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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 wet and dry gap bridges and equipment.

15. SUBJECT TERMS

Bridge Crossing Simulator	Military Load Classification Load Simulator	Trim
Metacentric Height	Reserve Buoyancy	
Military Load Classification	Span	

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US ARMY DEVELOPMENTAL TEST COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 9-2-027 15 September 2009
DTIC AD No.: ADA505642

BRIDGES AND EQUIPMENT

* This TOP supersedes TOP 9-2-027, 23 February 1972.

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1. SCOPE.

The procedures in this Test Operating Procedure (TOP) describe the test methodology and techniques to determine the technical performance and safety and human factors characteristics of wet and dry gap bridges and equipment.

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. Production tests of bridges that have satisfied extensive developmental test efforts can generally proceed to dynamic load testing. 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 as well as data obtained by concurrent testing will be considered to avoid duplication 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 and accomplish helicopter sling load (HSL) static lift testing.
Maintenance shop	Accomplish Technical Manual (TM) receipt inspection, servicing, inventories, scheduled and unscheduled maintenance, and chamber test preparation.
Still and fast water test sites	Accomplish site survey, training and testing of wet gap bridges.
Dry gap test site(s)	Accomplish training and testing of dry gap bridges.
Climatic chambers	Satisfy the needs of MIL-STD-810[1**] for low and high temperatures, humidity, salt fog, and fungus.
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.
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.
Lift and Tie-Down Test Facility	Satisfy the needs of MIL-STD-209[3].
Rail Impact Test Facility	Satisfy the needs of MIL-STD-810.
Cargo helicopter(s) and approved flight path	Satisfy the needs of MIL-STD-913[4].
Noise Test Facility	Satisfy the needs of TOP 1-2-610[5].
Bridge crossing simulator (BCS)	Accomplish dry gap bridge structural and durability testing.
Military load classification (MLC) load simulator and other simulated loads	Accomplish load testing and flotation and stability test measurements.
Tracked and wheeled vehicles	Accomplish dynamic, structural, and vehicle compatibility testing.
Chemical, biological, and radiological (CBR) surety hood or chamber	Accomplish CBR contamination survivability (CBRCS) testing.

[**] Superscript numbers correspond to those in Appendix E, References.

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)
Distance (bridge length)	±3 cm (±0.1 ft)
Vehicle and rail impact speed	±0.1 km/hr (±0.1 mph)
Surface temperature	±2°
Strain	±1% reading
Bridge deflection (string potentiometer)	±0.25 to 1% of reading
Permanent set (linear vertical displacement transducer (LVDT))	-0.20% reading
Engine speed (magnetic proximity sensors count teeth on the flywheel and integrate over a period of time)	±1% reading
Nautical speed	±0.05 kt (±0.1 ft/sec)
Water current (drift test)	±0.05 kt (±0.1 ft/sec)
Water depth	±0.3 m (±1 ft) accuracy will vary depending on the density of the ground under the water, aquatic plant life, and the amount of sediment suspended in the water
Wave measurement height/freeboard	±1% reading
Trim/angle of inclination	±0.5° static, ±2.0° dynamic
Tensile load/force	±1% reading
Potential of hydrogen (pH)	±1% 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 similar equipment.

b. Requirements. Review the test item's Capability Documents or Performance Specification (PS). For evaluated programs, the System Evaluation Plan (SEP) is the governing document. The SEP will document the methodology and data requirements. For nonacquisition 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. Test Sites.

(1) Wet Gap. Selection of suitable wet gap bridge and rafting test sites are extremely important to adequately assess the system PS and to provide a safe working environment for the test crew. The sites should be studied to determine the appropriate clear span width, soil conditions, bank heights and slopes, water depth, current, tide variations, crossing span, waterway traffic, maneuvering and working areas at each bank, and suitable anchorage and abutment areas. Access areas must be adequate for required bridge construction, assembly, recovery equipment, test support and bridge crossing vehicles. Inclusion of a circular path in the design for vehicle traffic should be considered when planning for live vehicle crossings.

(2) Dry Gap. The majority of dry gap bridge sites must be constructed to service the clear span width of each bridge system. The system specifications typically require testing in as many as four different bank conditions including level surface to level surface, 10-percent longitudinal and side slopes, and 5-percent transverse slopes. In the construction of the sites, an area of sufficient size on at least one of the banks must be provided to accommodate the bridge launching mechanism and equipment. Also, inclusion of a circular path in the design for vehicle traffic should be considered when planning for live vehicle crossings. The height of the banks must be constructed to accommodate the maximum expected mid-span deflection of the bridge under the heaviest load condition.

d. References. The Trilateral Design and Test Code for Military Bridging and Gap Crossing Equipment[7] is the primary reference for bridge testing. Field Manual (FM) 5-34/Marine Corps Reference Publication (MCRP) 3-17A[8], Chapter 10, provides wet gap and dry gap bridging equipment guidance for fielded systems.

3.2 Sequence.

To provide an early indication of test item suitability, conduct safety tests and inspections first and 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 unit maintainer level tasks, and the systems have completed all break-in time and are operating as intended. Per MIL-STD-810G, some environmental tests must be conducted on different test systems to assess vulnerability against particular environments. For example, humidity testing should not be conducted on the same test sample that has been subjected to salt fog, sand and dust, or fungus tests. Guidance for test sequencing is supplied in subparagraph 2.1.2, sequence among other methods for each test method described in MIL-STD-810G.

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 evaluated programs, document all test incidents, maintenance actions, hardware or software modifications, and emerging test results in Test Incident Reports (TIRs) in the Observer Data Input Nexus (ODIN) and stored on the Versatile Information Systems Integrated On-Line (VISION) Digital Library System (VDLS). Nonevaluated programs can choose to employ ODIN, or the test officer can submit daily/weekly status reports via e-mail or the VDLS.

