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14. ABSTRACT
This TOP provides guidance for preparing test plans and conducting test programs to evaluate the effectiveness and suitability for military use of water supply and treatment equipment.

15. SUBJECT TERMS

Coagulation	Filtration	Total Dissolved Solids	Water Quality
Conductivity	Potable water	Turbidity	Water Treatment/Purification
Disinfection	Reverse Osmosis	Wastewater	

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US ARMY DEVELOPMENTAL TEST COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 9-2-270 15 September 2009
DTIC AD No.: ADA505580

WATER SUPPLY AND TREATMENT EQUIPMENT

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1. SCOPE.

The procedures in this Test Operations Procedure (TOP) describe the test methodology and techniques to determine the technical performance and safety and human factors characteristics of water supply and treatment equipment with their associated extended modules and accessories.

All tests specified herein are not applicable to all test items. For example, U.S. Marine Corps (USMC) equipment is subjected to a salt fog environment when transported by ocean-going vessels and when deployed at seawater access/beach locations. Therefore, USMC typically requires a salt fog chamber test to assess the corrosion, electrical, and physical effects of an aqueous salt atmosphere on the test item. The test planner should be selective and include only those tests needed to satisfy the requirements for the specific item scheduled for test. Data from previous and similar tests and data obtained by concurrent testing will be considered to avoid duplication of effort and reduce the scope of testing.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

ITEM	REQUIREMENT
Material-handling equipment (MHE)	Offload and load test item from transportation asset.
Maintenance shop	Accomplish Technical Manual (TM) receipt inspection, servicing, inventories, scheduled and unscheduled maintenance, and chamber test preparation.
Water access test site(s)	Accomplish training and testing.
Climatic chambers	Satisfy the needs of MIL-STD-810[1**].
Sand and Dust Facility	Satisfy the needs of MIL-STD-810 or a suitable field testing environment.
Rain Test Facility	Satisfy the needs of MIL-STD-810 or a suitable field testing environment.
Automotive road courses	Accomplish road transport durability and reliability road missions.

** Superscript numbers correspond to Appendix E, References.

ITEM	REQUIREMENT
Reinforced concrete pad	Drop test surface.
Gantry-type crane of suitable load capacity	Means to lift the system/modules for drop testing.
Quick-release crane hook	Mechanism for release of item for drop testing.
Electromagnetic Interference Test Facility (EMITF)	Satisfy the needs of MIL-STD-461[2].
High-Altitude Electromagnetic Pulse (HEMP) Test Facility	Satisfy the needs of MIL-STD-461.
Rail Impact Test Facility	Satisfy the needs of MIL-STD-810.
Cargo helicopter and approved flight path	Satisfy the needs of MIL-STD-913[3].
Certified water quality analysis laboratory	Satisfy the water sampling and analysis needs of Technical Bulletin (Medical) (TB MED) 577[4].
Noise Test Facility	Satisfy the needs of TOP 1-2-610[5].

2.2 Instrumentation.

DEVICE FOR MEASURING	MEASUREMENT ACCURACY
Weight	±1% of reading
Physical dimensions, height (drop tests)	±1 cm (±0.4 in.)
Tire pressure	±7 kPa (±1 psig)
Ambient or chamber temperature	±2 °C (±3.6 °F)
Relative humidity (RH)	±1% reading
Wind speed	±1 kt
Distance (road)	±0.1 km (±0.1 mi)
Road and rail impact speed	±0.1 km/hr (±0.1 mph)
Conductivity/total dissolved solids (TDS)	±1% reading
Potential of hydrogen (pH)	±1% reading
Turbidity	±2% reading
Surface temperature	$\pm 2^{o}$
Chlorine	±2% reading
Water flow	±2% reading
Water volume (totalizer)	±2% reading

3. REQUIRED TEST CONDITIONS.

3.1 Planning.

a. Safety. Review the Safety Assessment Report (SAR) and all instructional material issued with the test item by the developer and manufacturer as well as test reports of previous tests conducted on the test item or similar equipment

b. Requirements. Review the test item's capabilities documents (e.g., Initial Capabilities Document (ICD), Capabilities Development Document (CDD), or Capabilities Production Document (CPD)) or Performance Specification (PS) documents. For acquisition evaluated programs, the System Evaluation Plan (SEP) is the governing document. The SEP will document the methodology and data requirements. For non-acquisition projects, the customer test requirements will be followed based on information supplied in the Request for Test Services (RFTS), contract documents, and direct communication with the customer. Refer to DTC Pam 73-1[6], Chapter 4, for additional test planning information.

c. Water Sources.

(1) Natural. The challenge with water purification/treatment system testing is to employ appropriate natural source waters to assess the operation and performance criteria. Reliability testing typically requires fresh water, brackish water, and seawater sources. Since the operating pressures for brackish waters fall between fresh water and seawater, testing to the two extremes is generally acceptable. A large source (ocean/bay) or free-flowing river site is optimum to provide adequate separation of the feed and waste (brine) waters. In some cases, the test team will be required to travel to another government or commercial facility to accomplish testing on a required natural source. Advance coordination is necessary with the host safety, environmental, and security offices to ensure all local regulations are met and required permits or approvals are obtained. The chlorine injection systems of the test items cannot be employed when returning the waste or product waters to the source. Chlorinated water must be diverted to a waste water stream (water treatment facility) and allowed sufficient time to dissipate, or be dechlorinated with sodium bisulfate. In order to test the operability of the chlorine injection pump, product water can be substituted.

(2) Water Withdraw Permit. Many states require a Water Appropriation and Use Permit at the natural water sources. The State of Maryland permit issued to the U.S. Army Aberdeen Test Center (ATC) identifies specific withdraw points on the facility, limits daily and monthly allocations, imposes limits during drought periods, limits the water flow intake (25.2 gpm), requires a screen/mesh of 1 mm on the intake pipe, and requires monthly withdraw reports (record of total quantity of water pumped). If the test system intake device does not satisfy the required screen size, a steel cage, wrapped in firing range target cloth, will be positioned in the water and the intake hoses routed into the cage.

(3) Operational Check Test. Operational check tests are conducted at an extreme condition (typically 45,000 or 60,000 TDS) to challenge the system. Since natural source waters are not available at these conditions, either all or a portion of the brine must be recirculated when operating on a seawater source. When a seawater source is not available or the required concentration cannot be achieved, American Standard Test Method (ASTM) D1141[7] ocean water substitute can be batched. A sufficient quantity of batch water is required to ensure that the water temperature does not exceed the maximum feed water temperature of the system (typically 35 ^{o}C (95 ^{o}F)) and damage the filtration media. Employment of a chiller should be considered to maintain lower water temperatures for the large systems that impart a lot of energy to the water. The batch water can be retained for a period of time, but chlorine must be added occasionally during storage periods to prevent excessive biological growth. The test team must ensure that

the chlorine has dissipated or is chemically treated prior to use since chlorinated water may damage the filtration media. When operating in a closed loop system, chemical injection of antiscalant for the reverse osmosis (RO) subsystem must be disabled, modified (reduced concentration), or batched in the water tank so as not to exceed recommended dosage limits.

(4) Waste Water. Filtration media cleaning and preservation procedures may generate a waste stream that requires collection and disposal at a water treatment facility. Advanced coordination is required to identify the plan for a means to collect, store and transport the waste water, gain access to the treatment facility, treat the waste water (to gain a specific range of pH), identify the discharge point, and flush the transport container. For example, at Aberdeen Proving Ground (APG), EAP Form 1223-R, Request for Sewer Discharge Guidance, March 1996, is required. The major constituents, concentrations and volumes of the waste are required, including the Material Safety Data Sheets (MSDSs). The Technical and Scientific Report from the manufacturer should address all of the requirements.

d. References. Field Manual (FM) 10-52[8] identifies the military water support requirements and guidance for planning and operations. FM 10-52-1[9] provides guidance for water supply point and equipment operations. TB MED 577 provides technical guidance and recommendations for the sanitary control and surveillance of land-based field water support. It establishes field water quality standards, describes the process for water portability certification and water quality surveillance requirements, and provides guidance on the management of wastes associated with the purification of field water.

e. Water Quality Analysis. On-site testing of the source and test system product waters is accomplished by the instruments listed in Table 1. Certified water analysis to assess TB MED 577 water quality is tasked to the U.S. Army Center for Health Promotion and Preventive Medicine (CHPPM). In addition to the product water from each test system, a representative sample from the source water should be drawn to identify its constituents. ATC and CHPPM have a partnership for testing services through a Memorandum of Agreement, 4 April 1997. The ATC test officer will prepare and submit a test support memorandum to CHPPM. CHPPM will prepare a cost estimate for their services and supply all sampling bottles, preservatives, and coolers for transport.

TABLE 1. TEST SITE WATER ANALYSIS INSTRUMENTS

INSTRUMENT	TEST PARAMETER
Hach 2100P Turbidimeter	Turbidity
Myron L Company Ultrameter II 6P[a]	Conductivity, TDS, pH, oxygen reduction potential (ORP), temperature, resistivity
Hach Pocket Colorimeter, part No. 46770-12	Free and total chlorine, pH

[a]Two meters are available. One should be calibrated and used for testing the low salinity waters (fresh water source and system product water) and the second should be calibrated and used for testing seawater sources and brine waste water.

3.2 Test Scheduling.

To provide an early indication of test item suitability, conduct safety-related tests and inspections first followed by physical characteristic measurements to ensure the system configuration requirements are satisfied. Initiate reliability testing when the data collection database is established, the test crew is competent in accomplishing all operator and field level tasks, the systems have completed all break-in time, and are operating as intended. Per MIL-STD-810G, some environmental tests should be conducted on different test systems to assess the vulnerability against particular environments. For example, humidity testing should not be conducted on the same test item or system that has been subjected to salt fog, sand and dust, or fungus tests.

