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14. ABSTRACT
This TOP provides the current standard methods for chemical aerosol detector testing and assessment with and without operational background materials for aerosol threats that include chemical warfare agents (CWAs), emerging threat agents, and their simulants.

15. SUBJECT TERMS
CWA – chemical warfare agent; WVC – water vapor content; aerosol; chemical point detector.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 08-2-054A 11 October 2022
DTIC AD No.

CHEMICAL AEROSOL POINT DETECTOR TESTING

* This TOP supersedes TOP 08-2-054 dated 16 October 2019

1. SCOPE.

This Test Operations Procedure (TOP), which has been endorsed by the Test and Evaluation Capabilities and Methodologies Integrated Process Team (TECMIPT), will address chemical aerosol detector testing and assessment with and without operational background materials for point sensors that interrogate aerosol hazards such as chemical warfare agents (CWAs), emerging threat agents, and simulants. Test procedures and operations have been provided in terms of a 'best practice' approach. Some detector-specific limitations may apply and should be addressed accordingly within test-specific documentation.

NOTE: From this point on, analyte will refer to the chemical challenge to be presented to the system under test (SUT) during test operations.

1.1 Purpose.

a. This TOP provides standardized procedures for test preparation, planning and conduct, and reporting test results that assess a chemical detector's capability to detect and/or identify chemical hazards.

b. Absolute humidity or water vapor content (WVC) will be used in this document instead of relative humidity. Absolute humidity is the measure of water vapor (moisture) in the air, regardless of temperature. It is expressed as grams of moisture per cubic meter of air (g/m^3). The maximum absolute humidity of warm air at 30 °Celsius (°C) is approximately 30 grams of water vapor per cubic meter of air or 30 g/m^3.

1.2 Limitations.

a. The procedures in this TOP alone are not sufficient to fully assess the effectiveness of a chemical detector. These procedures are designed to be used as one component in an overall assessment program evaluating the materiel performance and manufacturing of chemical detectors.

b. The results obtained by using these test procedures cannot be correlated to the full range of battlefield conditions; however, key documents, such as the system threat assessment, can help guide prioritization in establishing the range of battlefield conditions that should be tested.

c. This TOP is limited to currently approved standards and procedures. Developments in practices, equipment, and analysis may necessitate new testing procedures. Additionally, standards of performance must be adjusted as technologies advance. Test procedures and parameters listed in this TOP may require updating to accommodate new technologies in test items or in test instrumentation.

d. This TOP does not cover bioaerosols. Procedures involving the detection of bioaerosols will be included in TOP 08-2-066B (Aerosol Testing of Biological Point Detectors) at a future date.

2. FACILITIES, EQUIPMENT, AND INSTRUMENTATION.

2.1 Facilities.

Item	Requirement
Chemical surety laboratory and chemical agent storage facility.	Constructed to ensure safe and secure storage, handling, analysis, and decontamination of necessary quantities of chemical agents, other contaminants, or simulants.
Chemical agent test facility (chamber or laboratory) with environmental control system.	Constructed to house the aerosol exposure chamber during agent or simulant challenge and sampling. The chamber or laboratory should have sufficient volume to allow free air circulation around the SUT. Test areas in laboratories or chambers must be equipped with environmental controls that allow air temperatures and air-exchange rates to be maintained at prescribed levels throughout the testing period.
Aerosol exposure fixture	Constructed to house the SUT, analyte aerosol dissemination challenge, and referee instrumentation. The fixture includes aerosol generators and all instrumentation necessary to referee the aerosols being generated and environmental conditions for temperature and humidity.
Field aerosol test range	Test range appropriate for generating aerosols, integrated with generators and dissemination systems on platforms. Test range must be designed to allow SUTs to operate and perform all essential functions that are being tested. Simulant must be able to reach to challenge SUTs and appropriate referee instrumentation collocated with SUTs in a field setting.

2.2 Equipment.

Item	Requirement
Analyte Aerosol Dissemination System.	Designed and built to provide a threat challenge of the desired analyte at the appropriate particle size range, as defined by the program, to the SUT under required environmental conditions. A recommended particle size is typically about 0.2 to 10 micrometers.
Operational Background Materials Dissemination System.	Designed and built to deliver the desired operational background material (as required) mixed with the analyte challenge to the SUT under required environmental conditions.
Referee Aerosol Sampling System.	System to sample and quantify the challenge analyte and characterize aerosol particle size distribution profiles. There will also be a referee system for the operational background materials challenge to the SUT if the methodology is available.
Differential pressure (ΔP) measurement system.	Measure ΔP upstream, next to, and downstream of the SUT for safety and for data quality. Dissemination regions are at positive pressure (ΔP at least 1 inch water gauge (iwg)) so that laboratory air does not leak in and dilute the challenge flow. The SUT is at near ambient pressure so that pressure changes do not affect its performance. The exhaust line is at negative pressure (ΔP less than -1 iwg) so that agent vapor does not leak out.
Humidity generation and control system for the detector fixture.	System designed and built to provide water vapor to the detector fixture. Water vapor content (WVC) will be controlled and monitored.
Temperature control system.	System designed to provide temperature control and monitoring. One or more control systems may be used to provide temperature control to the SUT, detector fixture, and exposure chamber.
Temperature and humidity monitoring/recording system.	System designed to provide real time temperature and humidity measurements throughout the test duration at the test location.
Data Acquisition System (DAS).	System designed to automate data collection from the detector fixture. All data will be time tagged and synchronized (as much as possible).
Video data acquisition (optional).	A system to collect visible detector responses on screen. All video data will be time stamped. Adequate resolution and speed (frames/second) to document typical test procedures is required.