4. TEST PROCEDURES.

4.1 Initial Inspection and Operation.

4.1.1 Method.

a. Upon arrival, the system will be inspected for any damages attributed to transport. All applicable protective materials will be removed. Record any damage or deterioration resulting from handling, improper packaging, or inadequate preservation. Photograph representative damage. Inspect the system to identify any obvious defects in workmanship or construction. Conduct an initial safety inspection to identify all potential hazards.

b. Inventory all system components, basic issue items (BII), and the test support package (TSP). Compare the inventory to the packing list or TM and identify all shortages 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 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 any of the 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 demographic data questionnaire (Appendix B, Form 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 Material Safety Data Sheets (MSDSs) and post at the 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 (Form 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. 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.

Physical dimensions, weight, and center of gravity (CG) measurements will be accomplished as listed in TOPs 1-2-504[9], 2-2-800[10] and 2-2-801[11]. These measurements should be accomplished in each system stowage and transport configuration (truck, trailer, and pallet). Significant configuration changes during test will require measurements of the final configuration.

4.4 Safety.

TOP 1-1-060[12] 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 draft TMs are received and the operator/maintainer test team training is conducted, the hazards and means of mitigation identified in the SAR will be verified.

b. Inspection and Operation. A system-specific hazards checklist derived from TOP 10-2-508[13] 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[14], 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 MSDS of each material 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 percentile female to 95th percentile male) and quantities. 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.

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.

4.4.3 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 MIL-STD-882D[15]. 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. 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. Depending on the system configuration, noise testing should be considered for all system tasks including road transport, system assembly, deployment, and recovery. For each system task, measure the 85-dB(A) contour(s) and peak noise levels at all operator and maintainer personnel occupied areas. Consideration must also be given to capturing the noise generated from intermittent noise sources.

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 required tasks or accessing specific controls or equipment for operation or maintenance will be recorded.

c. Assembly, Deployment, and Recovery Requirements. After the operators are thoroughly familiar with system operations, time trials will be performed to verify PS requirements. Time trials for military crews will be accomplished with cold, mission-oriented protective posture (MOPP) and/or battle gear, if required in the SEP. Time trials will be performed a minimum of three times for each system configuration.

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 weather gloves and MOPP gloves and accomplish representative operator level tasks to determine if the control design and layout is conducive to 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 CG (paragraph 4.2) of each 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. Assembly, Deployment, and Recovery Requirements.

(1) System identification and configuration.

(2) Test personnel uniform configuration.

(3) 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 weather gloves 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[16], 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 assembly, deployment, and recovery time trial results will be presented in tables, and the data averaged for each system configuration. 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 questionnaires results will be tabulated and presented in tables. Any crew members' comments will be summarized in paragraphs or tables.

4.6 Dry Gap Bridge and Launcher Structural Testing.

Test center engineers will consult with the materiel developer and manufacturing engineering staffs to determine critical supporting members and anticipated critical stress areas on the bridge, launching structure(s), and launch vehicle attachment areas. The analysis will be based on a review of the design drawings, classical stress analysis, finite element analysis, and a review of areas known to exhibit high levels of stress during historical testing. If the bridge is manufactured from a material that is inherently corrosion resistant (i.e., aluminum), it is recommended that the bridge and launcher designated for structural testing be delivered in an unpainted state to facilitate routine physical and planned nondestructive test (NDT) inspections of all welded joints. The manufacturer should be requested to identify the materials of construction and material properties to assist in the stress analysis of the structure.

4.6.1 Method.

a. Pretest Inspection. If a detailed NDT inspection was not accomplished by the manufacturer prior to delivery to the test center, it is recommended that both a detailed physical and NDT (liquid penetrant, magnetic particle, and/or ultrasonic) inspection of all welded joints on the bridge and launcher be accomplished. NDT will be accomplished in accordance with TOP 3-2-807[17].

b. Instrumentation. The bridge and launcher will be instrumented with a combination of uniaxial and rosette strain gages at anticipated stress areas. Gages will also be installed at the planned locations of the BCS hydraulic actuators. All gage locations will be photographed and annotated on system drawings for reference. String potentiometers or LVDTs (one on each side of the bridge) will be installed at the mid-span to measure bridge deflection and/or permanent set. A thermocouple or other means to record a time history of the ambient temperature will be installed. For each data acquisition (DAQ) setup, each instrument shall be activated to verify its channel designation and response prior to collecting data. DAQ equipment to support the collection and storage of real-time data will be employed.

c. Static Bridge Loading. If the manufacturer has not accomplished significant structural testing (either simulated, static, or dynamic), the Acquisition Support Team (AST) may require that static loading be applied to the bridge prior to vehicle crossings. The U.S. Army Aberdeen Test Center (ATC) BCS, the U.S. Army Tank-Automotive Research, Development and Engineering Center (TARDEC) load frame, or the QinetiQ Test Facility at Christchurch, England, can be employed to accomplish the static loading. The working load test will be accomplished per the Trilateral Design and Test Code (TDTC), paragraph 8.5.9, using the North Atlantic Treaty Organization Standardization Agreement (NATO STANAG) 2021[18] hypothetical vehicle footprint. Following a successful working load test, an overload test will be accomplished per the TDTC, paragraph 8.5.10. Testing should include anticipated worst-case loading for bending and shear. If the structure does not satisfy the permanent set limit for the test overload, ultimate load testing will be accomplished per TDTC, paragraph 8.5.12. The determination of permanent set for bridge deflection, TDTC, paragraph 8.5.10.11, is a difficult measurement. The majority of the load facilities employ oak timbers to support the ramp ends of the bridge structure. The oak will experience some permanent deformation due to the applied loads; therefore, reference measurements should be made at both banks and the center of the bridge prior to the initiation and at the conclusion of each load test. Connection and pinhole measurements will be accomplished per the TDTC with a hole gage to measure out of round or slide shims around the pins to determine if clearance has increased.

d. Dynamic Bridge and Launcher Loading. Following successful static load testing, dynamic loading of the bridge with a series of tracked and wheeled vehicles representing the anticipated fatigue design loading (TDTC, paragraph 8.8) will be accomplished. The bridge will be launched per the TM, and the launcher/launch beam strain data will be recorded. If an anchorage system is provided and the TM or manufacturer requires the use of an anchorage system, it will be deployed. Testing will be accomplished at all required embankment conditions including level, longitudinal/side slope, racked, and bank height differential requirements. Each designated crossing vehicle will be operated at a range of vehicle speeds in increments of approximately 5 km/hr (3 mph) up to the TDTC design crossing speeds (paragraph 4.2.10). Controlled brake stops will be performed at all speeds in the level bank configuration with the vehicles centered on the bridge and at the near ramp section for impact loading. For bridges of sufficient length, crossings with two vehicles at the minimum acceptable spacing of 30.5 m (100 ft) between vehicle ground contact points will be conducted. A sufficient number of instrumented crossings will be accomplished at each test condition and vehicle speed until all data channels provide representative/acceptable data for analysis and use for durability drive files for the BCS. The anchorage system (if required) will be deployed with sufficient slack to measure bridge creep during brake stops and normal crossings. Detailed physical inspections will be accomplished following a series of vehicle crossings and will include deck wear inspections. Bridge launcher/launch beam strain data will be recorded during bridge recovery/retrieval operations.