3.3 Conduct.

a. Scheduled and Unscheduled Maintenance. The test item(s) will be maintained in accordance with the TMs, if available. If maintenance procedures are not available, the crew does not understand the procedure, or the crew has difficulty accessing the equipment, the manufacturer will be contacted for further information or guidance.

b. Test Data. For acquisition evaluated programs, document all test incidents, maintenance actions, hardware or software modifications, and emerging test results in Test Incident Reports (TIRs) in the Automated Data Collection System (ADACS). Non-evaluated programs can choose to employ ADACS or the test officer can submit daily/weekly status reports via e-mail or the Versatile Information Systems Integrated On-Line (VISION) Digital Library System (VDLS).

4. TEST PROCEDURES.

4.1 Initial Inspection and Operation.

4.1.1 Method.

a. Upon arrival, the system will be inspected. All applicable protective materials will be removed. Any damage or deterioration resulting from handling, improper packaging, or inadequate preservation will be recorded. Representative damage will be photographed. The system will be inspected to identify any obvious defects in workmanship or construction. An initial safety inspection will be conducted to identify all potential hazards.

b. All system components, basic issue items (BII), and the test support package (TSP) will be inventoried. The inventory will be compared to the packing list or TM and all shortages will be identified to the manufacturer and system developer for resolution. If more than one system is tested simultaneously, each system component will be marked with a test system identification number for tracking purposes. The major component serial numbers and service life (operating time or distance) will be recorded.

c. The system will be prepared and an initial service to fuel and lubricate the system will be accomplished per the TM or manufacturer instructions. The consumable amounts installed will be documented.

d. The system will be operated as intended (either with assistance from the manufacturer or following operator training) to verify that it is fully functional. All faults will be identified and recorded. Any corrective actions and replacement parts required to repair the system will be documented. A noise survey will be conducted to identify any operator or maintainer positions where 85 dB(A) is exceeded. The test site will be marked for the noise contour and the test crew will be equipped with the appropriate hearing protection. This noise survey may not constitute the official noise contour test (paragraph 4.5.1a) if the test site is not configured per the test procedure (on gravel pad, multiple systems operating, or reflective surfaces prevalent). The survey will serve to protect test personnel and visitors at the test and training site.

4.1.2 Data Required.

a. Record of receipt condition of the test system.

b. Photographs of any damage or deformation attributed to transport.

c. Test system, BII, or TSP inventory shortages.

d. Manufacturer, model, serial number, and service life of all major components.

e. Results of the safety inspection and noise survey.

f. Results of break-in or initial operation check.

4.1.3 Data Presentation.

Summarize the receipt condition and initial operation results in a paragraph or summary tables supported by photographs. List inventory shortages and document if the shortages were reconciled prior to initiating test. Summarize the results of the safety inspection in paragraph 4.4, Safety, the noise survey in paragraph 4.5, Human Factors Engineering (HFE), and document any modifications that corrected potential hazards or reduced the noise level during test conduct.

4.2 Operator and Maintainer Training.

4.2.1 Method.

a. Coordinate with the manufacturer or representative responsible for training to determine the training schedule, environments (classroom or field), and durations. Schedule the facilities and personnel as required. Trainers will instruct the test team in the capabilities, assembly, operating and maintenance procedures, disassembly, and storage of the system.

b. Request all test crew members complete a Test Participant Demographic Data Form (see Appendix A, Form A-1) to document their current position/rank, experience, and previous training.

c. Provide an overview of the test requirements, administration and site security procedures, and test schedule with the crew, support personnel, and manufacturer technical representatives. Provide a copy of the risk assessment and job hazard analyses (JHAs) for reading and signature and post a copy at the test site. Provide a copy of all applicable MSDSs and post at the test site. Review the general test facility hazards and safety precautions.

d. Record the adequacy and completeness of the TMs and/or other instructional materials used for training purposes. Test personnel will complete a new equipment training (NET) questionnaire (Appendix A, Form A-2) at the conclusion of the training class. All hardware or software incidents that are experienced, maintenance accomplished and replacement parts required to repair the system during the training will be documented.

4.2.2 Data Required.

a. Test Participant Demographic Data Forms.

b. NET questionnaires.

c. Incident documentation (TIR or status report as described in paragraph 3.3b).

d. TM or training instruction inadequacies and comments.

4.2.3 Data Presentation.

Summarize the results of the demographic data forms and NET questionnaires in tables and assign each respondent a numerical code. Summarize the TM or training inadequacies in a table.

4.3 Physical Characteristics.

Measure the physical characteristics of the test item as listed in TOPs 1-2-504[10], 2-2-800[11] and 2-2-801[12]. These measurements should be accomplished in each system stowage and transport configuration (e.g., truck, trailer, container, etc.).

4.4 Safety. TOP 1-1-060[13] provides general guidance for system safety analysis.

4.4.1 Method.

a. SAR Review. The SAR will be reviewed to identify all developer- or contractor-identified safety and health hazards. When the TMs are received and the operator/maintainer test team training is conducted, verification that the hazards and means of mitigation identified in the SAR will be addressed.

b. Inspection and Operation. A system-specific hazards checklist derived from TOP 10-2-508[14] will be developed and used during the safety inspection. Representative surface temperatures will be measured with a contact or infrared temperature measurement device to identify if any thermal contact hazards exist. Temperature results will be compared to the temperature exposure limits in MIL-STD-1472F[15], Table XXI. Moving and rotating parts will be checked for the presence of guards. Warning placards will be checked for appropriate location, security, content, format, and readability. All safety-related incidents or concerns will be reported, and physical configuration safety hazards will be photographed.

c. Safety Devices and Equipment. Safety and warning devices supplied on the system will be identified including type, location and rating/certification. The adequacy and functionality of the devices will be verified, to the maximum extent possible, without causing harm to the item. For example, pressure relief valves will be inspected to determine if they discharge down and away from personnel occupied areas. The type, size, storage location, and means of positive securement of the fire extinguisher(s) will be recorded.

d. Hazardous Materials (if applicable). The system hazardous materials and their intended use will be identified. The labeling and packaging of the chemicals provided in the BII or TSP will be inspected for clarity and understanding. The MSDS of each chemical will be reviewed to identify the personal protective equipment (PPE) specified for handling. The PPE in the BII will be checked for usability and provision of a sufficient range of sizes (5th to 95th percentile) and quantities available to support the test. The PPE will be employed by the test team during all required hazardous material-handling operations. Any instances of difficulty in donning, use, or doffing the PPE will be recorded. The resultant pH of all cleaning and preservative waste solutions will be measured and recorded. The quantity and type of chemical added to the waste solutions to gain the water treatment plant pH range of acceptance will be recorded.

e. Noise. Noise testing is addressed in paragraph 4.5.

4.4.2 Data Required.

a. SAR.

b. Inspection and Operation.

(1) Safety hazards checklist.

(2) Safety- or health-related test incidents or concerns.

(3) Findings related to the adequacy of safety instructions in the TMs.

(4) Results of the physical inspection of the system verifying the provision of warning or caution placards as listed in the SAR and/or TM.

(5) Photographs of safety-related physical configuration concerns.

c. Safety Devices and Equipment.

(1) Identification of safety and warning devices (type and purpose of device).

(2) Method and results of safety/warning device tests (suitability, adequacy, proper operation and malfunctions).

(3) Recommendations for additional or improved safety or warning devices.

d. Hazardous Materials (if applicable).

(1) Identification of hazardous materials and their intended use/function.

(2) Manual verification results regarding the use, handling, disposal, and storage of the hazardous materials supplied.

(3) Results of PPE form, fit, and function assessment.

(4) Results of chemical labeling and packaging inspections.

(5) Waste solution identification and resultant pH.

(6) Type and quantities of chemical employed to adjust the waste solution to the acceptable water treatment pH range of acceptance.

4.4.3 Data Presentation.

The potential safety hazards identified through inspection, operation, and maintenance will be summarized in a table. If the system is being evaluated, the hazards will be classified for hazard probability and severity in accordance with Department of Army Pamphlet (DA Pam) 385-16[16]. Recommendations to mitigate the hazard(s) will be made. Results of the safety device and equipment inspections and tests will be summarized in paragraph or tabular form. The hazardous materials employed during the test and waste solution pH measurements will be summarized in tables. Results of the chemical labeling inspections, form/fit/function of the PPE, and TM hazardous material procedure verification will be summarized in paragraphs. Recommendations to improve the safety devices, warning/caution placards, and TM procedures will be made.

4.5 Human Factors Engineering (HFE).

4.5.1 Method.

a. Sound Level Measurements, as listed in TOP 1-2-610, paragraph 5.2, noise measurement. With the system assembled per the TM, measure the 85-dB(A) contour(s) and peak noise levels at all operator and maintainer personnel occupied areas. At a minimum, the system should be operated at its highest pressure to capture the most significant noise signature.

