conditions will be used as the ambient conditions for the model.

(3) Specific limits, such as the dimensions of the TFA, will be determined IAW test parameters to ensure that the model reflects actual test conditions.

(4) Frequently, the default setting for convergence criteria for computational fluid dynamics (CFD) software, such as ANSYS® FLUENT® (ANSYS, Inc., Canonsburg, Pennsylvania), produce results which are not stringent enough to meet testing needs. Closure or convergence criteria for the modeling process should be set such that additional iterations of the model do not have an appreciable effect on the model solution. The caveat of more stringent convergence criteria is that a longer computer processing time is required. An appropriate balance of computer processing time and required accuracy must be reached in determining appropriate convergence criteria. For example, a CFD user's guide has suggested that the

convergence criteria to be set to a default 10^{-3}. However, in previous trials[1,2,3**], the convergence criteria were modified to the following values with successful results:

(a) The convergence criteria for velocity were set to 10^{-5} to 10^{-6}.

(b) The convergence criteria for species (simulant or agent) were set to 10^{-6}.

(c) The convergence criteria for temperature were set to 10^{-8}.

g. Atmospheric dispersion modeling will also be conducted before testing to determine the optimal location of the SUT on the test grid. This will help to obtain the challenge concentration specified in the requirements document for the program, and the optimal orientation(s) of the SUT for the challenge.

4. TEST PROCEDURES.

4.1 Test Method Outline.

a. Receipt inspection will be conducted on the SUT to document as-received material conditions. TOP 08-2-500A[4] may be used for this inspection.

b. The test grid set up will be performed.

c. The following instrumentation will be set up before testing starts: simulant dissemination equipment, meteorological instrumentation, challenge and TFA concentration referee system, and TFA instrumentation.

d. Trials for the following trial types will be conducted as outlined in the test plan.

(1) Closed ColPro system field trial.

(2) ColPro systems entry/exit trial.

(3) Mobile ColPro platform field trial.

NOTE: If the ColPro system requires over-pressurization, care should be taken to avoid over-pressurizing the SUTs beyond their intended operational pressure levels. Over-pressurization of soft-walled shelter systems has been known to cause ruptures and irreparable damage to seams and other areas of the shelter. Over-pressurization of building structures can also cause damage.

** Superscript numbers correspond to Appendix B, References.

4.2 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[4].

b. The electrical supply feed-through and the electric wire bundle will be visually inspected. Electrical cable assemblies should be free of kinked, nicked, or cracked wiring.

c. The operational status of the necessary ColPro system subcomponents will be verified.

d. Before issuing the ColPro SUTs to the TPs, the SUTs 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 SUT or SUT component or the manufacturer's serial numbers may be used as the identifier. The TICNs must be permanently marked or attached to the SUTs.

e. The TICNs must be used to track the SUTs from initial receipt through all system testing and should be structured based on utility for multiple developmental tests and operational tests, when applicable.

NOTE: An overarching TICN assignment plan will often be developed to facilitate data integration when there are multiple test sites.

f. A TICN database will be created and assimilated into the overall test database to permit easy access to the individual records of each test item. The TICNs will allow quick retrieval of specific data corresponding to the SUT, demographic/anthropometric data on the TP, data collection information, and test incident reports (TIRs).

4.3 Test Grid Setup.

a. The test grid will be designed to provide a vapor challenge to the ColPro system as defined by the program requirement to simulate specific threats for testing ColPro systems.

b. The referee detector systems will be placed on the grid as specified in the test plan.

c. The SUT will be set up or placed (in the case of mobile systems) on the grid as specified in the test plan.

d. The vapor generation system will be set up on the grid as outlined in the test plan. The precise location of the SUT and the distance from the vapor generator may depend on modeling results.