Note: For bridges that are assembled from multiple sections, the bridge will be assembled in the same manner (order and direction) for each test configuration except when testing for interchangeability.

e. Post-Test Inspection. If the test team has detected any cracks during scheduled physical inspections, or if the AST deems it appropriate (particularly for a prototype structure), a post-test NDT inspection will be accomplished following each or selective phases of the structural tests.

4.6.2 Data Required.

a. Inspections (pretest and post-test).

(1) Physical inspection results (inspection log or TIRs).

(2) NDT inspection results.

(3) Photographs of degradation or damage.

b. Instrumentation.

(1) Strain gage specification, locations, and amplitude distribution data.

(2) Deflection transducer locations and deflection data.

(3) Photographs and schematics of instrumentation locations.

(4) Identification of material composition at strain gage locations.

c. Static Loading.

(1) Test load frame/simulator identification, test configuration and method(s).

(2) Working load(s) applied and load application durations.

(3) Overload(s) applied and load application durations.

(4) Vertical deflection at the bridge center and abutment ends (for permanent set).

(5) Connection and/or pin hole measurements, as required.

(6) Instrumentation results (paragraph 4.6.2b).

(7) Results of pretest and post-test reference measurements (deflection and pinholes to determine permanent set).

(8) Results of post-test physical inspections.

d. Dynamic Loading.

(1) Bank configuration and clear span.

(2) Anchorage system identification and method employed (if applicable).

(3) Vehicle identification, load characteristics (load distribution, CG), bridge crossing speed, relative position on bridge during crossing (centered/eccentric), and number of bridge crossings.

(4) Vehicle stopping data including speed, position, and direction on the bridge.

(5) Ambient environmental conditions.

(6) Vertical deflection at the bridge center.

(7) Instrumentation results (para 4.6.2b).

(8) Number of launch and retrieve cycles.

(9) Results of scheduled physical and NDT inspections.

(10) Photographs and video of representative test operations.

(11) Record of any test incidents (TIRs).

4.6.3 Data Presentation.

Inspection results will be presented in tables, NDT laboratory reports, and with representative photographs. Structural test and instrumentation data will be presented in tables and graphs. Maximum strain results for each bridge and launcher test condition will be compared to the yield stress of the applicable material(s) to determine conformance to the structural load criteria. Dynamic data will be used to support the Verification and Validation Implementation Plan for the BCS Modeling and Simulation as detailed in durability test, paragraph 4.10.

4.7 Wet Gap Bridging and Rafting Operations.

Wet gap bridge systems typically encompass several interior and ramp bays/pontoons, bridge erection boats (BEBs), vehicle transporters, and/or trailers, boat and/or bay cradles, pier set barges, and anchorage systems. Testing should be accomplished at test sites of varying difficulty, bank conditions, and water depths. Site selection should provide for both gravity and power assisted launching methods when the transporter is so designed. An anchorage system will be deployed per FM 5-34 or the system TM when stream conditions or other emplacement conditions so justify.

4.7.1 Method.

a. Launch, Assembly/Disassembly and Retrieval. The bridge and boat assets will be launched per system training and TM instructions. The adequacy of transporter rollers, guides, cables, fairleads, winching, and attaching devices will be determined. The bridge or raft will be assembled. The equipment will be inspected for proper functioning of all folding, latching, and attachment devices. Special requirements for positioning or handling of the bays or boats will be noted. The bridge/raft will be tested per the paragraphs listed below. The bridge/raft will be disassembled and retrieved from the water per the system training and TM instructions.

b. Flotation and Stability.

(1) Reserve Buoyancy. Reserve buoyancy will be measured for raft combinations and pier set barges as identified by the AST. The ATC MLC load simulator will be used as the variable load by adjusting the volume of water in the tank. The MLC simulator will be centered both laterally and longitudinally on the designated assembly. Freeboard will be measured with respect to the roadway surface at the ends and center of the assembly. The weight will be increased until no freeboard is available for the majority of the roadway. The test will be repeated with steel weights added symmetrically on each end of the load simulator tank and distributed over the surface of the assembly to represent the mud load. TDTC, paragraph 4.2.12 defines the mud load as 0.75 kN/M^2 (15.67 lbf/ft^2) on the roadway.

(2) Metacentric Height. The metacentric height will be measured in accordance with TOP 9-2-251[19] or Naval Architecture for Non-Naval Architects[20], paragraph 2.5. The method is often referred to as an inclining experiment. Since the CG of the MLC load simulator will change as the raft inclines due to the displacement of the water, it is recommended that an actual vehicle load (tracked or wheeled vehicle) be employed for this test effort.

c. Structural Testing. Structural testing of the wet gap bridge will be accomplished similarly to the dry gap bridge method (para 4.6.1). Strain gages will be applied to the structure of the bays and selected connectors per the AST. Static and dynamic loading will be accomplished at still and fast water bridge sites. Bridge vehicle crossing data (para 4.7.1d) can be collected simultaneously.