If time permits, testing at a variety of settings (water sources) should be accomplished. Consideration must also be given to capturing the noise generated from intermittent noise sources (e.g., air compressors, pneumatic valves, etc.).

b. Workspace and Anthropometrics, as listed in TOP 1-2-610, paragraph 5.6. Anthropometric and static strength data will be measured and recorded for each test crew member (operators and maintainers). The required number of test personnel will be used to assemble and operate the system. Any difficulties experienced in accomplishing the required tasks or accessing specific controls or equipment for operation or maintenance will be recorded.

c. Set-up and Tear-down Requirements. After the operators are thoroughly familiar with system operations, time trials will be performed to verify PS requirements. Set-up time (unless specified differently in the specification) will begin when the system, in its transport configuration, is positioned on the test site. The crew will set up the system and begin operation. The set-up time will end when the system is in the operational configuration, the product water has entered the water storage tank, and all subsystems are fully functional and effective. The tear-down time will begin once the operator is notified to prepare the system for movement. The system (if applicable) will undergo a product water flush prior to teardown, and the water in the product water storage/distribution tank(s) will be discharged prior to the initiation of the tear-down time sequence. The tear-down time will end when the system is in the stowed configuration and prepared for transport (or loading for transport). Time trials for add-on kits will be performed if the hardware and procedures are available. Time trials for military crews will be accomplished with cold-wet, mission-oriented protective posture (MOPP) and/or battle gear, if required in the SEP or in the test scope for Rapid Acquisition Initiatives. Time trials will be performed a minimum of three times for each system configuration and add-on kit.

d. HFE Design. Control types will be identified. Control separation and dimensions will be measured and recorded. If applicable or of concern, force/torque measurements will be accomplished per TOP 1-2-610, paragraph 5.7. Crew members will don cold-wet gloves and MOPP IV gloves and accomplish representative operator level tasks to determine if the control design and layout is conducive to efficient operations in all mission environments. For manually handled equipment or modules, the number, type, and location of the handles will be recorded, and the physical size will be measured. The weight balance of the equipment/modules will be assessed quantitatively by measuring the center of gravity (CG) of each (paragraph 4.2) and qualitatively by including questions in the HFE questionnaires and crew interviews. System-specific HFE questionnaires will be developed and administered to all test personnel to rate the adequacy, ease of performance, intensity, and maintainability of the system.

4.5.2 Data Required.

a. Sound Level.

(1) System identification and configuration.

(2) List of calibrated instrumentation (nomenclature, model, serial number, manufacturer, date, and calibration date).

(3) Date, location, air temperature, RH, wind speed, and background noise level.

(4) Steady-state noise contour(s), 85 dB(A).

(5) Noise levels at operator and maintainer positions.

b. Workspace and Anthropometrics.

(1) Anthropometric and static strength data.

(2) Identification of workspace concerns, supported by photographs or measurements.

c. Set-up and Tear-down Requirements.

(1) System identification and configuration or add-on kit.

(2) Time trial results.

d. HFE Design.

(1) Controls and display identification.

(2) Measurements of control dimensions and separation.

(3) Operator comments regarding the ease/difficulty in performing system tasks with cold-wet or MOPP gloves.

(4) Number, type, location, and size of handles (manually handled components or modules).

(5) HFE questionnaires.

4.5.3 Data Presentation.

Steady-state noise data will be summarized in tables and compared to the limits for personnel occupied areas in MIL-STD-1474D[17], Tables 1 and 2, and the system PS. The noise contour(s) will be illustrated graphically over a top view of the system configuration. Anthropometric and static strength data will be compared to standard percentile charts, and a percentile rating will be assigned for each measurement. The set-up and tear-down times will be presented in tables and the data averaged for each system configuration or add-on kit. The averaged data will be compared to the PS requirements. Control and display data measurements and the lifting handles of manually handled components will be compared to recommended and preferred values for design criteria in MIL-STD-1472F. HFE questionnaire results will be tabulated and presented in tables. Any crew member comments will be summarized in paragraphs or tables.

4.6 Operational Check Test.

The objective of the operational check test is to determine the functionality of the system at its highest rated feed water TDS following a challenging environment or test sequence. Operating the system at its rated feed water TDS causes the system to operate at its highest rated pressure and most challenging feed water quality to verify the system meets the required product flow and water quality parameters.

4.6.1 Method.

Prepare a batch of ASTM D1141 ocean water substitute and dechlorinated tap water at the concentration listed in the PS (typically 45,000 or 60,000 TDS) for the check test. Assemble the system per the TM using the batched ocean water solution as the source and route both the product and brine water hoses to the batch tank to develop a closed loop system. In some cases, system filtration backwashes will be discontinued for the check test. The filtration system will not be harmed by the lack of backwashes since the source water has very low turbidity. Additionally, the chemical injection pumps will be disabled or injection rates (antiscalant) modified to prevent a chemical buildup in the source tank. Operate the system per the TM for a minimum of 2-hr. Inspect the system for the presence of leaks. Monitor the feed water temperature and shut down the system if it exceeds the maximum operating temperature listed in the system TM (usually 35 °C (95 °F)). Monitor the system filtration and RO pressures, product water flow, and other operating parameters applicable to the system and log the operating data (See Appendix A, Form A-3) a minimum of every 30 minutes. Sample the source and product water and test the product water quality (TDS or conductivity). If the product water quality exceeds the TB MED 577 criterion of 1000 mg/L TDS, accomplish an RO element check test to identify the degraded or damaged element(s). The degraded/damaged element(s) will be replaced and the test repeated until the product water quality is acceptable.

Alternative: If a natural seawater source is available, partial or total recirculation of the brine might achieve the required salt solution concentration.

4.6.2 Data Required.

a. System identification and test configuration.

b. System operating time (hours).

c. Source water temperature.

d. Filtration input, output, and/or differential pressure.

e. RO input, output, and/or differential pressures.

f. Product water flow rate and product totalizer volume.

g. Generator (if applicable) load (kW) and operating time (hours).

h. Source and product water quality (Form A-4).

i. RO Element Check Test Data, Form A-5 (if product water quality exceeded).

j. Results of physical inspection and record of any repair or maintenance accomplished to restore the system to a fully functional state recorded in TIRs.

4.6.3 Data Presentation.

The system operating and source water data will be presented in a table. The filtration and RO differential pressures will be calculated if differential gauges are not equipped on the subsystems. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables.

4.7 Reliability and Durability.

4.7.1 Method.

a. The reliability test is conducted in accordance with the Operational Mode Summary/Mission Profile (OMS/MP) and within the capabilities of the test center. Typically, water treatment equipment is operated on a 24-hr basis, requiring the scheduling of multiple shifts. The system nonoperating parameters must also be considered. If the system requires a chemical preservation or fresh water flush when it is shut down for more than a certain period of time, the test schedule should be maximized to reduce the number of preservations to reduce chemical costs and the volume of chemical solution waste. Systems are set up, assembled, operated per the TM, torn down, loaded onto a vehicle or trailer, driven a specific distance or time period (per the OMS/MP), and the procedure is repeated for the required number of hours identified in the PS or SEP. All test incidents are documented in TIRs. The TIR system operating parameters typically include system operating hours, total product water, number of setups and teardowns, vehicle miles, and trailer miles (when applicable).

b. As detailed in the PS, the reliability test is conducted on multiple natural source waters. The Army profile is typically 75-percent fresh water and 25-percent seawater and the USMC is the opposite based on their missions. In previous joint development water treatment programs, the percentages have been 50-50. U.S. Army Developmental Test Command (DTC) test centers are generally not equipped with both natural water sources and travel is required to support one test phase (as previously discussed in para 3.1c).

c. System operating data (para 4.6.2a through h) are recorded on an hourly basis. RO element checks are conducted upon initiation and conclusion of each test phase and when water quality rises above the TB MED 577 requirements. When the system operation exceeds TB MED 577 water quality or TM operating ranges, the system will undergo a chemical cleaning and/or troubleshooting per the TM and/or assistance from manufacturer service representatives or its engineering staff. All incidents will be documented in TIRs.

4.7.2 Data Required.

a. As listed in TOP 1-1-030[18] (TIRs).

b. As listed in paragraphs 4.6.2a through h.

4.7.3 Data Presentation.

a. As listed in TOP 1-1-030.

b. As listed in paragraph 4.6.3. The system operating and water quality data will be normalized (app B) and presented in tables and graphs.

4.8 Integrated Logistic Support (ILS).

ILS refers to the materiel and services required to enable the operating forces to operate, maintain, and repair the end item within the maintenance concept defined. For test programs, ILS encompasses test personnel training, repair parts, support equipment, technical publications, and contractor engineering and technical services. The criteria assessed include maintainability, self-sustained operation, fuel and power interfaces, military lubricants, water storage and supply equipment interfaces, procedures and tools, operation time meter, and monitoring instrumentation.

4.8.1 Method.

a. As listed in TOP 1-1-030.

b. The quantities of the consumables and lubricants used during the reliability test phase will be recorded on servicing forms. The power generating equipment used to power the system (if applicable) will be identified. A power analyzer will be employed in-line between the system and generator to determine the electrical energy required to operate the system. The operation time meter(s) will be checked for accuracy with a calibrated stop watch during representative test missions. The water quality instrumentation will be checked with calibrated test instruments. Interface inspections and operational missions will be conducted with all standard water storage and supply equipment listed in the specification.

4.8.2 Data Required.

a. As listed in TOP 1-1-030.

b. Electrical energy for each test system and water source.

c. Results of water storage and supply equipment interface trials.

d. Results of operation time meter time trials.

e. Results of water quality monitoring comparison tests.

4.8.3 Data Presentation.

a. As listed in TOP 1-1-030.

b. The results of the electrical energy, equipment interface, operation time meter and water quality tests will be summarized in tables and/or paragraphs.

4.9 Environmental Effects.

Environmental testing encompasses several different areas, including simulated climatic chamber tests, natural environments, and shock and vibration. For the purpose of this document, shock and vibration tests are addressed in paragraph 4.10.

MIL-STD-810G is the primary reference for the test methods. The water sources employed for the majority of these tests are temporary, and the quality and temperature of the source must be monitored so as not to degrade the operation of the test system or equipment. It is recommended that a batched seawater source in the range of 20,000- to 45,000-ppm TDS be employed for the chamber tests.