NOTE: Precise control of challenge concentration profiles is not possible because of the unpredictable behavior of simulants in the open air environment. Many uncontrollable variables, such as changing environmental conditions and terrain characteristics, can make precise control of challenge concentrations difficult.

e. The meteorology instrumentation will be set up based on the results of pretrial meteorological modeling to obtain wind speed, wind direction, temperature, and RH at a 2-meter elevation and other elevations as specified in the test plan. Measurements will be taken to define meteorological conditions upwind, downwind, and on each flank of the test setup.

f. Wind speed and direction, temperature, and RH sensors will be set up to gather data on the environmental conditions immediately around the SUT.

g. Referee RTMs, NRTMs, and M-analysis samplers will be used to detect the cloud and breakthrough concentrations. The locations of monitors/samplers will be based on modeling results and any other actual field conditions encountered.

(1) TFA areas that will be directly monitored are: entry/exit portals, work areas, ColPro equipment intake and exhaust, and other key locations as determined by the evaluation strategy outlined in the test plan.

(2) The number of referee instruments set up in the TFA will depend on the size of the system. A minimum of two referee instruments will be set up in the TFA. The actual number used should be based on the air flow modeling and specified in the test plan.

h. Simulant cloud detection/measurement instrumentation will be set up at optimal locations (based on model results) to provide an average height, length, and width of the cloud as a function of time.

i. Simulant point detection instrumentation for measuring the challenge concentration of the simulant cloud will be set up at the designated locations, as determined by modeling and as specified by the test plan.

j. All referee instruments will be checked for calibration and function at the beginning of each test day or before each individual trial.

4.4 Closed ColPro System Field Trial.

4.4.1 Interferences.

a. The nature of the open-air dissemination method produces a simulant cloud that may be difficult to maintain and quantify at lower concentrations.

b. Outdoor testing has inherently uncontrolled variances in temperature and/or humidity. The extreme variances are constituents or properties that will create interferences.

c. Open air dissemination is subject to the presence of operationally relevant background chemical compounds such as smoke, dust, fuel exhaust, or other substances that may be detected and interfere with the detection of simulants.

4.4.2 Test Procedures.

a. Pre-trial checks and procedures include:

(1) The TPs will abide by the following contamination avoidance procedures:

(a) All personnel entering the ColPro system will be required to shower (using soaps that do not contain the simulant) no more than 12 hours before the test begins. After showering, the TPs will also be required to avoid consumer products (e.g., deodorants, perfumes) that contain the simulant. No personnel who have handled simulant or used consumer products containing the simulant will be allowed to enter the ColPro system.

(b) Personnel entering the ColPro system will wear full PPE any time after the initial vapor challenge has been conducted. PPE clothing will be removed inside the airlock after the purge period is completed.

(c) Airlock purge periods will be observed during all entries to the shelter system. The purge timer will be set immediately after entry to the airlock.

(d) Test personnel will leave the airlock and enter the TFA only after the full purge period has been completed.

(2) The airlock airflow and purge rates will be checked to confirm that they are within the proper ranges, as specified by the technical manual (TM) or operator manual (OM).

(3) The flow rate of the filter units will be measured to determine whether the filter-blowers are operating properly.

(4) A halide trial should be conducted to detect any leaks in the filters (see Section 4.4 of TOP 08-2-199A[5]).

(5) Pretrial checks of all auxiliary SUT equipment and test equipment [i.e., electronic control unit, exterior sampling lines/pumps, and exhaust ports] will be conducted to verify the absence of interferent intrusion sources.

(6) Any significant background reading from the referee detector instrumentation on the interior of the TFA must be identified before a trial begins. If the detected concentration for the selected simulant exceeds the worker population limit then the contaminated area of the ColPro system or component will be identified and decontaminated, or measures will be taken to reduce the amount of contamination to an acceptable level before the test begins.