d. Bridge Vehicle Crossings. The bridge will be assembled, held in place by BEBs in the required ratio of bays to boats (per FM 5-34 or the TM), and anchored to the two shorelines. Wave staffs will be installed along both sides of the bridge and at selected roadway positions to determine available freeboard as the vehicle crossings are accomplished. The vehicles will cross the bridge initially at low speeds along the centerline of the roadway. The vehicle crossing speeds will be determined by measuring the time taken to traverse the known length of the bridge. Inspections of the anchorage system (para 4.8), BEB lashing, bay latching mechanisms, and deck surfaces will be accomplished after a series of crossings to determine if any deformation or degradation has occurred.

e. Rafting. The designated raft will be assembled. Wave staffs or other freeboard measuring transducers will be installed along the bow of the raft and selected interior locations to determine available freeboard and trim as rafting trials are accomplished. List and trim angle measurements can also be made with inclinometers or a three-axis inertial gyro. Transducers, a Global Positioning System (GPS), and an Advanced Distributed Modular Acquisition System (ADMAS) will be applied to record engine speed of the BEBs and the relative speed of the raft. The water current speed and depth will be measured with a current sensor and depth meter mounted on an auxiliary boat. The auxiliary boat will be anchored for representative current measurements. The BEBs will be configured in both the longitudinal and conventional configurations. The empty raft will undergo a series of maneuvers at a range of speeds and in varying waterway directions to verify stability and control. Testing will continue until the raft becomes unstable or the boats have attained their maximum speed. The stability limits are expressed as zero freeboard along the leading edge of the raft or a trim measurement of 2.9^{o} (1:20 slope) on the deck of the raft. Following empty raft trials, simulated or real vehicle loads will be applied. Simulated loads will be applied with cranes and forklifts. Vehicles will be loaded at low speed and guided onto the raft into their designated position(s). The vehicle parking brakes will be set. Loads should be applied in a balanced or centered fashion for initial trials, and then loads should be applied eccentrically. The load configuration as it was applied to the raft will be documented both with photographs and physical measurements. The loaded raft will undergo a series of maneuvers at a range of speeds and in varying waterway directions to verify stability and control and to record engineering measurements.

4.7.2 Data Required.

a. Launch, Assembly/Disassembly and Retrieval.

(1) Site description (bank slope, height above water, soil type and conditions, water current speed).

(2) Identification of system components tested.

(3) Minimum water depth of free floating components.

(4) Method of launch (free/controlled).

(5) Description of structure assembled (bridge, raft, number of BEBs deployed).

(6) Barge deployment Techniques, Tactics and Procedures (TTP) when used as an intermediate pier set support.

(7) Weather conditions and visibility.

(8) Record of test incidents (TIRs) and corrective actions.

(9) Video of representative launch, assembly, and retrieval trials.

b. Structural Testing, paragraphs 4.6.2b through d.

c. Flotation and Stability.

(1) Reserve buoyancy.

(a) Raft or bridge bay configuration.

(b) Test load configurations and weight (overhead schematic of load placement).

(c) Freeboard measurement locations and schematic.

(d) Freeboard measurements with respect to roadway surface.

(2) Metacentric height.

(a) Raft or bridge bay configuration.

(b) Test load configuration (overhead schematic of load placement), weight and CG.

(c) Load offset distance.

(d) Inclination angle.

d. Bridge Vehicle Crossings.

(1) Paragraphs 4.7.2a(1) through (3) and (5) through (7).

(2) Length of bridge assembled.

(3) Describe anchorage system and method of employment.

(4) Duration of time the vehicles consumed to traverse the bridge.

(5) Freeboard and trim results.

(6) Video of representative bridge crossing trials.

e. Rafting.

(1) Paragraph 4.7.2a(1) through (3) and (5) through (7).

(2) BEB raft configuration (longitudinal/conventional).

(3) Raft loading configuration measurements and photographs.

(4) Current speed and direction.

(5) Water depth.

(6) BEB engine speed and description of maneuver.

(7) Raft speed and direction on waterway.

(8) Freeboard and trim results.

(9) Video and stills of representative rafting trials.

4.7.3 Data Presentation.

Vehicle crossing speeds will be calculated by dividing the bridge crossing times by the length of the bridge. Results of the launch, assembly, bridge/raft loading tests, and disassembly and retrieval trials will be summarized in tables and/or paragraphs. Strain and/or load cell data for the anchoring system components will be compared to the yield strength of the component material(s) to determine conformance to the structural load criteria. The metacentric height of each test configuration will be calculated with the formula listed below. Reserve buoyancy and metacentric height results will be presented in tables and compared to the specification to determine conformance. Freeboard and trim measurements will be compared to the system specification or the Trilateral Test and Design Code, paragraphs 4.5.7 and 4.5.8, respectively, to determine conformance during bridging and rafting operations. Results of the rafting speed and stability tests will be reported in tables and compared to the specification requirements.

$$\text{Metacentric Height} = \frac{\text{Inclining Weight x Offset Distance of Inclining Weight}}{\text{Total Displacement x Tangent of Angle of Inclination}}$$

4.8 Anchorage System.

To prevent the dry or wet gap bridge system from moving excessively on the banks during vehicle crossings, an anchoring system may be employed once the bridge is launched. If not previously tested or certified, the test method in paragraph 4.8.1 will be accomplished to assess the utility and safety of the system. This testing is accomplished simultaneously with bridge performance testing (paragraph 4.6 or 4.7).

4.8.1 Method.

Sections of the anchoring system will be instrumented with strain gages and/or load cells. The anchorage system will be deployed per the system training and TM after the bridge system has been launched at the designated test area. After the anchoring system has been deployed, the position of the bridge on the banks will be identified by means of a marking system or survey techniques. The marker will be used to determine any lateral and longitudinal movement of the bridge due to vehicle crossings. Real-time strain and/or load data will be recorded during vehicle crossings. The anchorage system will be inspected after a series of crossings to determine if the anchors remained secure in the ground, the bridge did not experience excessive movement, and the hardware has remained secure at the bridge connection points. After a series of crossings, the bridge movement will be measured with respect to the reference points.

4.8.2 Data Required.

a. Description of anchorage system and method deployed.

b. Description of instrumentation applied and locations.

c. Bridge ramp position reference locations.

d. Strain and/or load cell amplitude distribution data.

e. Bridge movement, lateral and longitudinal, following vehicle crossings.

f. Results of physical inspections and a record of test incidents (TIRs).