4.9.1 Low Temperature.

Testing of water systems and equipment in temperatures below freezing creates some interesting challenges. Proper drainage of all test system pumps, hoses, hardware, and tanks is critical prior to exposure to low temperature environments. If employing a climatic chamber, the source water must be stored external to the chamber and either employed with system hoses directed through available openings in the chamber walls or relocated to the chamber's interior prior to system operation. Source water temperatures ranging from 2 to 4 ^{o}C (35 to 40 ^{o}F) are desired for the test to simulate a natural water source. The physical space available in the climatic chamber may limit the quantity of hardware items that can be tested. For example, installing short or single sections of hose between pumps and subsystems is encouraged. In order to properly drain the system brine/waste water to the source tank, it may be necessary to assemble the system on a raised platform or trailer. Have the test team practice deploying the system and cold weather kit (CWK) in the chamber prior to initiating the chamber test.

4.9.1.1 Method.

a. A pretest functional or operational check test will be conducted to baseline the system. All nonfunctional components or subsystems should be repaired or documented. Inspect all components to verify that they are equipped with drain valves and that the valves are positioned as low as possible to facilitate proper drainage.

b. The test system will be prepared for low temperature testing in accordance with the TM. The system will be positioned in the climatic chamber in the stored configuration. Thermocouples will be prepositioned in the chamber at the water source, hose blanket, and pump locations. If a generator or auxiliary heater is included in the system, transducers to measure battery voltage and starter current will be installed. The use of weighted hangers is encouraged for the water tank(s). Storage testing will be accomplished in accordance with MIL-STD-810G, Test Method 502.5, Procedure I for a minimum of 24 hr after temperature stabilization. The chamber temperature will be increased to the required low operating temperature and all of the components and subsystems will be visually inspected.

c. When the system has stabilized at the low operating temperature, MIL-STD-810G, Procedure III, manipulation will be accomplished. The test system will be assembled and the CWK (if applicable) will be deployed per the TM. Attempt to position the water tanks or system drain hoses adjacent to the chamber floor drains as much as possible. The water tank thermocouples will be positioned within the center of each tank and the pump volute thermocouples will be attached. The water source will be directed into the system or test support tanks, or the inlet and discharge hoses will be directed to the water storage tank(s) external to the test chamber.

d. MIL-STD-810G, Procedure II, operation, will be conducted. The CWK will be activated per the TM instructions and the proper warmup time will be allocated. The system will be operated per the TM. Any difficulties experienced by the test crew in manipulating or engaging the system hardware or controls with the bulky cold weather gloves will be documented. The test team will follow the flow of water through the system to ensure that all components and subsystems are fully functional and no significant water leaks are experienced. If not specified in the PS, the system will be operated for a minimum of 4 hr. System operating data will be recorded at least hourly. Water quality samples will be drawn and analyzed. Following the completion of the operational test, the system will be deactivated and drained per the TM. The chamber temperature will be increased to standard ambient. All system components and hardware will be visually inspected to determine if any low temperature degradation or damage was experienced.

4.9.1.2 Data Required.

a. Test system identification.

b. Record of pretest functional test results.

c. Record of low temperature preparation or servicing accomplished.
d. Record of post-test low temperature storage visual inspection.

e. Generator battery voltage and starter current time histories.

f. Record of cold start procedures accomplished and results.

g. Chamber, source water and system temperature time histories.

h. Test system operating and water sample quality data (Forms A-3 and A-4).

i. Record of any malfunctions, deformation or leakage during system and cold weather module (CWM) operation (TIRs).

j. Comments regarding the employment of cold weather waterproof gloves.

4.9.1.3 Data Presentation.

System operating and source water data will be presented in a table. Water quality data will be compared to the TB MED 577 requirements to determine conformance. Generator starting data and temperature time histories will be presented in graphs. The inspection and operating results documented in TIRs will be summarized in paragraphs or tables.

4.9.2 High Temperature.

Testing of water systems and equipment in high temperatures creates some interesting challenges. Source water temperatures must remain below 35 ^{o}C (95 ^{o}F) during test conduct to prevent damage to the RO membranes. If employing a climatic chamber, the source water should be stored external to the chamber and either employed with system hoses directed through available openings in the chamber walls or relocated to the chamber's interior and routed through a heat exchanger. The physical space available in the climatic chamber may limit the quantity of hardware items that can be tested. For example, installing short or single sections of hose between pumps and subsystems is encouraged. In order to properly drain the system brine/waste water to the source tank, it may be necessary to assemble the system on a raised platform or trailer. Storage of chlorine or other chemicals in high storage temperatures may cause spontaneous combustion. Review the MSDS for each system chemical to verify suitability.

4.9.2.1 Method.

a. A pretest functional or operational check test will be conducted to baseline the system. All nonfunctional components or subsystems should be repaired or documented.

b. The test system will be prepared for high temperature testing in accordance with the TM. The system will be positioned in the climatic chamber in the operational configuration. Attempt to position the water tanks or system drain hoses adjacent to the chamber floor drains as much as possible. Thermocouples will be positioned at the water source locations. The use of weighted hangers is encouraged for the water tank(s). Storage testing will be accomplished in accordance with MIL-STD-810G, Test Method 501.5, Procedure I for a minimum of 24 hr after temperature stabilization. All of the components and subsystems will be visually inspected. The chamber temperature will be decreased to the required high operating temperature and permitted to stabilize.

c. When the system has stabilized at the high operating temperature, MIL-STD-810G, Procedure II, operation will be accomplished. The water source will be directed into the system or test support tanks, or the inlet and discharge hoses will be directed to the water storage tank(s) external to the test chamber. The system will be operated per the TM. Any difficulties experienced by the test crew in manipulating or engaging the system hardware or controls will be documented. The test team will follow the flow of water through the system to ensure that all components and subsystems are fully functional and no significant water leaks are experienced. If not specified in the PS, the system will be operated for a minimum of 4 hr. System operating data will be recorded at least hourly. Water quality samples will be drawn and analyzed. Following the completion of the operational test, the system will be deactivated and drained per the TM. The chamber temperature will be decreased to standard ambient. All system components and hardware will be visually inspected to determine if any high temperature degradation or damage was experienced.

4.9.2.2 Data Required.

a. Test system identification.

b. Record of pretest functional test results.

c. Record of high temperature preparation or servicing accomplished.

d. Record of post-test high temperature storage visual inspection.

e. Chamber, source water, and system temperature time histories.

f. Test system operating and water sample quality data (Forms A-3 and A-4).

g. Record of any malfunctions, deformation, or leakage during system operation (TIRs).

4.9.2.3 Data Presentation.

System operating and source water data will be presented in a table. Water quality data will be compared to the TB MED 577 requirements to determine conformance. Temperature time histories will be presented in graphs. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables.

4.9.3 Humidity.

Source water temperatures must remain below 35 °C (95 °F) during test conduct to prevent damage to the RO membranes. Due to the extended storage requirement for this test procedure, a chemical preservation of the filters and RO membranes may be required. Refer to the system TM and accomplish a fresh water flush or preservation procedure as specified. If employing a climatic chamber, the source water must be stored external to the chamber and either employed with system hoses directed through available openings in the chamber walls or relocated to the chamber's interior prior to system operation. The physical space available in the climatic

chamber may limit the quantity of hardware items that can be tested. For example, installing short or single sections of hose between pumps and subsystems is encouraged. In order to properly drain the system brine/waste water to the source tank, it may be necessary to assemble the system on a raised platform or trailer. Storage of chlorine or other chemicals in high storage temperatures may cause spontaneous combustion. Review the MSDS for each system chemical to verify suitability. Test sequence guidance is supplied in MIL-STD-810G, Test Method 507.5, paragraph 2.1.2.

4.9.3.1 Method.

a. A pretest functional or operational check test will be conducted to baseline the system. All nonfunctional components or subsystems should be repaired or documented. A complete visual inspection will be performed and any existing corrosion documented.

b. The system will be positioned in the climatic chamber in the operational configuration. Attempt to position the water tanks or system drain hoses adjacent to the chamber floor drains as much as possible. Thermocouples will be positioned at the water source locations. The use of weighted hangers is encouraged for the water tank(s). Aggravated testing will be accomplished in accordance with MIL-STD-810G, Test Method 507.5, Procedure II. A 24-hr conditioning cycle will be accomplished followed by a minimum of ten cycles of the aggravated test cycle. An operational check will be accomplished every five cycles. If the system was chemically preserved (per the TM), an operational check will be accomplished at the conclusion of the test. The test team will follow the flow of water through the system to ensure that all components and subsystems are fully functional and no significant water leaks are experienced. If not specified in the PS, the system will be operated for a minimum of 2 hr. System operating data will be recorded at least hourly. Water quality samples will be drawn and analyzed. Following the completion of the operational test, the system will be deactivated and drained per the TM.

c. At the completion of the humidity exposure, a detailed visual inspection will be accomplished. Any corrosion or material degradation will be documented. A post-test functional or operational check test will be accomplished and the results recorded.

4.9.3.2 Data Required.

a. Test system identification.

b. Record of pretest functional test results.

c. Record of pretest visual inspection.

d. Chamber temperature and humidity time histories.

e. Test system operating and water sample quality data (Forms A-3 and A-4).

f. Record of any malfunctions, deformation, or leakage during system operation (TIRs).

g. Record of post-test visual inspection.

4.9.3.3 Data Presentation.

System operating and source water data will be presented in a table. Water quality data will be compared to the TB MED 577 requirements to determine conformance. Temperature and humidity time histories will be presented in graphs. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables. All corrosion noted will be classified in accordance with the U.S. Army Tank-automotive and Armaments Command (TACOM) Corrosion Rating Criteria[19].