(7) Time synchronization will occur at the beginning of each day and will be maintained using local standard time.

b. Trials will not be conducted if the minimum required environmental test conditions as outlined by the test plan are not met. Wind speeds between 1 and 6 meters per second are optimal. The forecast for the test grid will be checked each day before starting trials.

c. Meteorological data recording will be initiated 1 hour before the scheduled test start.

d. The SUT will be started and checked for proper performance IAW the OM.

e. Instrumentation will be turned on to measure the simulant background concentration within the TFA and obtain background dosage sample data for a duration of 15 to 30 minutes. If the simulant background concentration is above the LOD, the SUT will need to be air-washed until the interior concentration returns to baseline levels.

f. A background check on the test grid will be performed at the beginning of each trial to establish the simulant concentration baseline. The background check will be performed for a duration of 15 to 30 minutes. If the simulant background concentration for the test grid is above the LOD, sufficient time must be given to allow the test grid concentration to return to baseline levels.

g. All other data collection will be initiated before dissemination begins. The data collection initiation time will depend on the sample cycles for RTM and NRTM samplers.

h. At the start of dissemination, the cumulative dose samplers in the TFA will be activated.

i. Start simulant dissemination.

j. Operational activity will be initiated by the test personnel in the TFA when a steady simulant vapor cloud surrounds the SUT.

k. Delayed-analysis samplers that will measure the total TFA concentration during the challenge period will be started. NRTM instrumentation will continue to record near real-time concentration data in the TFA.

l. Monitor the SUT for any alarms when an overpressure system is being tested.

m. Stop the simulant dissemination when the challenge concentration specified in the test plan is reached and stop the trial.

n. Data collection from all referee detector instruments will continue for 30 minutes beyond the end of dissemination.

o. Referee instrumentation will be used as a safety precaution to monitor the decrease in challenge concentration outside the TFA. At the end of the 30-minute period, referee instrumentation will determine whether or not the TPs will be required to don PPE before exiting the SUT.

p. If another trial is possible, then prepare all instrumentation and the TT for the next trial.

q. If no more trials will be conducted, then download all data collected for post-test analysis or processing. Begin SUT air wash procedures if the interior shows high simulant concentrations.

r. Conduct any required post-test TP interviews.

4.5 ColPro Systems Entry/Exit Trial.

The purpose of the entry/exit trials is to determine if contaminated personnel can enter the TFA without transporting unacceptable quantities of simulant into the TFA. The number and frequency of entry/exit procedures will be outlined in the test plan. Test procedures are as follows.

a. Pre-trial procedures found in Paragraph 4.4.2.a through d will be performed.

b. Before dissemination, instrumentation will be powered on and operated to establish the simulant background concentration within the TFA and to obtain background sample data. During this process, the data collectors must be inside the shelter continuously to measure all background concentrations.

c. All personnel entering the SUT will be required to shower no more than 12 hours before the test begins. After showering, the TPs will also be required to avoid consumer products that contain the simulant. No personnel who have handled simulant or used consumer products containing the simulant will be allowed to enter the SUT. The TPs will be given a list of products to avoid for at least one day before the test begins.

d. Designated TT personnel will ensure that all TPs follow the procedures as specified in the test plan.

e. TPs will be engaged in the designated normal operational activities that would be conducted in the SUT TFA.

f. Other test personnel will be positioned outside the airlock entry door, inside the airlock, and inside the TFA entry door. They will assist and monitor the entry/exit procedures, if it is part of the concept of operations (CONOPS). Test personnel will record a time log of all events that occur during the entry/exit test trial.

g. Entry/exit procedures will be halted when the TFA concentration rises above the military exposure guideline (MEG) level specified in the test plan guidelines or in the most recent U.S. Army Public Health Center (APHC) Technical Guide 230[6].

h. TPs will be contaminated in the SEA. The SEA will be set up, as specified by the DTP, within 20 feet of the entrance to the airlock of the ColPro SUT.

i. All participants involved in the entry/exit testing must wear a disposable, non-permeable protective suit underneath their standard uniform to help eliminate simulant contact with human skin while the outer uniform is contaminated by the simulant.

(1) TPs will enter and remain within the SEA for the period of time specified in the test plan while being exposed to the simulant. The exposure concentration and duration will depend on the program requirements outlined in the test plan.