4.8.3 Data Presentation.

Any test incidents and measured bridge movement will be summarized in tables or paragraphs. Peak strain and load data will be compared to the yield strength or rated breaking load of the hardware. Per the Trilateral Bridge Test and Code, paragraph 6.8.5, a safety factor of 3 on the breaking load is required of all steel wire rope cables, slings, and fittings.

4.9 Reliability.

As detailed in the PS and/or SEP, the reliability test is conducted at multiple test sites (dry gap bank configurations, wet gap still, and fast water). Due to the number of missions required to adequately assess reliability, it is likely that the test sites will require maintenance and repair of the banks, traffic roadways and water access ramps during test conduct.

4.9.1 Method.

a. The reliability test is conducted in accordance with the Operational Mode Summary/Mission Profile (OMS/MP), within the capabilities of the test center, and upon approval of the AST. Systems are assembled, deployed, traversed by vehicles, recovered, loaded onto a vehicle or trailer (if not vehicle mounted), and driven a specific distance or time period (per the OMS/MP), and the procedure is repeated for the required number of hours or cycles identified in the PS or SEP. If the system employs a load-handling system (LHS), the AST should consider use of the TARDEC palletized loading system (PLS) LHS simulator.

b. All test incidents should be documented in TIRs. The TIR system operating parameters typically include system operating hours, number of assembly and retrieval operations, number of vehicle crossings (by vehicle type and load configuration), and vehicle/trailer miles.

c. Hardware failures should be documented with photographs. After the damaged or degraded component is removed from the test system, it should be labeled with the system identification number, date, part nomenclature, identification number, and a short description of the test incident.

d. Instrumentation (pressure transducers, thermocouples, fluid flow meters, etc.) can be applied to the transport vehicle(s) and launcher systems to aid in troubleshooting or as desired by the AST and/or system manufacturer.

4.9.2 Data Required.

a. As listed in TOP 1-1-030[21] (TIRs).

b. Time histories of instrumentation applied.

4.9.3 Data Presentation.

a. Reliability calculations and data as listed in TOP 1-1-030.

b. The volume of instrumented reliability data is generally too voluminous to present in the final test report. ADMAS data will be available on the VDLS site. Only representative time histories or summaries will be presented in the report or to aid in reporting specific reliability test failures.

4.10 Durability - Dry Gap Bridging.

Durability testing prior to the development of the ATC BCS was limited in duration (typically 5000 cycles) due to the expense and time required to accomplish the test. The BCS has provided the bridge development, manufacturing, and acquisition community a means to assess the fatigue limit of the structures. Additionally, the Trilateral Design and Test Code, paragraph 4.2.11, refers to a 15-percent impact factor for bending moment and deflection for crossing vehicle speeds of 25 km/hr (15 mph). Since the BCS is equipped with both strain and load control features, the impact factor of each vehicle load and speed can be determined. BCS testing to date has revealed that wheeled vehicle impact factors are approximately 10 percent and tracked vehicle impact factors range from 25 to 50 percent.

4.10.1 Method.

a. Bridge.

(1) Live and Simulated Crossings. Dry gap bridge durability testing is accomplished with a combination of live vehicle crossings and the ATC BCS. The live vehicle crossings conducted during reliability (paragraph 4.9) and bridge and launcher structural testing (paragraph 4.6) partially satisfy the durability requirement. Experience has shown that the majority of bridge failures have resulted from fatigue due to loads and loading conditions. The simulator was designed and fabricated to duplicate the rolling loads produced by the crossing vehicles. The simulator operates through the use of a precisely controlled hydraulic system which reproduces the moment curves or bending stress experienced by the bridge. The appropriate bending stress is determined by collecting strain measurements during actual vehicle crossings (paragraph 4.6). BCS and drive file selection procedures are outlined in Appendix A. The entire bridge structure will be physically inspected a minimum of once per day during BCS testing in

accordance with the Fracture Control Plan designed by the manufacturer and approved by the AST. If desired by the AST, strain and bridge deflection data from the field gages and deflection transducers can be collected for representative crossings on the BCS for comparison purposes.

(2) Impact Factor Measurement. The BCS is controlled by the strain measurements recorded during the field trials (and developed into BCS drive files). The BCS hydraulic cylinders are equipped with load cells. When the BCS is cycled, the loads imparted to the bridge are measured and recorded. To determine the impact factor of the vehicle load, the BCS control is switched to load control. The loads imparted to the bridge structure on the BCS are the same as those generated by the vehicle crossing.

(3) Number of Crossings. The bridge durability requirement (n) will be specified in the PS. Per Trilateral Design and Test Code, paragraph 8.8.4.2, the minimum fatigue test duration shall be 1.5n to satisfy the design life (80-percent confidence level). If successful, the test should continue to increase the probability of success to 95-percent confidence of 95-percent exceedance. If only a single test sample is available for testing, the duration of the test will be 3.8n. If additional samples are provided, a table in paragraph 8.8.4.2 identifies the testing factors. Testing to failure is encouraged to provide a datum point for the evaluators on the stress-cycle or S-N diagram.

b. Launcher. Launcher or launch beam durability is accomplished by launching and recovering a single bridge asset the required number of iterations specified in the SEP. If insufficient test assets or funding are available, a load simulation method can be developed and will require approval from the AST. Care in developing the simulation procedure and method must be taken to incorporate all or a majority of the launcher sequences and loading profiles.

c. NDT Inspection. If not tested to failure, and if desired and funded by the AST, the bridge and/or launcher will undergo an NDT inspection in accordance with TOP 3-2-807 following the required number of crossings or launch/retrieve cycles to verify the structural integrity of the system.

4.10.2 Data Required.

a. Bridge Durability.

(1) Bank configuration and clear span.

(2) Number of vehicle crossings (by vehicle type and load, bank configuration, and vehicle speed).

(3) Number of simulated crossings (by drive file designation and bank configuration).

(4) Measured loads for each drive file.

(5) Physical inspection results.

(6) NDT inspection results (if applicable).

b. Launcher Durability.

(1) Bank configuration and clear span.