4.9.4 Salt Fog (if applicable).

Due to the four- to five-day storage requirement for this test procedure, a chemical preservation of the filters and RO membranes may be required. Refer to the system TM and accomplish a fresh water flush or preservation procedure, as specified. Test sequence guidance is supplied in MIL-STD-810G, Test Method 509.5, paragraph 2.1.2.

4.9.4.1 Method.

a. A pretest functional or operational check test will be conducted to baseline the system. All nonfunctional components or subsystems should be repaired or documented. A complete visual inspection will be performed and any existing corrosion documented.

b. The system will be positioned in the salt fog chamber in the operational configuration. If available space is limited, representative cables, hoses, and hardware items will be selected. Testing will be accomplished in accordance with MIL-STD-810G, Test Method 509.5. Following the test, the system will be removed from the chamber and rinsed with water. A detailed corrosion inspection will be conducted and documented.

c. The system will be assembled at the test site and an operational check test (para 4.6) will be accomplished.

4.9.4.2 Data Required.

a. Test system identification.

b. Record of pretest functional test results.

c. Record of pretest visual inspection.

d. Chamber temperature, salt-fog pH, and fallout rate time histories.

e. Record of post-test visual inspection.

f. Paragraph 4.6.2 data elements.

4.9.4.3 Data Presentation.

System operating and source water data will be presented in a table. Water quality data will be compared to the TB MED 577 requirements to determine conformance. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables. All corrosion noted will be classified in accordance with the TACOM Corrosion Rating Criteria.

4.9.5 Fungus (if applicable).

Test sequence guidance is supplied in MIL-STD-810G, Test Method 508.6, paragraph 2.1.2. Recommend to the U.S. Army Test and Evaluation Command (ATEC) System Team (AST) that the test system manufacturer develops a list of all component and subsystem materials. The materials should be compared to the fungus-inert and fungus nutrient lists supplied in MIL-STD-810G. Test Method 508.6, Annex B. Manufacturer-specific brand names should be researched to determine the common terminology or constituents. Materials listed on the fungus nutrient list that have been treated will require identification of the treatment method. Those materials not certified as fungus-inert, or are treated fungus nutrient materials, should be submitted for laboratory testing. Samples of the materials can be submitted in lieu of the entire component (i.e., a 10- to12-in. sample of hose material could be submitted in place of a 50-ft hose line).

4.9.5.1 Method.

a. Conduct the test in accordance with MIL-STD-810G, Test Method 508.6. If the test duration is not included in the PS, a minimum duration of 28 days (desire 84 days) should be employed.

b. Record the results of the test item(s) visual inspection immediately following the test.

4.9.5.2 Data Required.

a. Test material and component identification and condition (new or used).

b. Record of any pretest cleaning accomplished (if any).

c. Record of the species of fungus grown and inoculated on the cotton control strips and test item material samples.

d. Chamber temperature and humidity time histories.

e. Test duration (days).

f. Results of post-test visual and/or functional inspections per MIL-STD-810G, Test Method 508.6.

4.9.5.3 Data Presentation.

The components and materials selected for testing will be presented in a table. The test procedure and inspection results will be summarized in paragraphs or tables.

4.9.6 Blowing Rain.

4.9.6.1 Method.

a. A pretest functional or operational check test will be conducted to baseline the system. All nonfunctional components or subsystems should be repaired or documented. Lubricant reservoirs (engine oil) will be sampled.

b. The system will be positioned at the rain test facility in the operational configuration. The system will be operated in a closed loop. Testing will be accomplished in accordance with MIL-STD-810G, Test Method 506.5, Procedure I. If not specified in the PS of the test system, the rainfall rate will be 1.7 mm/min (4 in./hr), and the wind speed will be 18 m/s (40 mph). After each side of the system is exposed to blowing rain, the system will be inspected and operating data will be recorded. All instruments and pressure/temperature/ flow measuring devices will be inspected to determine if they were degraded. Electrical control panels (if applicable) will be inspected for water intrusion. Lubricant reservoirs (engine oil) will be sampled and both pretest and post-test samples will be submitted to a chemistry laboratory for water analysis.

4.9.6.2 Data Required.

a. Test system identification and orientation.

b. Record of pretest functional test results.

c. Ambient temperature and wind speed.

d. Side of test system exposed and duration.

e. Record of post-test visual inspection.

f. Test system operating and water quality data (Forms A-3 and A-4).

g. Lubricant water analysis results.

4.9.6.3 Data Presentation.

System operating and source water data will be presented in a table. Water quality data will be compared to the TB MED 577 requirements to determine conformance. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables.

4.9.7 Blowing Sand and Dust.

Test sequence guidance is supplied in MIL-STD-810G, Test Method 510.5, paragraph 2.1.2. TOP 1-2-621[20] provides guidance for sand and dust tests conducted at an outdoor facility.

4.9.7.1 Method.

a. A pretest functional or operational check test will be conducted to baseline the system. All nonfunctional components or subsystems should be repaired or documented.

b. Blowing Sand. The system will be positioned at the sand and dust test facility in the operational configuration. The system will be operated in a closed loop. Testing will be accomplished in accordance with MIL-STD-810G, Test Method 510.5, Procedure II. If not specified in the PS of the test system, the sand concentration will be 1.1 ± 0.3 g/m^3 (for material used or stored unprotected near operating surface vehicles), and the wind speed will be 18 ± 1.3 m/s (40 ± 3 mph). After each side of the system is exposed to blowing sand, the system will be inspected, operating data will be recorded, and a product water sample drawn for onsite water analysis. Particular attention will be given to inlet air filters to determine when the filters are saturated and require cleaning or replacement. All equipment, instruments, and pressure/temperature/flow measuring devices will be inspected to determine if they were degraded.

c. Blowing Dust. The system will be positioned at the sand and dust test facility in the operational configuration. The system will be operated in a closed loop. Testing will be accomplished in accordance with MIL-STD-810G, Test Method 510.5, Procedure I. If not specified in the PS of the test system, the dust concentration will be 10.6 ± 7 g/m^3, and the wind speed will be 8.9 ± 1.3 m/s (20 ± 3 mph). After each side of the system is exposed to blowing dust, the system will be inspected, operating data will be recorded and a product water sample drawn for onsite water analysis. Particular attention will be given to inlet air filters to determine when the filters are saturated and require cleaning or replacement. All equipment, instruments, and pressure/temperature/flow measuring devices will be inspected to determine if they were degraded.

4.9.7.2 Data Required.

a. Test system identification and orientation.

b. Record of pretest functional test results.

c. Ambient temperature, humidity, and wind speed.

d. Side of test system exposed and duration.

e. Wind speed and sand/dust concentration.

f. Record of post-test visual inspection.

g. Test system operating and water quality data (Forms A-3 and A-4).

4.9.7.3 Data Presentation.

System operating and source water data will be presented in a table. Water quality data will be compared to the TB MED 577 requirements to determine conformance. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables.

4.10 Transportability.

4.10.1 Method.

a. As listed in TOP 1-2-500[21], plan to test all of the system stowage and transport configurations (i.e., truck, trailer, container, etc.). If the test system is within the gross weight and CG parameters of previously tested systems transported in/on type classified trucks and trailers, a majority of the safety-related road testing (i.e., braking, steering and handling, etc.) will not require repeating. If the road march profile is not included in the OMS/MP for the system, the designated transport truck or trailer profile should be used.

b. Drop Test. Containerized systems typically require a drop test to simulate rough handling. If the test system is stowed and transported in a container (International Standards Organization (ISO), triple container (TRICON), quadruple container (QUADCON)), the drop test associated with that container will be performed. For example, the 20-ft ISO drop test requirements are specified in ASTM E 1976-05[22], paragraph 7.22.

c. Following all shock and vibration tests (rail impact, drop, road, airdrop), an operational check test (paragraph 4.6) will be accomplished to verify that system operability and water quality have not been compromised.

4.10.2 Data Required.

a. As listed in TOP 1-2-500.

b. Height, test configuration, and number of drop tests completed.

c. Video of drop tests.

d. Post-drop physical inspection results and photographs.

e. As listed in paragraph 4.6.

4.10.3 Data Presentation.

a. As listed in TOP 1-2-500.

b. Results of the drop tests will be presented in a table and illustrated with photographs.

c. As listed in paragraph 4.6.

4.11 Electromagnetic Interference (EMI)/Electromagnetic Compatibility (EMC) (if applicable).

4.11.1 Method.

a. As listed in TOP 6-2-542[23] (EMI) and 6-2-560[24] (EMC), specific radiated and conducted emissions and susceptibility tests will be accomplished as detailed in the PS and per MIL-STD-461E.

b. The system will be operated in a closed loop with a large water source in the EMITF. If the system is powered by a type-classified generator, the system will be operated on house power to isolate any test system-specific emissions and susceptibilities. If the generator supplied with the system has not been type-classified, testing of the generator as a stand-alone system should be considered to verify its ability to meet the requirements.

c. System operating data will be recorded during all tests that permit personnel in the chamber. Otherwise, the system will be monitored remotely by cameras focused on the control panel or specific engine or system instruments to verify the system operation has not been degraded. Water quality is generally not affected by EMI/EMC, therefore, water sampling and analysis is not required for this test.

4.11.2 Data Required.

a. As listed in TOP 6-2-542 (EMI) and 6-2-560 (EMC).

b. Paragraph 4.6.2a through f (Form A-3).

4.11.3 Data Presentation.

a. As listed in TOP 6-2-542 (EMI) and 6-2-560 (EMC).

b. The system operating and source water data will be presented in a table. The inspection and operating results documented in TIRs will be summarized in paragraphs or tables.