2.3 Instrumentation.

Instruments must accurately measure the respective test parameters as described to meet the test program requirements. Note that program offices may require data about the aerosol concentration in the airstream independent of potential vapor concentration. If this is required, additional instrumentation listed in TOP 08-2-188 Change Notice 1[1**] may be used to referee the vapor component of an airstream.

Parameter	Measuring Device	Permissible Measurement Uncertainty
Aerosol particle size distribution	Particle sizers, such as Optical Particle Sizer [(OPS) TSI Incorporated, Shoreview, Minnesota] units, or equivalent.	±10 percent for the particle diameters of interest
Aerosol particle number distribution	Particle counters	±10 percent number of particles per liters (L) of air.
Analyte concentration (mg/m^3)	Calculated based on particle size and particle count or through analytical methods, such as a filter sample analyzed by gas chromatograph, liquid chromatograph, or equivalent.	±25 percent.
Temperature (-32 through 50 °C).	Temperature sensor with digital recording capability or equivalent.	±0.5 °C.
Humidity	Humidity sensor, probe, or equivalent providing absolute humidity as WVC.	±2 g/m^3.
Differential pressure [(ΔP) iwg]	ΔP gauge.	±0.2 iwg.

2.4 Test Controls.

Tolerance values are the permissible limit or limits of variation in a measured value (temperature, humidity, etc.). The following are suggested tolerance values for the test parameters identified. Specific program requirements may require more or less stringent

** Superscript numbers correspond to Appendix C, References.

tolerances, as defined in the Detailed Test Plan (DTP) to meet test needs. Many variables must be considered when determining the permissible error of measurement. The final outcome of the data analysis must be considered along with the criteria for the SUT that is being assessed. The statistical considerations that have gone into the test design must be included in the determination of tolerances as well as the propagation of uncertainty and bias that will be a part of the final data output from testing. The table identifies tolerances that have been considered "best practice" for various test events, but each test event should adjust the tolerances to best fit the data needs for the analysis of the SUT. Actual instrumentation may have greater precision and accuracy; actual values will be reported.

Parameter	Accuracy
Analyte Challenge Concentration	±25 percent
Temperature	±2 °C
Water vapor content (WVC)	The WVC in the condition/challenge airstream will be within ±10 percent of the target value when the target WVC is ≥5 g/m^3. When the target WVC is less than 5 g/m^3, the WVC in the condition/challenge airstream will be within ±0.5 g/m^3 of the target.
Mass Air Flow	±5 percent of full scale
Differential pressure [(ΔP) iwg]	±0.2 iwg.

NOTE: Special consideration should be taken during selection of the flow meter or controller used. The required airflow should dictate an appropriately ranged flow controller for the application. Unnecessarily high range flow controllers should not be used to control lower mass flow measurements. Ideally, a flow controller or flowmeter should be operated between about 20 and 80 percent of its maximum rated flow rate.

3. REQUIRED TEST CONDITIONS.

3.1 Test Planning.

a. This TOP provides guidance on test design issues and data requirements that should be enhanced by information from other documents, such as the Operational Test Agency System Evaluation Plan (OEP), system threat assessment, the Test and Evaluation Master Plan (TEMP), and/or the DTP. For those testing programs in which a systems engineering plan (SEP) is not available or applicable, the test facility should consult with the customer and use previous documents as a guide in addition to this TOP.

b. This TOP will be used as guidance when preparing DTPs. The test procedures described in this document (Paragraph 4) must be referenced and/or incorporated in the test-specific

document and may be modified in the DTP to accommodate unique items or materials, limitations of the SUT, or to satisfy testing requirements specified in the OEP or other acquisition documents. However, alterations will be made only after full consideration of how the changes may affect the reliability and validity of the data. These alterations, justification for the alteration, and the anticipated impacts to the test data must be fully described in the DTP. At a minimum, coordination efforts must address the impact of the modifications to the following test areas:

(1) Safety.

(2) Test conditions.

(3) Environmental effects.

(4) Human use.

(5) Data quality.

(6) Test validity.

(7) Manufacturer limitations for the SUTs.

3.1.1 Experimental Design.

When performed correctly, using Design of Experiments (DOE) is the most efficient way to test. Multiple factors are varied simultaneously in a specific, systematic manner that is scientifically sound. This means that DOE techniques minimize the number of trials needed to obtain mathematical statistical validity. It is recommended that proper use of DOE be applied for all testing. When creating a DOE the following should be considered:

a. The test objective(s).

b. The response variable(s).

c. The factors that affect the response variable(s).

d. The levels (or ranges) of the factors.

e. Any mathematical model assumptions.

f. Statistical measures such as confidence, power, variability, and error structures, etc.

g. Acceptable errors.

h. The final analysis method.

i. Any limitations of funding, SUT availability, and/or schedule.

j. Variability among SUTs.