(2) Number of bridge launch and retrieval cycles.

(3) Method description, photographs, and number of simulated launcher durability cycles.

(4) Physical inspection results.

(5) NDT inspection results (if applicable).

4.10.3 Data Presentation.

a. Durability. The total number of launch/retrieval cycles and vehicle crossings will be presented in tables. The durability incidents experienced will be summarized in tables.

b. Impact Factors. Load data will be reviewed for each unique drive file test. For a specific point in time, the measured loads recorded in each actuator will be totaled. The measured gross weight of the crossing vehicles will be divided into the measured actuator loads. The ratio between the two represents a time series version of the impact factor. The impact factor has been more traditionally determined by comparing the strain readings under static and dynamic loading in the field.

4.11 Integrated Logistic Supportability (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. The criteria assessed include maintainability, supply support, military lubricants, support and test equipment, technical data/equipment publications (TD/EPs), training and training devices, design for maintainability, and safety and human factors during maintenance. Testing and reporting will be accomplished per TOP 1-1-030.

4.12 Environmental Effects.

Environmental testing encompasses several different areas, including simulated climatic chamber tests, natural environments, and shock and vibration. For the purposes of this document, shock and vibration tests have been addressed in paragraph 4.13. MIL-STD-810G is the primary reference for the test methods. Due to the physical size of some of the bridge systems, the operational tests may be restricted due to the limitations of the environmental chamber(s) available during the test schedule. If a full system deployment or recovery is required by the AST, the system may require transport to a test facility with a chamber of sufficient size or conduct testing in a geographical location possessing the requisite environment. Environmental effects testing of wet gap bridge systems are often limited to the ambient conditions at the test facility. Individual wet gap bridge components, for example, the BEBs and transporters, can often be subjected to the required simulated environments.

4.12.1 Low Temperature.

4.12.1.1 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.

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 lubricant reservoirs. Transducers to measure battery voltage and starter current will be installed. Storage testing will be accomplished in accordance with MIL-STD-810G, Test Method 502.5, Procedure I for a minimum of 24 hrs after lubricant 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 II, Operation, will be conducted. The cold weather kit (CWK) (if applicable) 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 cold weather gloves will be documented. The system will undergo an operational cycle and any test incidents experienced will be documented. The chamber temperature will be increased to ambient temperature. All system components and hardware will be visually inspected to determine if any low temperature degradation or damage was experienced.

4.12.1.2 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 and system temperature time histories.

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

i. Comments regarding the employment of cold weather gloves.

4.12.1.3 Data Presentation.

System operating data will be presented in a table. Engine starting data and temperature time histories will be presented in graphs. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables.

4.12.2 High Temperature.

4.12.2.1 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 stored configuration. Thermocouples will be positioned in the lubricant reservoirs. Storage testing will be accomplished in accordance with MIL-STD-810G, Test Method 501.5, Procedure I, for a minimum of 24 hrs after lubricant 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 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 chamber temperature will be decreased to ambient temperature. All system components and hardware will be visually inspected to determine if any high temperature degradation or damage was experienced.

4.12.2.2 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 and system temperature time histories.

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

4.12.2.3 Data Presentation.

System operating data and test incidents will be presented in a table. Temperature time histories will be presented in graphs. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables.

4.12.3 Humidity (if applicable).

4.12.3.1 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. 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. Following the completion of the operational test, the system will be returned to the stowed configuration 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 will be recorded.

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

f. Record of post-test visual inspection.

4.12.3.3 Data Presentation.

System operating data will be presented in a table. Temperature and humidity time histories will be presented in graphs. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables. Any corrosion during the pretest or post-test inspections will be classified in accordance with the U.S. Army Tank-automotive and Armaments Command (TACOM) Corrosion Rating System[22].

4.12.4 Salt Fog (if applicable).

Test sequence guidance is supplied in MIL-STD-810G, Test Method 509.5, paragraph 2.1.2.

4.12.4.1 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 will be documented.

b. The system will be positioned in the salt fog chamber in the operational configuration. If chamber 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/deployed at the test site to determine if the system suffered any degradation in system function.

4.12.4.2 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 and photographs.

f. Record of post-test operational test.

4.12.4.3 Data Presentation.

System operating and physical inspection data will be presented in a table. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables. All corrosion noted during the pretest or post-test inspections will be classified in accordance with the TACOM Corrosion Rating System.

4.12.5 Fungus (if applicable).

Test sequence guidance is supplied in MIL-STD-810G, Test Method 508.6, paragraph 2.1.2. Recommend to the AST that the test system manufacturer develop a list of all component and subsystem materials that are not included on the fungus-inert list supplied as MIL-STD-810G, Test Method 508.6, Annex B. Manufacturer-specific brand names should be researched to determine the command 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- to 12-in. sample of hose material could be submitted in place of a 50-ft hose line).

4.12.5.1 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.

4.12.5.2 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.

4.12.5.3 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.

4.12.6 Blowing Rain.

4.12.6.1 Method.

Due to the physical size of most bridge systems, documenting the natural rainfall and wind conditions experienced during reliability testing may be sufficient to satisfy the blowing rain criteria. If not, the rain and wind generation structures should be positioned adjacent to all engine and hydraulic power units and electrical control and instrument panels.

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 system will be positioned at the rain test facility in the operational configuration. 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 or subsystem of the test system is exposed to blowing rain, the system will be inspected and operational data will be recorded. All instrument and electric control panels will be inspected to determine if water penetrated the housings. Lubricant samples will be drawn and submitted to the chemistry laboratory for water analysis.

4.12.6.2 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. Post-test operational check results.

g. Post-test lubricant sample water analysis results.

4.12.6.3 Data Presentation.

System operating results will be reported in a paragraph. Inspection and lubricant water analysis results will be documented in TIRs and summarized in paragraphs or tables.

4.12.7 Blowing Sand and Dust (if applicable).

Test sequence guidance is supplied in MIL-STD-810G, Test Method 510.5, paragraph 2.1.2. Testing for sand and dust would generally only apply to vehicle mounted or launched systems.