4.12 High-Altitude Electromagnetic Pulse (HEMP).

HEMP testing must be coordinated with the Electromagnetic Environments Branch, Naval Air Warfare Center (NAWC) Aircraft Division, Patuxent River, Maryland, or the Electromagnetic Pulse Facility, White Sands Missile Range (WSMR), New Mexico. The test officer should provide the system PS to the NAWC or WSMR contact and request that he/she develop a test plan and report for the test efforts. The trained water purification system test officer and crew generally travels to the HEMP Test Facility to assemble, operate, and tear down the system. The need to chemically preserve the filtration system and flush the chemical waste upon arrival should be considered in selecting the test facility. For example, ATC has chosen historically to conduct HEMP testing at NAWC since their physical proximity requires a short travel duration and does not require the test team to accomplish the chemical preservative procedure.

4.12.1 Method.

a. Testing will be accomplished in accordance with MIL-STD-461E, Test Method RS105.

b. The system will be operated in a closed loop with a large water source and the designated generator. Since the test facilities are open ranges, the ambient temperature is significant (source water temperature limitation was discussed earlier). System operating data will be recorded following each pulse to verify that all system components are fully functional before proceeding to the next scheduled pulse. Water quality is generally not affected by HEMP, therefore, water sampling and analysis is not required for this test.

4.12.2 Data Required.

a. As listed in MIL-STD-461E, Test Method RS105.

b. Paragraph 4.6.2a through f.

4.12.3 Data Presentation.

a. As listed in MIL-STD-461E, Test Method RS105.

b. System operating and source water data will be presented in a table. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables.

4.13 Extended Capability Modules.

Recent water purification systems have been supplied with extended capability modules to supplement the standard mission of the system. The modules include, but are not limited to, cold weather, ocean intake structure system (OISS), nuclear, biological, chemical (NBC) water treatment, and NBC survivability. The modules are sometimes packed with the primary system or supplied in a supplemental container or boxes.

4.13.1 Method.

a. Inventory each module and verify that all required components have been supplied and are in good working order. Measure the physical dimensions and weight of each module, if supplied as separate containers. If desired, or as specified in the PS, weigh the individual components of each module. The modules will be stored during ambient and chamber temperatures to verify utility and effectiveness. Any degradation of the module structure, hardware, or paint will be recorded and photographed.

b. Cold Weather. The physical configuration and functionality of the CWK will be tested during ambient and environmental chamber low temperature testing (paragraph 4.9.1).

c. OISS. Testing will require environmental approval at the designated beach area to deploy the system, withdraw ocean water, and discharge the brine/reject water. The OISS and test system will be deployed at the beach area per the TM. The system should be deployed at the water's edge at low tide to ensure sufficient water volume. The system will be operated on water drawn through the OISS. Water samples will be drawn and system operating data will be recorded. The OISS will be recovered and deployed a minimum of three times during the test to verify the recoverability and reuse of the structures. After each deployment, the raw water flow rate will be measured to assure it will provide sufficient water to the test system for operation at rated production.

d. NBC Survivability. If contamination avoidance covers (CACs) are supplied, they will be deployed for representative missions. Once deployed, the configuration will be inspected to determine if sufficient excess material is supplied at the ground level to accept sandbags, or if some sort of ground stakes were supplied. The details of the system's NBC survivability effectiveness will be assessed in paragraph 4.14.

e. NBC Water Treatment. The water treatment system of one representative test system will be deployed per the TM to verify the procedures. Any hardware incompatibilities experienced will be recorded. The details of the NBC water treatment system effectiveness will be assessed in paragraph 4.15.

4.13.2 Data Required.

a. Results of module inventories.

b. Module physical dimension and weight measurements.

c. Results of module inspections during and following ambient and chamber testing.

d. OISS Module.

(1) Beach test area identification and description.

(2) Test configuration or modifications of TM procedure.

(3) Operating and water quality data (Forms A-3 and A-4).

(4) Vertical tide variation (from published tide books or available reference point for direct measurement).

(5) TIRs.

e. NBC water treatment module deployment inspection results and any corrections to the TM procedures.

f. NBC CAC deployment trial and inspection results.

4.13.3 Data Presentation.

a. Module inventory, physical dimension, and weight results will be presented in tables. The data will be compared to the PS for conformance, if applicable. The modules or individual component weights will be compared to HFE lifting and carrying standards (para 4.5).

b. Cold Weather. The CWK assessment will be addressed in paragraph 4.9.1.

c. OISS. System operating and water quality data will be presented in tables. Deployment, inspection, operating, and recovery results documented in TIRs will be summarized in paragraphs or tables.

d. NBC. The results of the water treatment module and CAC deployment trials will be summarized in paragraphs.

4.14 Chemical, Biological, and Radiological Contamination Survivability (CBRCS).

CBRCS testing is the responsibility of the West Desert Test Center (WDTC), U.S. Army Dugway Proving Ground (DPG), Utah. CBRCS testing can be conducted as a separate tasking from DTC and reported as a stand-alone document, or it can be incorporated as a subtest of the ATC test plan and report documents. The utility and fit of the CACs, if supplied with the system, will be assessed by the test crew (para 4.13.2c).

4.14.1 Method.

CBRCS can be addressed in three ways. The choice of method should be coordinated with the system developer and system evaluator.

a. The first method is testing of the system with a radiological stimulant, a biological stimulant, and chemical warfare agents. This testing produces actual data that allow the evaluator to determine if the system meets the Department of the Army (DA)-approved NBC Contamination Survivability Criteria for Army Materiel[25] and AR 70-75[26]. Testing of the system will depend on the size of the system. Small items that can fit inside of a surety laboratory hood will be tested in accordance with TOP 8-2-111[27]. Larger systems will be tested in a surety chamber in accordance with TOP 8-2-510[28].

b. Testing of coupons of the system materials of construction can be performed. This testing will be conducted in accordance with TOP 8-2-061[29]. Data will be acquired on the effects of chemical agents and decontaminants used for chemical, biological, and radiological decontamination on the materials of construction tested. The effects of the contaminants and decontaminants on the system itself are nearly impossible to determine because of the issues of extrapolating data collected from small coupons to the 3-D surface of a system.

c. The third method of addressing CBRCS is to conduct a CBRCS assessment (CBRCSA) (paper study). The CBRCSA is the expert opinion of the individual conducting the assessment on the expected ability of the system to meet the DA-approved NBC Contamination Survivability Criteria for Army Materiel. The CBRCSA report considers the system, the materials of construction, and any actual test data available on the materials.

4.14.2 Data Required.

As listed in TOPs 8-2-111, 8-2-510, or 8-2-061, coupon test method.

4.14.3 Data Presentation.

As listed in TOPs 8-2-111, 8-2-510, or 8-2-061, coupon test method.

4.15 Nuclear, Biological and Chemical (NBC) Water Treatment.

CHPPM should be tasked by the materiel developer to accomplish a paper study to assess the NBC water treatment criterion.

4.15.1 Method.

Assessment of the ability of an item of water treatment equipment to remove NBC contaminants will be performed by means of a paper study, i.e., an expert evaluation of the water treatment components of the equipment and the expected performance thereof based on published and unpublished data from all sources.

4.15.2 Data Required.

The data required to accomplish the paper study will depend on the technology employed, but in any case, will include the operations manual, the CDD, CPD, line drawings, hydraulic characteristics and all test data, including performance data required in the Critical Operational Issues and Criteria (COIC). In addition:

a. For technologies employing RO or nanofiltration, identification of the membrane cartridges, TDS rejection data generated by the equipment developer and/or the membrane manufacturer, and any other available rejection data for the specific membrane;

b. For technologies employing membrane ultrafiltration and/or membrane microfiltration, identification of the manufacturer, specification of the pore size, and any total suspended solids (TSS) removal data available;

c. For technologies employing multimedia and/or cartridge filters, a description of the filter bed, including media sizes, identification of the manufacturer and specification of the porosity for cartridge filters, and any TSS removal test data available;

d. For technologies employing activated carbon, activated alumina, or any similar activated materials, identification of the media manufacturer, media specifications, and available adsorption isotherms;

e. For technologies employing ion exchange, identification of the resin manufacturer, resin characteristics and available isotherms, and similar information for electrodialyis membranes;

f. For innovative technologies, such as water-from-air, water-from-exhaust and membrane distillation, any performance data generated during development.

g. It is essential that technical points of contact for CHPPM be established with the Materiel Developer, the testing authority, and the equipment manufacturer.

4.15.3 Data Presentation.

The accuracy and timeliness of the paper study will depend in large measure on the quality of data recovered. However, it is recognized that much of the desired information will be unavailable from any source. The analysis will be presented in an information paper.

4.16 High Turbidity Water.

High turbidity water generally occurs at rivers and tributaries following rain storms due to runoff. If a naturally occurring water source is not available, Naval Facilities Engineering Service Center, Port Hueneme, California, is equipped to generate high turbidity source water.

4.16.1 Method.

a. If a naturally occurring high turbidity source water is not available, ISO 12103-1[30], A2 Fine Grade test dust will be added to a tank of the raw water. The tank must be mixed continuously. The test dust laden water will be injected into the raw water supply line. Water samples will be drawn prior to the inlet of the filtration system to verify that the turbidity is within the desired range. The test system will be operated on the high turbidity source water in accordance with the TM for the duration required in the PS or a minimum of 20 hours.

b. The differential pressure of the filtration system or subsystems will be monitored at least hourly to determine if the system requires filter replacement, backwash or cleaning. System operating data will be recorded and water quality samples will be drawn and analyzed.

4.16.2 Data Required.

a. Test system identification.

b. Description and photographs of the method to generate and inject the high turbidity source water.

c. System operating and water quality data (Forms A-3 and A-4).

d. Record of system adjustments and maintenance actions.

e. Pretest and post-test RO Element check test data (Form A-5).