3.1.2 Simulant Selection.

a. The Test and Evaluation Working Integrated Product Team (T&E WIPT) will coordinate the selection and use of any simulants. Simulant selection (TOP 08-2-196A[2]) may be conducted under the acquisition program of record to identify and verify optimal simulant(s), based on the program's threat and performance documents.

b. The simulant should produce a signature signal similar to the one from the analyte. Additional considerations are as follows:

(1) When the detector will be used for multiple chemicals, several different simulants may be needed to cover the range of signals produced by the various chemicals.

(2) Because the recognition algorithm is a major component of the detector that is being tested, the simulant must produce a signal similar in complexity to the chemicals being analyzed.

3.1.3 Documentation.

a. All pertinent test documentation that is required will be available before testing begins.

b. Familiarization.

(1) All pertinent current TOPs and standing operating procedures (SOPs) should be reviewed.

(2) Potential problem areas and test duplication must be identified by reviewing previous records and results of similar tests, if available.

(3) Development of DTPs requires familiarization with the applicable test planning and requirements documents such as the TEMP, SEP, Capability Development Document (CDD), or Capability Production Document. Test specifications such as selection of appropriate samples, methods, test sequences, facilities, and test equipment will be collected from review of requirement documents and background information such as references from preceding development, test phases, and similar studies.

(4) Safety and health issues must be given prime consideration in test planning. All applicable/available safety documents such as the safety assessment report and health hazard assessments should be reviewed to determine if any safety or health issues require special test protocols. For any tests involving military personnel that are not assigned as testers, safety release and human use committee approval are required.

3.2 Test Fixture.

3.2.1 Dissemination System.

a. The design and type of dissemination system (Paragraph 2, Facilities and Instrumentation) depends on the state of matter of the analyte being used. Liquid aerosols and

solid aerosols require different dissemination systems. Dust-laden (dusty) aerosols are liquid chemicals loaded onto a solid carrier particle and may require a separate dissemination system or the solid aerosol dissemination system.

b. The dissemination system must be characterized to determine the ability to maintain the concentration or dynamically change the concentration predictably for a time period specified in the program requirements (e.g., CDD, SEP, and TEMP).

NOTE: 1. Crystalline solid materials may not be synthesized at particle ranges specified in program requirements. A milling process may be necessary between synthesis and dissemination to generate solid particles in the appropriate range. Milling methods should not change the chemical composition of the analyte before dissemination.
2. Aerosol characteristics may change when introduced to heat. Liquid aerosol particles may vaporize during dissemination and reduce in size. The liquid component of dusty particles may vaporize from the carrier.
3. Aerosol characteristics may change when introduced to water vapor. Water may react with the agent, simulant, or substrate. Water may condense on the aerosol, making the particles larger. Dissemination systems should be characterized to ensure these characteristics are appropriately understood before testing in hot or humid conditions.

c. Aerosol concentration adjustment may be achieved by introducing dilution gas between the aerosol generator and the distribution manifold (DM). Mass flow controllers placed upstream of the aerosol in the system can be used to meet the aerosol flow rate requirements.

d. When a dissemination system is placed in an environmental chamber that is at a significantly different temperature than the ambient laboratory, the air entering the chamber for the purpose of agent dilution or conditioning often does not have enough residence time inside the chamber to equilibrate to the environmental conditions. This can result in mismatches between the environment that the detector is in and the temperature of the agent and conditioning airstreams. When testing with fixtures or chambers, allow for the independent conditioning of the air sources before entering the environmental chambers. Furthermore, ensure that the temperature measurement equipment is placed to properly characterize the challenge airstream and the detector's immediate environment.

e. Referee line(s) inside the chamber may experience water condensation from a flow meter outside the chamber. Calibrated flow meters are generally kept outside of agent contaminated environmental chambers whenever possible. This causes condensation during flow measurements when outside air is being drawn through the meter into a cold environment. A dry air purge system (an inert gas may be used) should be developed to prevent this from happening.

3.2.2 Detector Test Fixture.

a. Best practice principles for the SUT test container dictate that it be designed to meet the following requirements:

(1) Water vapor, interferent, and analyte atmosphere will be well mixed before reaching the SUT inlet.

(2) The SUT will be easy to access by test operators.

(3) The electrical connections will be made easily and securely.

b. One or more transfer lines are used to transport the conditioned airstream and the challenge airstream through the test fixture. They connect the dissemination system to the DM.

(1) It is extremely important that during test planning the minimum amount of airflow to provide the detectors with a valid analyte challenge is established (typically from the detector tech package, customers, or evaluators). This minimum airflow should also take into account any airflow requirements from the OPS or other referee equipment. The total airflow moving to the detectors must be greater than what is taken in by the SUTs and referees, plus a margin of error for expected flow fluctuations to eliminate the possibility of "starving" the detector and not presenting a valid analyte challenge.