(2) If the exposure level is higher than allowed based on the Safety Data Sheet and confined space requirements level, the TPs will be required to wear a self-contained breathing apparatus (SCBA) for respiratory protection within the SEA.

j. After the exposure time specified, the TPs will leave the SEA and immediately enter the airlock of the SUT. The airlock will be monitored by RTMs and NRTMs.

k. Each TP (one at a time) will step inside the airlock and close the outer door, wait for the airlock pressure to rise to the level specified by the test plan, and then start the purge cycle.

l. The items specified in the SUT's TM must be present inside the airlock. The following are examples of items that may be present in the airlock:

(1) Trash bags or sealable containers for protective overgarments.

(2) Trash bag ties.

(3) Communication equipment.

(4) Household bleach.

(5) Personal decontamination kits.

m. Inside the airlock the TP will wait for two full NRTM reading cycle to occur at the current MEG for the simulant being used. Once a safe reading is verified, then the TP will remove their mask and enter the TFA. Masks will not be removed until the entry purge is complete.

n. After taking their masks off, the TPs will place them in designated spots on a numbered rack inside the airlock. Masks should not come in contact with masks used by other TPs. The masks will off-gas while the TPs are in the TFA.

o. If an inner door is present in the SUT, it will be securely closed.

p. Once a TP enters the TFA, the remaining TPs will process through the airlock one at a time following the same procedures as coordinated IAW the test plan to meet the specified entry/exit rate.

q. To exit the TFA, a TP will take their assigned mask off of the numbered rack in the airlock and prepare to exit as coordinated by the TT between entries of other TPs (not all TPs will enter the TFA and then exit the TFA; entries and exits will be interleaved at some point).

4.6 Mobile ColPro Platform Field Trial.

a. The purpose of this test is to determine whether a mobile ColPro platform can operate within a simulant vapor cloud while maintaining the integrity of the TFA. The mobile ColPro platform will make multiple passes through the simulant vapor cloud. The number and frequency of passes will be outlined in the test plan.

b. The test grid setup procedures in Paragraph 4.3 will be repeated.

c. The TPs will receive the training specified in the operator's training manual for operating the mobile ColPro platform.

d. PPE will be provided and worn by all TPs within the mobile ColPro platform for the duration of the trial.

e. Simulant detection instrumentation will be mounted to the interior of the mobile ColPro platform to monitor the simulant concentration.

f. Simulant detection instrumentation capable of continuous-air monitoring will be set up within the platform TFA to monitor the breakthrough concentration.

g. SSTs will be placed in the TFA and used to measure the total exposure of simulants inside the mobile ColPro platform's TFA.

h. Background readings will be collected and recorded at the beginning of each trial for the duration of time specified in the DTP to establish the simulant baseline.

i. The mobile ColPro platform will travel, at a relatively constant speed (specified by the system requirements), within the ground-truth box in a path perpendicular to the path of the simulant cloud. The vehicle, with all doors and windows securely closed, will make multiple passes, following a predetermined path back and forth through the simulant cloud.

j. The simulant detection systems will be activated at a predetermined time before simulant dissemination, as specified by the test plan.

k. Any onboard meteorological sensors will record temperature, RH, and barometric pressure. A global positioning system (GPS) should be used to gather accurate data on the location and speed of the mobile ColPro platform.

l. Before each trial, if the background concentration level is above one-third of the toxicity concentration limit for the selected simulant, the surface of the platform must be decontaminated before the next trial begins. The decontamination of the internal compartments and the surface of the ColPro platform will follow the procedures outlined in the test plan.

m. The procedures in Paragraphs 4.6.a through 4.6.l will be repeated for each trial.

5. DATA REQUIRED.

5.1 Data To Be Collected.

a. Model data will include:

(1) Optimal placement of meteorological stations.

(2) Optimal placement of internal and external referee instrumentation.