4.16.3 Data Presentation.

The system operating and source water data will be presented in a table. The filtration and RO differential pressures will be calculated if differential gages are not equipped on the subsystems. The inspection, maintenance and operating results documented in TIRs will be summarized in paragraphs or tables.

4.17 Pump Performance. As listed in TOPs 9-2-181[31] and 9-2-182[32].

5. DATA REQUIRED.

Data required is listed throughout Section 4: Test Procedures.

6. PRESENTATION OF DATA.

Data presentation is listed throughout Section 4: Test Procedures.

APPENDIX A. TEST DATA FORMS

Form A-1. Test Participant Demographic Data

Date: _____

Name: _____

Birth Date: _____

Age (years/months): _____

Military Rank: _____ Civilian Job Description: _____

Years of Military Service: _____ Years of Civilian Service: _____

Military MOS (number and description): _____

Time in service at current MOS: _____

Is this a primary or secondary MOS (circle one)? PRIMARY SECONDARY

List the training you have completed in water purification equipment: _____

_____

_____

_____

List the experience you have had with water purification equipment (identify systems):

_____

_____

_____

Form A-2. New Equipment Training (Net) Questionnaire

Evaluated By (Name): _____ Date: _____
(First) (Day)

Rank/Grade: MOS/Job Title: Experience:

Related Training:

Related Experience: _____

Instructions: Circle a number between the adjectives which best represents your opinion of the instruction you have received during this training period.

A. Instructor(s)

1.	Used jargon or confusing terms	Never	1	2	3	4	5	6	7	8	9	Always
2.	Speaking ability (enunciation, volume, etc.)	Poor	1	2	3	4	5	6	7	8	9	Excellent
3.	Subject knowledge	Poor	1	2	3	4	5	6	7	8	9	Excellent
4.	Treatment of students	Discourteous	1	2	3	4	5	6	7	8	9	Courteous
5.	Aware of student understanding	Never	1	2	3	4	5	6	7	8	9	Always
6.	Preparation of instruction	Poor	1	2	3	4	5	6	7	8	9	Excellent
7.	Response to student questions	Poor	1	2	3	4	5	6	7	8	9	Excellent
8.	Overall rating	Unsatisfactory	1	2	3	4	5	6	7	8	9	Outstanding

B. Instruction:

1.	Basic concepts were defined at the beginning of each block of instruction	Never	1	2	3	4	5	6	7	8	9	Always
2.	Basic concepts were developed logically	Never	1	2	3	4	5	6	7	8	9	Always
3.	Presentation of material was	Boring	1	2	3	4	5	6	7	8	9	Interesting
4.	Classroom discussions were	Waste of time	1	2	3	4	5	6	7	8	9	Valuable
5.	Material was presented	Too slowly	1	2	3	4	5	6	7	8	9	Too rapidly
6.	Coverage of material was	Too basic	1	2	3	4	5	6	7	8	9	Too technical
7.	Training slides/presentation quality was	Poor	1	2	3	4	5	6	7	8	9	Excellent
8.	Training aids were used	Too seldom	1	2	3	4	5	6	7	8	9	Too often
9.	Lectures led into practical exercises	Never	1	2	3	4	5	6	7	8	9	Always

C. Practical Exercises (PEs) or hands-on equipment experiences:

1.	Time scheduled for PE was	Inadequate	1	2	3	4	5	6	7	8	9	Adequate
2.	PEs were conducted on actual hardware	Never	1	2	3	4	5	6	7	8	9	Always
3.	All students participated in PEs	Never	1	2	3	4	5	6	7	8	9	Always
4.	PEs were conducted as scheduled	Never	1	2	3	4	5	6	7	8	9	Always
5.	What percentage of the instruction time was "hands on" for you?		10	20	30	40	50	60	70	80	90	

D. Lesson Assignments and References:

1.	Assignments were necessary	Never	1	2	3	4	5	6	7	8	9	Always
2.	Assignments were	Too simple	1	2	3	4	5	6	7	8	9	Too difficult
3.	Manuals and reference materials were	Too elementary	1	2	3	4	5	6	7	8	9	Too complicated
4.	Manuals and reference materials were designed for easy use	Never	1	2	3	4	5	6	7	8	9	Always

E. Examinations:

1.	Material covered in exams was presented during instruction/PE	Never	1	2	3	4	5	6	7	8	9	Always
2.	Exams were	Too short	1	2	3	4	5	6	7	8	9	Too long
3.	Exams were	Too simple	1	2	3	4	5	6	7	8	9	Too difficult
4.	Performance-type exams were given	Never	1	2	3	4	5	6	7	8	9	Always
5.	Exams tested knowledge of material presented during instruction/PE	Not at all	1	2	3	4	5	6	7	8	9	Completely

Please make any comments you desire. Suggested areas for comment are superior or unsatisfactory instruction, missing elements of instruction, questions you still have concerning system operation or maintenance but are not comfortable asking in a classroom setting, or recommended deletions to course content.

Form A-3. System Operating Data Log

System ID: _____ Test Phase: Freshwater Seawater
Date: _____ Settling Tank Employed? Yes No
Operator Name: _____

Time, 24 hr	Raw Water Pump Module		Filtration Module		HP Pump Module		RO Module					
										RO Brine Flow gpm	Product	
	Water Temp, °F	Feed Flow Rate, gpm	Pressure, psi		Time, hr	Operating Pressure, psi	Pressure, psi				Flow Rate, gpm	Total, gal.
			Inlet	Outlet			Inlet	Outlet	Differential[a]			

[a]If a differential pressure gauge is not provided on the system, the differential will be calculated by subtracting the outlet pressure from the inlet.

Form A-4. On-Site Water Quality Data Log

System ID: _____ Test Phase: Freshwater
Seawater
Settling Tank Employed? Yes No

Date	Time of Day	Raw Water			Product Water		Brine/Waste Water	
		Conductivity[a]	Turbidity, NTU	Temperature, ^{o}F	Conductivity[a]	Turbidity, NTU	Conductivity[a]	Turbidity, NTU

[a]Conductivity units are us/cm or ms/cm, depending on the source water.

Form A-5. RO Element Check Test Data

System ID: _____

Date: _____

Source Water: Fresh Water Seawater High Turbidity

Intake System Description: _____

Operating hours	
Product flow rate, gpm	
Operating pressure, psi	
Feed conductivity, us/cm	
Feed temperature, ^{o}F	
Product conductivity, uS/cm	

RO Element No.	Conductivity	Volume	Time	Flow Rate
1				
2				
3				
4				
5				
6				
7				
8				
Total Flow, gpm				

Remarks:

_____

_____

_____

_____

APPENDIX B. WATER PRODUCTION AND QUALITY DATA NORMALIZATION CALCULATIONS

Note: Highlighted areas will be completed during actual testing.

Since the natural water sources at the test locations are not at the temperature and TDS requirements of the PS, it is necessary to analyze the collected operating data to determine whether the test system can meet the product water TDS and flow rate requirements at the temperature and TDS conditions stated in the PS. Highlighted sections of this appendix cannot be completed until the test is started and some initial data recorded.

The operating data collected from the system is used to calculate the water (*A*) and salt (*B*) transport coefficients for the RO system array. The calculated *A* and *B* values can then be used to determine whether the system would meet the water production and water quality requirements in the PS. The data collected include the following:

- RO concentrate flow, Q_c (gpm)
- RO product flow, Q_p (gpm)
- RO feed flow, Q_f (gpm) = $Q_c + Q_p$
- Product conductivity converted to product TDS, C_p (mg/L)
- RO feed pressure, P_f (psi)
- RO concentrate pressure, P_c (psi)
- RO product pressure, P_p (psi)
- RO feed temperature, T (^{o}C)
- RO feed conductivity converted to feed TDS, C_f (mg/L)
- Analysis of major ions present in the raw water in units of molality, C_i

These data are used to calculate the measured water (equation 5) and salt transport (equation 17) coefficients using the solution-diffusion model. The model assumes that solvent and solute transport is the result of pressure and concentration differences across the membrane and neglects any convective transport. The equations are setup in an Excel spreadsheet.

The TDS for the product and the feed have been calculated using conductivity (EC) to TDS approximation based on sea salt solutions. The following equations summarize the correlation used for TDS determination from the solution conductivity in micromhos/cm:

For conductivity >5550 micromho/cm:

$$\text{TDS} = -503+0.6076*\text{EC}+(1.1*10\text{^-}6)*\text{EC}\text{^}2 \quad (1)$$

For conductivity >600 and <5550 micromho/cm:

$$\text{TDS} = -44.78+0.548*\text{EC} \quad (2)$$

For conductivity > 60 and < 600 micromho/cm:

$$TDS = -1.99+0.4932*EC \quad (3)$$

For conductivity < 60 micromho/cm:

$$TDS = -0.027+0.4693*EC \quad (4)$$

The water transport coefficient, *A*, and salt transport coefficient, *B*, can be calculated from the following equations which were developed based on the solution-diffusion model for predicting performance of reverse osmosis elements. The water transport coefficient has the units of gpd/psi and is defined by the following equation:

$$A = \frac{1440 * Q_{TCF}}{P_{NDP}} \quad (5)$$

where Q_{TCF} is the temperature corrected product flow rate in gpm and P_{NDP} is the net driving pressure in psi.