(2) Aerosol impaction on transfer lines may cause future vapor contamination. It is critical to ensure that cleaning processes be established to remove aerosol particles and vapor contamination for impacted aerosols before continuing tests with a different analyte. If there is a concern for cross contamination, it is recommended to sample for residual vapor contamination. A more thorough procedure would be to rinse the transfer lines with a suitable solvent and analyze the rinsate for residual analyte.

c. The DM is used to equally distribute the challenge stream to multiple SUTs and referee probes/sample lines. For point chemical detectors, the DM and transfer lines should be made of the most chemically resistant material possible. Plastic materials in the sample path may build up a charge, so metallic materials are preferable.

d. The DM interface to the SUT (which may vary depending on the design of the SUT) is designed to present an analyte challenge (with temperature, WVC, and operational background materials, as required, at appropriate conditions) to the SUT and must not affect the SUT's response. The fixture must be capable of allowing the SUT to sample clean air (conditioned air free of contamination) between analyte challenges. Care should be taken to design an interface that minimizes overpressure at the SUT inlet.

e. Gases or aerosols will be generated into a headspace and mixed with the analyte airstream. Vapor background materials will be generated from a liquid or solid material by having an airstream pass through the saturated headspace before entering the analyte airstream. Liquid or solid aerosol operational background materials may be generated separately in the same manner as the analyte and the airstreams of the aerosol operational background materials will be mixed before presenting to the detectors. Additionally, compressed cylinders of operational background vapors or aerosols may be introduced to the analyte airstream before presenting to detectors.

3.2.3 Referee Systems.

a. Aerosol Number/Mass Concentration. Aerosol concentration referee systems or sampling lines should be connected to the DM. Sampling probes/lines should be installed as close as practically possible to the SUT to avoid any line effects and to accurately characterize the condition/challenge airstream. Referee systems should acquire data at a rate sufficient to characterize changes in concentration throughout the trial, or demonstrate stability over durations longer than required by the SUT.

b. Background Aerosol Concentration. Aerosol concentration of the airstream or the gas stream that are being used to generate the aerosol of interest will be measured using the aerosol referee systems.

c. Temperature. Temperature probes will be installed in the aerosol exposure fixture and the DM. Locations for probe placement should be chosen such that the data recorded can be used to properly characterize the environment within the fixture and the DM.

d. Humidity (WVC). Humidity probes (or temperature/humidity probes) will be installed in the aerosol exposure fixture and the DM. Locations for probe placement should be chosen such that the data recorded can be used to properly characterize the environment within the fixture and the DM.

3.2.4 Control/Data Systems.

a. The control software is used to establish the required aerosol concentration, temperature, and WVC.

b. Data Acquisition System (DAS) recording software will be used to digitally record the data.

NOTE: The DAS should be capable of digitally storing the data and translating it into comma-separated value format for export, which is compatible with commonly used statistical and data analysis software.

c. All clocks and time stamps for all data collection devices must be synchronized. Synchronized equipment must include, but not be limited to, all referee instruments, all sampling instruments, and remotely operated dissemination equipment (e.g., pressure, temperature, and humidity sensors, etc.).

d. Still photographs should be taken to document the test fixture setup. When possible, photograph with scales or rulers in the frame to show relative dimensions and distances.

e. The SUT display must be recorded using digital video. These data will be used to ensure that DAS and SUT timing are synchronized and verify detector response performance. The video data may also be used with optical character recognition software to extract display data.

3.2.5 Test Fixture Verification and Validation (V&V).

a. The aerosol exposure fixture must have a V&V before starting record testing. The V&V effort will determine and demonstrate the fixture capabilities. The V&V effort will also demonstrate repeatability and reproducibility of test methods and resulting data.

b. Pilot trials and/or accreditation will be conducted to confirm test procedures, data collection, and analysis methods before conducting record trials.

3.2.6 Pretest Systems Checks and Calibrations.

a. Ensure all equipment and instrumentation are functioning and/or recording properly.

b. Conduct a confidence check for each SUT as needed (Paragraph 3.4.1).

c. Verify that all calibrated items' certificates are current. If a calibrated item's certificate expires during testing for whatever reason, ensure that a replacement is calibrated and available for installation. If the calibrated item was used for testing while expired, perform an instrument check to verify performance. Calibrated items not used to collect record data are exceptions.

d. For any newly installed calibrated item, perform a pretest instrument check to verify that drift has not occurred and is within the tolerance.

e. Verify that the calibration covers the particle size being distributed.

3.3 Safety.

3.3.1 General.

a. Operators should develop a risk management worksheet to quantify the risks involved in the operation based on the severity and probability of the hazards for the use of this test as well as the controls implemented to minimize the level of risk based on test site-specific requirements. The composite risk management worksheet may be developed in accordance with (IAW) Army Regulation (AR) 385-10[3], *The Army Safety Program*, Department of the Army (DA) Pamphlet (PAM) 385-61[4], *Toxic Chemical Agent Safety Standards*, and DA PAM 385-30[5], *Risk Management*.

b. The required Safety Data Sheets (SDS), testing protocols, and safety procedures will be available at the test site.

c. When appropriate, the test personnel will wear required personal protective equipment (PPE).

d. Test personnel will be informed of potential safety and health hazards involved in test conduct and the precautions required to prevent accidents and limit exposure to the chemicals used in the test.

e. Safety checks and briefings will be conducted to ensure that all identified safety hazards have been addressed before testing proceeds.

f. For tests that involve carrying or lifting, test personnel and participants will be instructed in the proper lifting procedures.

g. Safety Air Monitoring should be used, whenever possible, to ensure the safety of the test personnel during test conduct.

h. Training and Familiarization. Test personnel must be trained in the operation of the SUTs and test fixture to include the following:

(1) Description of the physical activities required during actual testing, to include applicable general operation. These will be provided in a written form, through audiovisual presentation, demonstration, or a combination of these methods.

(2) Any corrective maintenance and preventive maintenance that must be performed IAW the technical manuals.