4.12.7.1 Method.

a. A pretest functional or operational test will be conducted to baseline the system. All nonfunctional components or subsystems should be repaired or documented. TOP 1-2-621[23] provides guidance for sand and dust tests conducted in an outdoor environment.

b. Blowing Sand. The system will be positioned at the sand and dust test facility in the operational configuration. 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 $\pm$ 0.3 g/m^3 (for material used or stored unprotected near operating surface vehicles), and the wind speed will be 18 $\pm$ 1.3 m/s (40 $\pm$ 3 mph). After each side of the system is exposed to blowing sand, the system will be inspected. Particular attention will be given to inlet air filters to determine when the filters are saturated and require cleaning or replacement. A post-test operational test will be accomplished.

c. Blowing Dust. The system will be positioned at the sand and dust test facility in the operational configuration. 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 $\pm$ 7 g/m^3, and the wind speed will be 8.9 $\pm$ 1.3 m/s (20 $\pm$ 3 mph). After each side of the system is exposed to blowing dust, the system will be inspected. Particular attention will be given to inlet air filters to determine when the filters are saturated and require cleaning or replacement. A post-test operational test will be accomplished.

4.12.7.2 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 and operational tests.

4.12.7.3 Data Presentation.

Inspection and pretest and post-test operating results will be documented in TIRs and summarized in paragraphs or tables.

4.13 Transportability.

4.13.1 Method.

a. As listed in TOP 1-2-500[23], plan to test all of the system stowage and transport configurations (i.e., truck, trailer, container). If the test system is within the gross weight and CG parameters of historically tested systems transported in/on type classified trucks and trailers, a majority of the safety-related road testing (braking, steering and handling) will not require repeating. If the road march profile is not included in the OMS/MP for the system, the transport truck or trailer profile should be used.

b. Rough Handling or 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)), the drop test associated with the designated container will be performed. For example, the 20-ft ISO drop test requirements are specified in American Standard Test Method (ASTM) E 1976-05[24], paragraph 7.22.

c. Following all transportability tests (rail impact, road, airdrop), an operational test will be accomplished to verify system functionality.

d. Shock and vibration data may be collected during selected transportability tests to assist in defining the system environment.

4.13.2 Data Required.

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

b. Results of post-test operational tests (when applicable).

4.13.3 Data Presentation. As listed in TOP 1-2-500.

4.14 Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) (if applicable).

4.14.1 Method.

a. As listed in TOPs 6-2-542[25] (EMI) and 6-2-560[26](EMC), specific radiated and conducted emissions and susceptibility tests will be accomplished as detailed in the PS and per MIL-STD-461E.

4.14.2 Data Required.

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

4.14.3 Data Presentation.

As listed in TOP 6-2-542 (EMI) and 6-2-560 (EMC). Inspection and system operating results documented in TIRs will be summarized in paragraphs or tables.

4.15 High-Altitude Electromagnetic Pulse (HEMP), Near Strike Lightning (NSL), and Electrostatic Discharge (ESD) (if applicable).

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 task the NAWC or WSMR contact to supply a test plan and report for their test efforts. HEMP testing, data analysis and reporting will be accomplished in accordance with MIL-STD-461E, Test Method RS105. NSL and ESD testing will be accomplished in accordance with MIL-STD-464[27].

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

CBRCS testing is the responsibility of the West Desert Test Center (WDTC) at 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 test plan and report documents.

4.16.1 Method.

CBRCS can be addressed in three ways. The choice of method should be coordinated with the system developer and evaluator. The majority of bridge system programs are addressed with a paper study.

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 nuclear, biological, and chemical (NBC) Contamination Survivability Criteria for Army Materiel[28] and Army Regulation (AR) 70-75[29]. 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[30]. Larger systems will be tested in a surety chamber in accordance with TOP 8-2-510[31].

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[32]. Data will be acquired on the effects of chemical agents and the 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 three-dimensional (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.

4.16.2 Data Required.

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

4.16.3 Data Presentation.

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

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. ATC BRIDGE CROSSING SIMULATOR (BCS) PROCEDURES.

1. BCS System Description. The BCS uses a computer-controlled hydraulic load actuation system to impart simulated crossing loads onto an entire bridge structure undergoing fatigue test simulation. The BCS with the 40-m dry support bridge (DSB) installed is shown in Figure A-1. The BCS accomplishes this using a load sequencing process that mimics the traversing load that a crossing vehicle imposes on a bridge structure. The traversing nature of the load ensures that the induced shear load and bending moment have parity with the real-world events upon which the simulation is based. The loads are imposed on the bridge by hydraulic actuators acting on specially designed load distribution whiffles that recreate a military vehicle footprint. The BCS end supports, on which the ends of the bridge under test are supported, can each be rotated to a lateral slope of 5 percent in both directions. This allows the geometry of the bridge on the BCS to reproduce the geometry of the bridge on laterally sloping or racked embankments.

Figure A-1. 40-m DSB on ATC BCS.

2. BCS Configuration. The bridge gap will be set at the clear span of the test system, with a 1-m length of each end of the bridge supported on an oak surface secured to the BCS load frame. The number of load stations applied will be dependent on the length and configuration of the bridge. Each load station consists of one whiffle assembly connected to two hydraulic actuators (one hydraulic actuator on each side of the bridge). The contact surface for load application on the bridge consists of M1A1/A2 track pads. The track pads are located in rectangular groups comprising bridge contact pads. The lateral spacing of the pads is equal to the lateral spacing of the track on an M1A1/A2 main battle tank (MBT). The longitudinal spacing of the pads is such that each pad is approximately equally spaced along the length of the bridge. Drawings illustrating a representative whiffle assembly footprint on a bridge surface are provided in Figures A-2 and A-3.