Since the *A*-value is a function of feed TDS it is necessary to correct the measured *A*-value in equation 5. All pertinent operating data as described above will be collected to develop the correlation when operating the system during a special salinity test where the feedwater TDS is varied between 60,000 and 35,000 mg/L. A normalized water transport coefficient (A_{60000}) based on the system producing its rated flow rate from a 60,000-mg/L TDS water source (this results in an average concentrate TDS of _____ mg/L) can be determined from this correlation and will have the following general form with the constants a and b determined from the special salinity test:

$$A_{60000} = A * \frac{(a * ????? + b)}{(a * C_{AVG} + b)} \quad (6)$$

where a = _____ and b = _____

Since the B-value is also a function of feed TDS it is necessary to correct the measured B-value in equation 17. All pertinent operating data as described above was collected to develop the correlation when operating the system during a special salinity test where the feedwater TDS was varied between 60,000 and 35,000 mg/L. A normalized water transport coefficient (B_{60000}) based on the system producing its rated flow rate from a 60,000-mg/L TDS (this results in an average concentrate TDS of _____ mg/L) can be determined from this correlation and will have the following general form with the constants *g* and *h* determined from the special salinity test:

$$B_{60000} = B * \frac{(g * ????? + h)}{(g * C_{AVG} + h)} \quad (7)$$

where g = _____ and h = _____

The temperature corrected flow rate (Q_{TCF}) for the RO element, where Q_P is the measured product flow rate and T is the product water temperature in ^{o}C, is approximated by the following equation provided by Filmtec in their RO data software for temperatures less than 25 ^{o}C:

$$Q_{TCF} = Q_p * \exp(????*(1/(273.15 + T) - (1/298.15))) \quad (8)$$

The net driving pressure is given by the following equation:

$$P_{NDP} = (P_f + P_c)/2 - \pi_{AVG} - P_p + \pi_p \quad (9)$$

where P_f is the feed pressure to the element array, P_c is the concentrate pressure of the element array, P_p is the product water pressure, and π_{AVG} and π_p are the average feed and product water osmotic pressure respectively. Equation 9 is from ASTM D 4516-00(2006)e1[33].

A correlation between the TDS and osmotic pressure (π_f in psi) can be developed based on the ionic analysis of the raw water. Equation 10 is used to calculate the osmotic pressure based on the molalities (C_i) and osmotic coefficients (Φ_i) of the major ionic constituents (Ca, Mg, K, Na, chloride, sulfate, and bicarbonate). Assuming the ionic distribution does not vary with TDS the osmotic pressure versus TDS correlation will be linear with slope, d, and intercept, f, and will take the form of equation 11.

$$\pi_f = 333.93 * \sum \varphi_i C_i \quad (10)$$

$$\pi_f = d * C_f + f \quad (11)$$

Once the correlation is developed the average osmotic pressure of the feed/concentrate will be calculated based on the log mean concentration difference (C_{AVG}) in equation 15 and the concentration polarization factor in equation 13 (Filmtec ROSA program).

$$\pi_{AVG} = CP * (d * C_{AVG} + f) * (T + 273.15)/298 \quad (12)$$

$$CP = \exp(0.7 * (1 - (1 - \frac{Q_P}{Q_F})^{1/??})) \quad (13)$$

The osmotic pressure of the permeate is approximated simply by equation 14 assuming most of the ions in the product water are sodium and chloride.

$$\pi_P = 0.01 * C_p * (T + 273.15) / 298 \tag{14}$$

C_p is the product TDS in mg/l.

C_{AVG} is the average feedwater TDS concentration based on the log mean concentration difference and is defined by the following:

$$C_{AVG} = C_f * \left[\frac{\ln(\frac{C_c}{C_f})}{(1 - \frac{C_f}{C_c})} \right] \tag{15}$$

where C_f and C_C are the feed and concentrate TDS. The concentrate TDS, C_C , is calculated based on a mass balance of the system:

$$C_C = \frac{(C_f * Q_f - C_p * Q_p)}{Q_C} \tag{16}$$

The salt transport coefficient is a measure of the amount of salt that passes through the membrane in gpd. It is defined by equation 17 where the concentrations are in TDS as mg/L:

$$B = \left[\frac{1440 * C_p * Q_{TCF}}{CP * C_{AVG} - C_p} \right] \tag{17}$$

Once the measured *A* and *B* values have been calculated, the operating pressure of the system producing the rated flow rate of product on a 60,000 mg/L, 77 ^{o}F source water can be estimated by a trial and error method. The trial and error method requires guessing the product TDS and RO feed pressure until the *A* and *B* values match the measured values. This trial and error solution procedure was implemented on the Excel spreadsheet using Excel's Solver function. The same trial and error method can be used to estimate the product TDS by guessing the product TDS and operating pressure with a fixed product flow rate when operating on a 60,000 mg/L, 95 ^{o}F source water. For both trial and error procedures, if the guessed operating pressure and product TDS are less than the maximum system operating pressure and 1000 mg/L, respectively, the system meets the requirements in the PS.

APPENDIX C. GLOSSARY

Term	Definition
Antiscalant	A chemical injected into the filtered raw water that interferes with precipitation reactions and prevents the formation of salt crystals on the surface of the reverse osmosis membranes.
Brine	Water saturated or nearly saturated with salt as a result of the reverse osmosis process.
Coagulation	Injection of a chemical (polymer) to the raw water to destabilize and bring together (coagulate) the suspended material to form particles. These particles are removed with filtration.
Conductivity	Conductivity is a measurement of the ability of an aqueous solution to carry an electrical current. The measurement estimates the amount of TDS, or the total amount of dissolved ions in the water. Seawater contains a large quantity of dissolved salts therefore, has a high conductivity.
Disinfection	The process of killing (inactivating) harmful and objectionable bacteria, cysts and other microorganisms (pathogenic) found in the raw water. The preferred Army field method of water disinfection is chlorination.
Filtration	Filtration is a mechanical or physical operation which is used for the separation of solids from the raw water by interposing a medium to fluid flow through which the fluid can pass, but the solids (or at least part of the solids) in the fluid are retained.
Ground water	Water that comes from wells or springs.
Nonpotable water	Water that has not been determined to be safe for human consumption.
Palatable water	Water that is pleasing to the senses. It looks, tastes and smells good and is neither too hot or too cold.
Potable water	Water that is safe for drinking.
Reverse osmosis (RO)	RO is a separation process that uses pressure to force the filtered water through a membrane that retains the solute on one side and allows the pure water to pass to the other side.

GLOSSARY CONT'D

Surface water	Water sources that the Military water purifiers can treat and include rivers, streams, lakes, ponds, seas and oceans.
TDS	The total solids dissolved in a solution. This is a measurement of all conductive ions in the solution. Abbreviated TDS.
Turbidity	Turbidity is the cloudiness or haziness of a fluid caused by individual particles (suspended solids).
Wastewater	Water generated from three waste streams; (1) filter and membrane cleaning and preservation processes with citric acid, detergents or hypochlorite solutions, (2) RO brine and (3) filter backwash.
Water quality	Water quality has two areas of concern as it relates to the daily operation of a water point. The first is the quality of the raw water source and how it affects the operation of the water purification equipment and use of treatment chemicals. The second is the quality of the product water and surveillance techniques used to guarantee its potability.
Water treatment/ purification	Water treatment/purification is the combination of one or more processes employed to improve the quality of water. Treatment involves removing suspended and dissolved contaminants and killing or inactivating microorganisms, with the goal of making the water potable and palatable.

APPENDIX D. ABBREVIATIONS

ADACS	Automated Data Collection System
APG	Aberdeen Proving Ground
AR	Army Regulation
AST	U.S. Army Test and Evaluation Command (ATEC) System Team
ASTM	American Standard Test Method
ATC	U.S. Army Aberdeen Test Center
BII	basic issue items
CAC	contamination avoidance cover
CBRCS	chemical, biological, and radiological contamination survivability
CBRCSA	CBRCS Assessment
CDD	Capabilities Development Document
CG	center of gravity
CHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
COIC	Critical Operational Issues and Criteria
CPD	Capabilities Production Document
CWK	cold weather kit
CWM	cold weather module
DA	Department of the Army
DPG	Dugway Proving Ground
DTC	U.S. Army Developmental Test Command
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EMITF	EMI Test Facility
FM	Field Manual
HEMP	high-altitude electromagnetic pulse
HFE	human factors engineering
ICD	Initial Capabilities Document
ILS	integrated logistic supportability
ISO	International Standards Organization
JHA	job hazard analysis
MHE	material-handling equipment
MOPP	mission-oriented protective posture
MSDS	Material Safety Data Sheet
NAWC	Naval Air Warfare Center
NBC	nuclear, biological, and chemical
NET	new equipment training
NTU	nephelometric turbidity unit
OISS	ocean intake structure system
OMS/MP	Operational Mode Summary/Mission Profile
ORD	Operational Requirements Document
ORP	oxygen reduction potential
pH	potential of hydrogen

ABBREVIATIONS CONT'D

PPE	personal protective equipment
PS	Performance Specification
QUADCON	quadruple container
RFTS	Request for Test Services
RH	relative humidity
RO	reverse osmosis
SAR	Safety Assessment Report
SEP	System Evaluation Plan
TACOM	U.S. Army Tank-automotive and Armaments Command
TBMED	Technical Bulletin (Medical)
TDS	total dissolved solids
TIR	Test Incident Report
TM	Technical Manual
TOP	Test Operations Procedure
TRICON	triple container
TSP	test support package
TSS	total suspended solids
USMC	U.S. Marine Corps
VDLS	VISION Digital Library System
VISION	Versatile Information Systems Integrated On-Line
WDTC	West Desert Test Center
WSMR	White Sands Missile Range

APPENDIX E. REFERENCES

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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: Test Business Management Division (TEDT-TMB), US Army Developmental Test Command, 314 Longs Corner Road Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: Support Equipment Division (TEDT-AT-WFE), US Army Aberdeen Test Center. Additional copies can be requested through the following website: http://itops.dtc.army.mil/RequestForDocuments.aspx, 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.