(3) The types of data to be collected, Quality Control (QC) methods for data collection, and the relationship of the data to overall success of the test program [decision rules or data quality objectives (DQOs)].

(4) Chemicals being used in testing and any health hazards of the chemicals.

3.3.2 Chemical Handling.

a. Chemicals (CWAs, emerging threats, and simulants) must be handled with care. Tests will only be conducted IAW the approved SOPs from the testing installation and the procedures specified in the DTP.

b. Test personnel must read and understand the SDSs associated with the chemical to be used. Also, the SDS for each chemical used in testing must be available in the test area along with the DTP, testing protocols, and safety procedures as required by the test site.

c. Appropriate PPE will be worn by personnel operating aerosol disseminators whenever there is a potential hazard.

3.3.3 Hazards.

Identified safety hazards are those associated with using hazardous chemicals during testing. The safety section of the test plan should be coordinated with the test site’s safety office.

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

3.4.1 General.

a. Each test facility's QA program will be designed to ensure that data of the required quality are obtained from each test. The data quality requirements will be established by the customer as well as by the test facility's QA/QC SOPs.

b. The quality of instrument data produced depends on appropriate instrument maintenance, periodic calibration, QC measures, and careful documentation procedures. 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. Examples of QC measures associated with data reporting are sample collection documentation, tracking and assessment of analytical results, and comparison of results. QC measures will be detailed in the DTP and will follow the test facility's QA/QC plan.

d. Sample collection QC measures will be IAW the test facility's sampling SOPs or as specified in the DTP. Any problems associated with a particular sample will be noted on the appropriate log sheet or data file. All data collected must be date and time stamped. Clocks of all data collection systems, instruments, referees, SUTs etc. will be time synched to correlate SUT responses to referee responses.

e. Data will be independently reviewed and authenticated as required by the test facility or the test program.

f. All analysis results and calculations will be peer reviewed to ensure that random errors in transcribing data or in performing analysis are eliminated, as required by the test facility or the test program.

g. For each trial, the analyte concentration at all required sample points will be measured and recorded. Analyte concentrations should be monitored as close to the SUT inlet as possible.

h. For each trial, the temperature and WVC will be monitored and recorded. If there are temperature and WVC changes between trials, exceeding the tolerances outlined in the DTP, these changes should be noted. The next trial will not proceed until the values are within prescribed tolerances.

i. Statistical analysis can be used to determine measurement uncertainty and to process trial data. There is an on-going working group to develop a standardized calculation of measurement error in referee samples. Future methods developed for the measurement of uncertainty will be considered.

3.4.2 Quality Objectives for Chemical Point Detector Testing.

a. In addition to the program-specific requirements, the following procedures will be followed:

(1) All detectors, samplers, sampling locations, and raw data will be labeled in a manner precluding misidentification.

(2) Data and analysis files will be reviewed and verified by qualified personnel knowledgeable and familiar with the test process, as determined by the test officer/director or the test facility's SOPs.

(3) Each real-time monitor and/or near real-time monitor must be calibrated and checked IAW test site SOPs.

(4) Details of data collection and handling (e.g., backups, data flow path) procedures are as follows:

(a) It is preferable to continuously record all test data with the DAS so that a complete analysis may be made of the test data.

(b) The DAS should record data from all instruments that have either a digital or analog output.

(c) Data should be time stamped and recorded in local time. Examples of these data streams are temperature and humidity statistics collected from an analog probe.

b. DQOs are designed to ensure scientifically valid and defensible data are obtained during testing. Both random and systematic errors in the measurements can occur because of shortcomings in test procedures, instrumentation, and in data collection systems. DQO principles are applied to measurements to determine how much error is acceptable before the data should be rejected.

c. Independent parameters most likely to vary during a single trial include: airflow through dissemination equipment, analyte aerosol flow rate through dissemination equipment, analyte dissemination concentration, analyte particle size, airstream temperature, and WVC. Lack of consistency in these parameters will affect performance measurements. If any DQOs are not met, subsequent trials should not continue until the source of the error is addressed or corrected.

d. Initial DQOs for the fixture will be established based on the fixture's V&V process and recorded in the V&V report and configuration control documents. Program specific DQO needs that exceed the limits of a validated capability require coordination with the program office and the T&E WIPT.

4. TEST PROCEDURES.

4.1 Receipt Inspection.

a. Upon receipt, all SUTs will be inspected IAW TOP 08-2-500A[6].

b. As part of the receipt inspection, a SUT-specific functional check will be conducted to ensure that the SUT is undamaged, fully functional, and ready for testing.

c. Any problems or issues will be reported in test documentation.