(3) Location where the simulant cloud stream from the disseminator would coalesce within the truth box.

b. Meteorological data: wind speed, wind direction, temperature, weather forecast, RH, and barometric pressure.

c. Identification of equipment positions in the field.

d. Instrument parameters and calibration range for all detection and monitoring instruments.

e. Background concentration taken from instrumentation located in the TFA.

f. Description of ColPro system setup configuration that includes all components of the system and their layout (diagrams of the test grid setup are encouraged).

g. Start and stop times for all timed events.

h. Date and total duration of trial performed.

i. Instrument QC data.

j. Instrument identification information.

k. Near real-time and real-time detector data.

l. Closed ColPro trial specific information:

(1) Total SUT challenge concentration.

(2) Challenge concentration versus time for all sampling points.

(3) Breakthrough concentration in the TFA as a function of time (NRT concentration data).

(4) Time of dissemination.

(5) Total cumulative dosage after breakthrough.

(6) Total dosage [concentration × time (Ct)] calculated by multiplying detected simulant concentration by the total detection time.

m. Entry/exit trial information:

(1) Simulant concentrations in the SEA, the TFA, and the airlock throughout the entire entry/exit trial.

(2) Simulant concentration in airlock as a function of time.

(3) Sequential air samples collected continuously throughout the duration of the trial.

(4) A complete record of pressure levels in both the TFA and airlock.

(5) The amount of time that test personnel remain in purging/airlock area before proceeding to the TFA.

(6) The amount of time TPs remain in the TFA before exiting.

n. Mobile ColPro Platform specific information:

(1) Simulant concentration of the platform TFA during normal operation as a function of time.

(2) Pressure in the SUT platform as a function of time.

(3) Data from the onboard monitors, if available.

(4) Description or illustration of the path that the SUT followed for the trial.

(5) GPS data on the speed and position of the SUT.

(6) Distance traveled by the SUT.

(7) Challenge Ct.

(8) TFA breakthrough Ct and time of breakthrough.

(9) Concentration profile over time.

(10) Data sheets should be used to record data from the test. Hand-recorded data sheets, if used, will be scanned and saved as electronic files.

(11) The overall results of the test and the ColPro system performance will be reported.

(12) Detailed discussion on any failures noted will be included in the test report. Analysis should be conducted to determine the cause of failures.

5.2 Data Analysis.

a. The data collected during the trial will be analyzed to determine whether the simulant infiltrated the SUT. Challenge data will be compiled to determine the exact dosage of simulant to which the SUT was exposed during each trial. Results from TFA samplers will be analyzed to determine the background simulant concentration and the concentration of any simulant breakthrough measured during the challenge portion of the test. Sampling results will be averaged for the different instruments.

b. NRT data will be analyzed to determine the average concentration inside the TFA.

NOTE: Background levels should be below the limit of detection (LOD) of the instrumentation.

c. Data collected from the referee instruments will be analyzed to determine the total exposure dosage (TED) using Equation 1.

$$TED_{TFA} = \sum TVC \times CT \qquad \textit{(Equation 1)}$$

where:

TED_{TFA} = total exposure dosage in mg·min/m^3
TVC = total vapor concentration in mg/m^3
CT = challenge time in minutes.

d. If samples will be stored for more than 4 hours after being collected at the test site, they must be refrigerated at 4 °C.

e. Samples will not be stored for more than 30 days.

f. Any detectable breakthrough concentration will be compared with the thresholds for the MEG values reported by APHC or the program requirements, which provide categories of health effects and hazard severity. The breakthrough concentrations will be used to assess protection effectiveness within the TFA.

g. Total vapor concentration from NRTM will be obtained as shown in Equation 2.

$$TVC = \frac{\sum mass\ Detected\ per\ NRT\ Cycle}{Flowrate \times \sum sampling\ time} \qquad \textit{(Equation 2)}$$

where:

TVC = total vapor concentration in mg/m^3

Mass = Summed mass for the near real-time (NRT) sampler in micrograms or nanograms
Flowrate = air flow through the sampler in m^3/minute
Sampling time = summed sample time in minutes

h. In order to correlate historical data from previous field trials with data from new trials, the protection factor (PF) of the SUT will be calculated using the following steps:

(1) The PF will be calculated by subtracting the background from the breakthrough dosage and dividing the total challenge dosage by the net TFA dosage (Equation 3).

$$PF = \frac{TCD}{IBtD - IBgD} \qquad \textit{(Equation 3)}$$

where:

PF = protection factor
TCD = total challenge dosage in mg·min/m^3
IBtd = interior breakthrough dosage in mg·min/m^3
IBgD = interior background dosage in mg·min/m^3

(2) The PF will be calculated using the vapor concentration measured for each sampler location of the exterior and interior SUT or ColPro platform.

i. For the entry-rate data (the number of entries per hour) and average TFA dosage (in mg·min/m^3), the mean, standard deviation, and 95 percent confidence interval will be calculated.

j. If a comparison with previous data is planned, special caution must be taken to use the same conditions as the desired comparison test. Results obtained by using this TOP may be compared with results from other systems tested during the same experiment or from those tested previously under the same conditions. The test conditions must be the same among compared results for statistical accuracy.

6. PRESENTATION OF DATA.

a. Simulant vapor detection results from referee instruments will be used to construct a plot of the vapor concentrations detected over time.

b. Averaging of repeat trial data and calculation of the test plan-specified confidence intervals are the analysis methods required for interpretation of the data.

c. Meteorological data will be plotted as a function of time.

d. TFA near real-time (NRT) average concentration values will be tabulated. The values will be compared with the exposure MEG values.

e. The RTM and NRTM data sets will be used to generate a concentration-of-simulant-versus-time curve.

f. The PF value will be evaluated to determine if the SUT passes the PF criterion required by the Program of Record. If the PF value is above this level, then the shelter will meet the test criterion. The PF calculation is not a required first line of measurement for field trials.

g. Graphically, trial-to-trial variation can be evaluated by plotting the percent deviation of the mean (for the parameter of interest) against the run number and comparing the deviation with the specification limits.

h. Processed summary data from each test (including data from control and standards samples) will be presented in tabular form in an appendix to the test report.

i. The data for each trial will be grouped according to the parameter tested, type of sample, sampling location, and replications. Critical reference information, such as time of sample collection or test conduct and timing of sample collection or test conduct relative to a critical event, will be included in the table.

j. An explanation of the conversion process, equations, and conversion factors used to process instrument and test readings into data will be presented in the body of the report or in the text of the appendix along with the tabulated data.

k. The data will be treated statistically on the basis of the parameters and criteria from the requirement documents and the summarized data, and statistical derivations will be presented in tabular form in the body of the test report.

(1) For each parameter, the tables will present the statistically treated data and derivations together with verification criteria values or ranges from the DTP.

(2) Appropriate graphics will show the distribution of data points for comparison of test values with critical values from the DTP.

l. Reliability and accuracy indices will be presented in the body of the test report along with the summarized data.

m. Textual explanations, TIRs, time lines, photographic evidence, and diagrams, among other data, will be presented in the body of the test report to explain any data anomalies, gaps, and/or other deficiencies.

n. Statistical methods used in processing and evaluating the reliability and accuracy of the data will be described in an appendix to the test report.

o. For each trial, the Ct will be measured at each sampling location. The Ct will be calculated as an average of concentrations at each sampling location to determine the Ct at each position. The averages from each sampling location will be combined and averaged again to determine the overall Ct. Sample concentrations, average concentration at each position, and the

overall Ct will be recorded. Measurements throughout the trial must be within ±10 percent of the target Ct as specified by the test plan.

p. For each trial, the vapor concentration at all sample points will be measured, recorded, and plotted on a chart. Measurements throughout the trial must be within ± 10 percent of the target challenge concentration as specified by the test plan.