4.2 Testing Procedures.

4.2.1 Pretest.

a. Examine the SUT for the applicable test fixture integration parameters, including inlet type, inlet flow requirements, and any data connections. The SUT data stream also needs to be examined to see if any or all parts of the data stream will be used to determine SUT response to the challenge. Some SUTs may not provide a data stream. At this time any proprietary software data downloading or data uploading onto networked computers can be addressed or mitigated. Information from this examination will help determine if any modifications to the DM inlet interfaces are required for a specific SUT being tested.

b. In coordination with the customer and the program T&E WIPT, determine whether building electrical or battery power will be used during SUT testing.

c. The customer and program T&E WIPT need to determine the frequency of performing confidence checks (e.g., at the start and end of every trial day) unless this information is provided by the manufacturer. The environmental conditioning time (the time the SUT will be at the desired environmental conditions before initiating the contaminant challenge) will also need to be established.

d. Establish the challenge airstream and SUT environmental tolerance limits. The challenge airstream may have more restrictive tolerance limits than the SUT environment.

e. The customer and program T&E WIPT will also need to establish the challenge duration unless this information is provided by the manufacturer. The challenge duration is the amount of time the SUT will sample the challenge airstream for each detection opportunity.

f. The conditioning time, challenge time, time to achieve environmental conditions, and time to achieve a specific contaminant concentration will be used to determine how many detection opportunities at a specific set of conditions can be performed, and how many trials total can be performed in a trial day and still allow end of day activities to be performed (e.g., data downloading).

g. It will be important in pre-planning to identify any potential classification issues with SUT performance or merged data streams that will impact data collection. This will allow procedures to be developed before testing is started to deal with those issues.

h. Relevant considerations listed above must be documented in the DTP. Additionally, the DTP should include the number of trials or replicates (per condition) that are sufficient to generate a performance curve and the number of SUTs that can be tested at a time.

i. The calibrations of all measurement equipment must be verified before the start of any record testing.

4.2.2 Point Detector Test Procedures.

a. The SUTs will be placed into the test fixture. The SUTs' inlets will be aligned with the inlet interface on the DM. If an electrical connection is required to operate the SUT, then those connections will be made and verified that they will not come loose. The data connections will be made and data communication will be verified. Video cameras will be aligned with the SUT display screen.

b. Verify the time and date sync and start video cameras.

c. Perform a SUT confidence check if required by the DTP.

d. Establish the initial environmental conditions as outlined in the DTP trial matrix.

e. Start the challenge dissemination system to achieve the contaminant concentration required by the trial matrix. Any time there is no challenge being directed to the SUT, the airstream to the inlet interface will only have clean, conditioned air as outlined in the DTP trial matrix.

NOTE: Sometimes (depending on fixture and on condition) the establishment of environmental conditions and analyte concentration may be in a different order.

f. Once the challenge concentration is achieved, then the inlet airstream will be switched from the clean airstream to the challenge airstream for the required time. When the challenge time is reached, the SUT inlet will be switched back to the clean, conditioned airstream.

g. The trial will continue until the required detection opportunities specified by the DTP or the predetermined trial duration limit is reached.

h. When a change in environmental conditions is required, the sequence for making the changes are:

(1) Stop the water vapor injection system to drop the WVC.

(2) Change the temperature as required.

(3) When the required temperature is achieved, then the water vapor generator can be initiated to achieve the desired WVC.

(4) Sufficient time should be allowed for the SUT to achieve equilibration as described in the DTP.

i. When the challenge concentration level must be changed, it may be necessary to drop the WVC until the new concentration level is achieved and then the WVC can be restored to the required level.

j. Execute the trial matrix outlined in the DTP.

k. A confidence check will be performed on each SUT if required at the end of each day's testing. At the end of each trial day, stop video cameras, and download all data for the trials conducted. Ensure that the SUTs are on clean, conditioned air. Stop all temperature conditioning and water vapor and contaminant challenge dissemination.

l. Whenever the SUT fails to function properly (e.g., fails to clear down after a detection opportunity), all pertinent information will be recorded. In consultation with the customer and program T&E WIPT, repair the SUT per the new equipment training and technical manual.

m. During execution, monitor the fixture for invalid readings. Monitor the fixture data for increasing uncertainty or bias. In a multi-port fixture, monitor for different flows or concentrations in different ports. Identify changing readings such as pressure, flow rate, or temperature that may indicate an emerging safety issue.

n. Monitor for recurring issues with the SUTs, such as a SUT that repeatedly does not detect at a concentration at which other SUTs detect.

4.2.3 Final Retrograde.

Upon completion of all testing, SUTs will be decontaminated, if required, IAW site specific regulations and procedures and the SUT technical manual. The test fixture will also be retrograded as required.

5. DATA REQUIRED.

The types of data collected should be well defined before testing starts and outlined in the DTP. The types and frequency of data that will be collected, and the data format for presentation, should be agreed upon by the evaluators and testers. All referee data must be date and time stamped. Examples of data for consideration are included below.

5.1 Receipt Inspection Data.

a. A photographic and text record [e.g., a test incident report (TIR)] of all inspected SUT equipment and accessories. The test item identification number assigned to any item and the name of the manufacturer.

b. Any test material deterioration or damage.

c. Record of repaired or replaced test material.

d. The operational status of the SUTs.

e. Any additional observations noted during the receipt inspection.

f. Results of SUT function checks.

5.2 Pretest Data.

a. Referee calibration.

b. SUT confidence checks (as required).

c. Calibration equipment verification.

5.3 Performance Test Data.

a. Trial date.

b. Analyte concentration (mg/m^3). This may include the concentration of the vapor and aerosol components of the agent stream, if required.

c. Number of analyte challenge particles, reported in standard particle sizer size bins, in time intervals over the duration of the challenge or as an average over a trial duration. In consultation with the customer and program T&E WIPT, determine the mass median diameter from the particle size distribution.

d. Size of analyte challenge particles, reported as mass median diameter in time intervals over the duration of the challenge or as an average over a trial duration.

e. Calculated operational background material concentration (percentage of total airstream or measured concentration).

f. Airstream temperature (°C).

g. Airstream WVC (g/m^3).

h. SUT chamber temperature (°C).

i. SUT chamber WVC (g/m^3).

j. Time analyte and operational background challenge (if applicable) initiated.

k. Time analyte and operational background challenge (if applicable) ended.

l. SUT response to analyte challenge such as the name and concentration of each analyte detected.

m. Type of alarm (audible, visible).

n. Time of alarm.

o. Time alarm ceases.

p. Calculated time to clear-down.

q. Analyte concentration at time of alarm (as available).

r. Analyte concentration when alarm ends (as available).

s. Log of TIRs issued.

t. Comment column.

u. Test center assessment if the trial met criteria.

5.4 Data Analysis.

a. Data will be recorded, consolidated, and verified throughout testing and at the completion of the test. Level III data (checked by peer and QC review) will be released to the customer and evaluation community.

b. Any additional data analysis will be performed IAW the DTP.

c. Data will be archived for future use.

d. A Data Authentication Group (DAG) will review all test data and TIRs for evaluation purposes. One of the main goals of the DAG is to determine if the test data meet the DQOs established in the DTP.

6. PRESENTATION OF DATA.

a. All receipt inspection data must be reported. Results will be summarized and presented in tabular form, including surface cleaning or maintenance performed, and emphasizing deviations from manufacturer specifications.

b. Data pertaining to SUT function checks will be reported in a form that will allow pretest and posttest functional performance data to be compared.

c. A graph showing temperature and WVC over time for each trial will be presented with alarms noted. Each graph will show the upper and lower control limit for temperature and WVC.

d. A graph showing the analyte concentration over time for each trial with the upper and lower control limits. The alarms for that trial will be noted on the graph.

e. A graph showing the particle mass median diameter over time for each trial with the upper and lower control limits. The alarms for that trial will be noted on the graph.

f. A graph showing the particle size distribution over time for each trial.

g. A table for each trial will list each controlled parameter (temperature, WVC, and analyte concentration) and whether or not the parameter was maintained in control based on the tolerance limits.

h. A table for each trial will present the time to alarm, analyte concentration during the alarm, and clear down time (if required).

i. All calculated data will be clearly indicated as such to differentiate them from directly measured data.

j. Comments/observations made during test conduct will be reported, if applicable.

k. Any additional desired information will be determined by the customer and specified in the DTP.

l. TIRs will be part of the final test report package.

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APPENDIX A. GLOSSARY.

Term	Definition
Analyte	A substance or chemical constituent that is undergoing analysis.
Calibration	A comparison between measurements, one of which is a measurement standard of known accuracy, to detect, correlate, adjust, and report any variation in the accuracy of the item(s).
Chamber	A natural or artificial enclosed space or cavity.
Confidence check	A means to check the system under test (SUT) to ensure correct functionality and performance during operation through the use of a simulant.
Data quality objectives (DQOs)	A systematic, scientific method to establish data quality criteria and performance specifications for decision making.
Distribution manifold (DM)	A piece of equipment that is used to equally distribute the airstream containing the trial analyte and background material (if present) to multiple SUTs and referee probes/sample lines.
False alarm	In the event that the referee system indicates no analyte is present and the SUT signals the presence of an analyte.
Time to alarm	The time it takes the SUT to respond when exposed to a constant concentration of an analyte.
Test fixture (apparatus)	A group or combination of instruments, machinery, tools, materials, etc., having a particular function or intended for a specific use.
Time to clear down	The time it takes the SUT to stop alarming once challenge concentration drops below detectable levels (as determined by the referee system).

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APPENDIX B. ABBREVIATIONS.

AD No.	accession number
AR	Army Regulation
ATTN	Attention
°C	degrees Celsius
CDD	capability development document
CWA	chemical warfare agent
DA	Department of the Army
DAG	data authentication group
DAS	data acquisition system
DM	distribution manifold
DOE	Design of Experiments
DQO	data quality objective
DTIC	Defense Technical Information Center
DTP	detailed test plan
IAW	in accordance with
iwg	inch water gauge
L	liter
OEP	Operational Test Agency System Evaluation Plan
OPS	optical particle sizer
PAM	pamphlet
PPE	personal protective equipment
QA	quality assurance
QC	quality control

APPENDIX B. ABBREVIATIONS.

SAR	safety assessment report
SDS	safety data sheet
SEP	systems engineering plan
SOP	standing operating procedure
SUT	system under test
T&E WIPT	Test and Evaluation Working Integrated Product Team
TECMIPT	Test and Evaluation Capabilities and Methodologies Integrated Process Team
TEMP	test and evaluation master plan
TIR	test incident report
TOP	Test Operations Procedure
V&V	verification and validation
WVC	water vapor content

APPENDIX C. REFERENCES.

1. US Army Test and Evaluation Command (ATEC), Aberdeen Proving Ground (APG), Maryland, Test Operating Procedure (TOP) 08-2-188 Change Notice 1, *Chemical Point Detector Vapor Testing*, 10 May 2019.

2. US Army Test and Evaluation Command (ATEC), Aberdeen Proving Ground (APG), Maryland, Test Operating Procedure (TOP) 08-2-196A, *Simulant Selection for Laboratory, Chamber, and Field Testing*, 25 January 2022.