q. For each trial, the wind speed and wind direction will be monitored, recorded, and plotted. These measurements should be taken at several representative locations to ensure that the test grid area is adequately characterized. Particular attention should be given to grid areas where shade interferes with direct sunlight, or where other environmental characteristics may lead to variation in wind speed and direction.

r. For each trial, the temperature and RH will be monitored, recorded, and plotted on a chart. If there are significant temperature and RH changes between trials, these changes should be noted during the trial analysis process. These measurements should be taken at several representative locations to ensure that the test grid area is adequately characterized. Particular attention should be given to grid areas where shade interferes with direct sunlight or where other environmental characteristics may lead to a variation of the results.

APPENDIX A. ABBREVIATIONS.

AD No.	accession number
APHC	U.S. Army Public Health Center
ATEC	U.S. Army Test and Evaluation Command
°C	degrees Celsius
CBR	chemical, biological, and radiological
CDD	Capability Development Document
CFD	computational fluid dynamics
ColPro	collective protection
CONOPS	concept of operations
Ct	concentration over time
CWA	chemical warfare agent
DPG	U.S. Army Dugway Proving Ground
DTP	detailed test plan
GPS	global positioning system
HUC	Human Use Committee
IAW	in accordance with
LOD	limit of detection
m/sec	meters per second
mbar	millibar
MEG	military exposure guideline
mg/m^3	milligram per cubic meter
MOPP	mission-oriented protective posture
NRT	near-real time
NRTM	NRT monitor
OM	operator manual
PF	protection factor
PPE	personal protective equipment
QA	quality assurance
QC	quality control

APPENDIX A. ABBREVIATIONS.

RH	relative humidity
RTM	real-time monitor
SCBA	self-contained breathing apparatus
SEA	simulant exposure area
SOP	standing operating procedure
SST	solid sorbent tube
SUT	system under test
TED	total exposure dosage
TFA	toxic-free area
TICN	test item control number
TIR	test incident report
TM	technical manual
TOP	Test Operations Procedure
TP	test participant
TT	test team

APPENDIX B. REFERENCES.

1. U.S. Army Dugway Proving Ground (DPG), Dugway, Utah, *Methodology Investigation Report for Collective Protection (ColPro) Airflow Mapping II*, WDTC-MR-08-062, October 2008.

2. U.S. Army Dugway Proving Ground (DPG), Dugway, Utah, *Final Test Report for the Characterization and Validation of the Active Standoff Chamber (ASC)*, WDTC-TR-09-024, September 2009.

3. U.S. Army Dugway Proving Ground (DPG), Dugway, Utah, Final Test Report (FTR) WDTC-TR-08-017, *Final Test Report for the Characterization and Validation of the Joint Ambient Breeze Tunnel (JABT)*, March 2008.

4. TOP 08-2-500A, Receipt Inspection of Chemical - Biological Materiel, 31 August 2017.

5. TOP 08-2-199A, Collective Protection (ColPro) System Chamber Tests, 9 April 2019.

6. US Army Public Health Center (APHC). 2013. Technical Guide 230, *Environmental Health Risk Assessment and Chemical Exposure Guidelines for Deployed Military Personnel*, Aberdeen Proving Ground, Maryland, https://phc.amedd.army.mil/PHC%20Resource%20Library/TG230-DeploymentEHRA-and-MEGs-2013-Revision.pdf.

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APPENDIX C. APPROVAL AUTHORITY.

CSTE-CI 19 October 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 08-2-198A, Collective Protection (COLPRO) Field Testing

1. Test Operations Procedure (TOP) 08-2-198A, Collective Protection (COLPRO) Field Testing, 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 the standard process for preparation, planning, conduct, and reporting for field-testing of ColPro systems. The process is designed to test and evaluate the effectiveness of mobile and stationary ColPro systems under operational field conditions during exposure to an agent by using a simulant vapor cloud.

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, US 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.