3. Headquarters, Department of the Army (DA), Washington, DC, Army Regulation (AR) 385-10, *The Army Safety Program*, 24 February 2017.

4. Headquarters, Department of the Army (DA), Washington, DC, DA Pamphlet (PAM) 385-61, *Toxic Chemical Agent Safety Standards*, 1 November 2018.

5. Headquarters, Department of the Army (DA), Washington, DC, DA Pamphlet (PAM) 385-30, *Risk Management*, 2 December 2014.

6. US Army Test and Evaluation Command (ATEC), Aberdeen Proving Ground (APG), Maryland, Test Operating Procedure (TOP) 08-2-500A, *Receipt and Inspection of Chemical-Biological (CB) Materiel*, 5 September 2017.

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APPENDIX D. APPROVAL AUTHORITY.

CSTE-CI (73-1jj) 11 October 2022

MEMORANDUM FOR

Commander, U.S. Army White Sands Missile Range
Executive Director, U.S. Army Evaluation Center
Commander, U.S. Army Operational Test Command
Commander, U.S. Army Yuma Proving Ground
Commander, U.S. Army Dugway Proving Ground
Commanders, U.S. ATEC Test Centers
Director, U.S. ATEC Tropic Regions Test Center
Director, U.S. ATEC West Desert Test Center

SUBJECT: Test Operations Procedure 08-2-201A Collective Protection Novel Closures Testing

1. Test Operations Procedure (TOP) 08-2-201A Collective Protection (ColPro) Novel Closures 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 presents standard test methods for vapor challenge testing of candidate novel closures, openings, and seams intended for use in collective protection shelters. Testing and/or characterization will be performed using simulant vapor to measure the protective capability of the candidate novel closure. The procedures in this TOP are designed to determine the amount of chemical analyte that permeates or penetrates the candidate seam and/or closure.

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@army.mil.

ZWIEBEL.MICHAEL.J.1229197289 Digitally signed by ZWIEBEL.MICHAEL.J.1229197289 Date: 2022.10.18 17:20:49 -04'00'

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

APPENDIX D. APPROVAL AUTHORITY.

TECMIPT Test Operations Procedure (TTOP)
08-2-054A Chemical Aerosol Point Detector Testing

The Chemical Detection (CD) Capability Area Process Action Team (CAPAT) recommends approval of the TECMIPT Test Operations Procedure (TTOP) 08-2-054A. If a representative non-concurs, a dissenting position paper will be attached.

Organization	Signature	Date
Secretary of the Army (Secretariat) Under Secretary for Test and Evaluation (SAUS-TE)	FRIESE.AMY.JEAN.1127559216 Digitally signed by FRIESE.AMY.JEAN.1127559216 Date: 2022.06.17 08:29:28 -04'00' Amy Friese	
Joint Program Executive Office of Chemical Biological Defense (JPEO-CBD) Test & Evaluation	RYBAK.JOSEPH.1364953735 Digitally signed by RYBAK.JOSEPH.1364953735 Date: 2022.06.02 10:41:58 -04'00' Joseph Rybak	
Joint Requirements Office for Chemical, Biological, Radiological and Nuclear Defense (JRO-CBRND)	BULSON.CHRISTOPHER.D.1236325462 Digitally signed by BULSON.CHRISTOPHER.D.1236325462 Date: 2022.06.05 15:58:05 -04'00' Lt Col Christopher D. Bulson	
Joint Science and Technology Office (JSTO)	ODELL.BRETT.KYLE.1274940553 Digitally signed by ODELL.BRETT.KYLE.1274940553 Date: 2022.06.08 13:21:07 -04'00' Brett Odell	8 June 22
US Army Evaluation Center (AEC)	HUGHES.JULIANE.OLSEN.1285055837 Digitally signed by HUGHES.JULIANE.OLSEN.1285055837 Date: 2022.08.30 18:15:03 -04'00' Juliane Hughes	
Operational Test and Evaluation Force (OPTEVFOR)	THIERING.JOSEPH.LEE.1257775557 Digitally signed by THIERING.JOSEPH.LEE.1257775557 Date: 2022.08.17 15:17:19 -04'00' Joseph Thiering	
Air Force Operational Test and Evaluation Center (AFOTEC)	MADRIGAL.KEVIN.M.1015386319 Digitally signed by MADRIGAL.KEVIN.M.1015386319 Date: 2022.06.16 16:45:54 -06'00' Col Kevin M. Madrigal	
Marine Corps Operational Test & Evaluation Activity (MCOTEA)	WADLEY.MICHAEL.CRAIG.1130810841 Digitally signed by WADLEY.MICHAEL.CRAIG.1130810841 Date: 2022.06.14 14:40:14 -04'00' Michael Wadley	
Chemical Detection CAPAT Co-Chair	ALTENBAUGH.RYAN.EDWARD.1275434538 Digitally signed by ALTENBAUGH.RYAN.EDWARD.1275434538 Date: 2022.06.16 13:19:06 -04'00' Ryan Altenbaugh	
Chemical Detection CAPAT Co-Chair	CURTISS.JUSTIN.MICHAEL.1407399630 Digitally signed by CURTISS.JUSTIN.MICHAEL.1407399630 Date: 2022.06.03 12:31:44 -04'00' Justin Curtiss	

Forward comments, recommended changes, or any pertinent data, which may be of use in improving this publication to the 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-CO, 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.