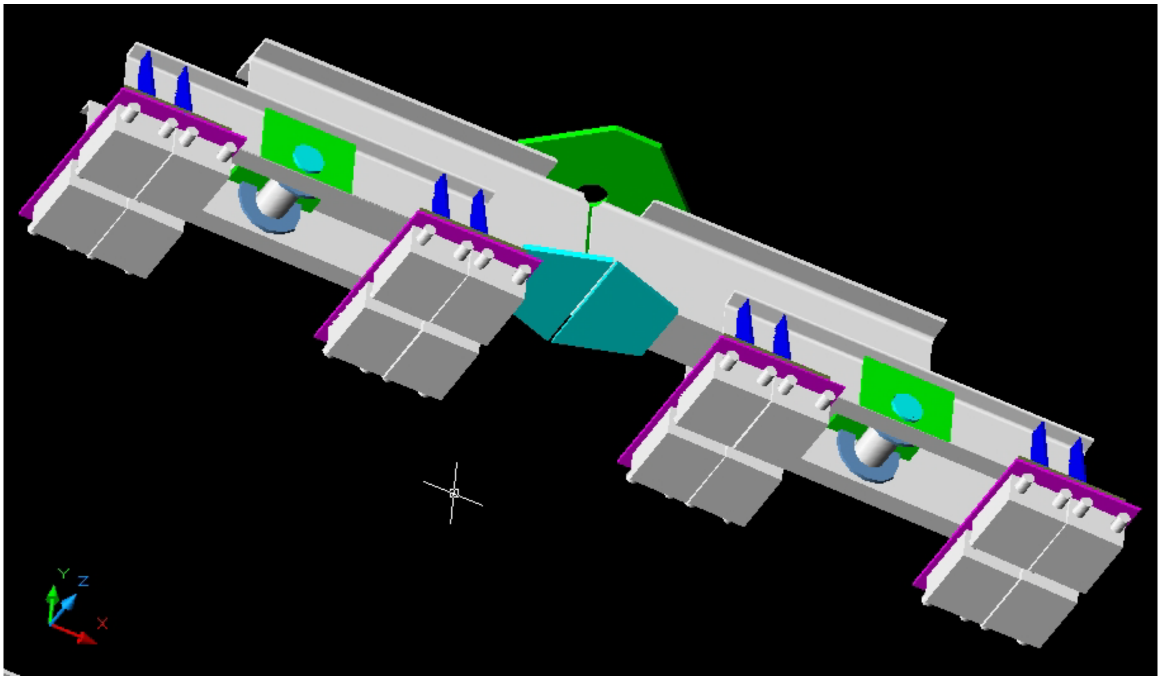

Figure A-2. Drawing of half of one whiffle assembly (left or right side), showing the rectangular contact pads that contact the bridge surface during test.

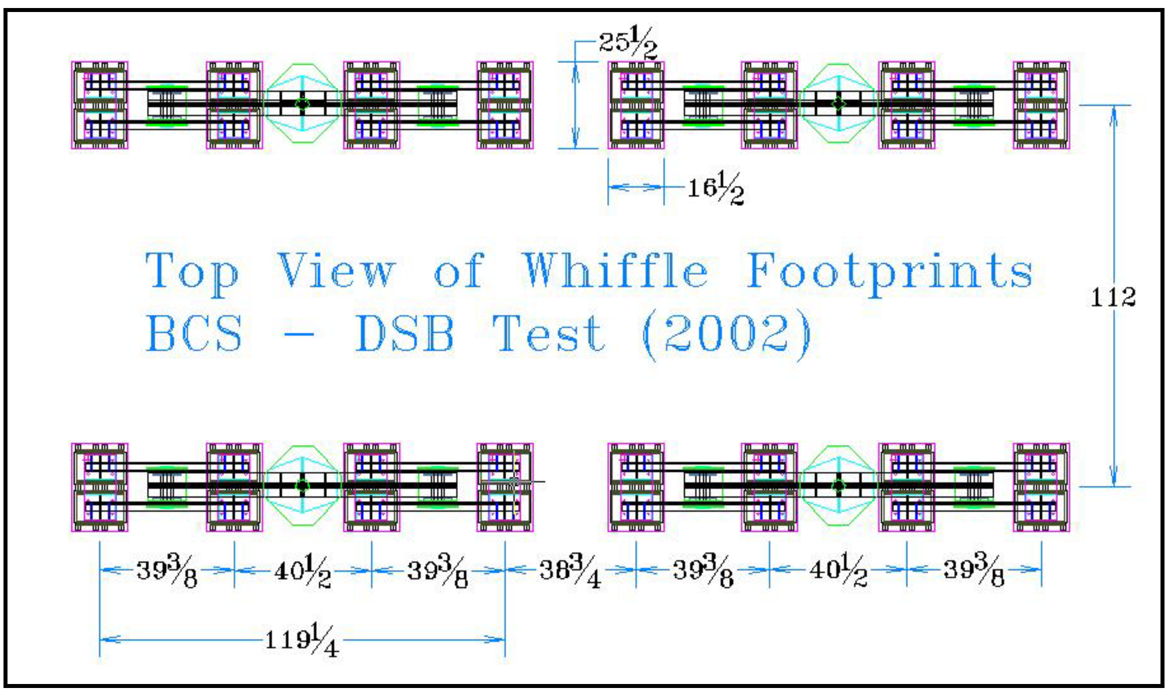

Figure A-3. Drawing showing the contact pad spacing used during a previous test program. The contact pads and part of two whiffle assemblies are depicted, but the interconnecting whiffle assembly structure is not shown. The eight pads on the left (or right) side are connected to one whiffle assembly. The bridge would be oriented left-to-right under the whiffles. Dimensions are in inches.

3. BCS Control and Operation. The BCS uses proprietary software to control the hydraulic actuators that impose the simulated crossing loads on the bridge. The software possesses a learn mode capable of formulating the required sequence of hydraulic actuator loads to match the strain from live vehicle crossings at locations where strain gages on the bridge feed signals back to the control system. In learn mode, the software causes the BCS to match the relative time histories of the pertinent strains and in this manner create simulated bridge crossings. The test instrumentation suite uses strain feedback to the BCS controller. Each of the channels corresponds to a strain gage adjacent to a load actuator laterally in line with the actuator. When the simulated bridge crossing is created in learn mode, the software creates a load file containing the sequence of hydraulic actuator loads used to match the strains. This load file becomes the drive file that represents a specific live vehicle crossing for the BCS. Each drive file is associated with the crossing vehicle type and speed and the gap geometry used during a live crossing. After the creation of the drive files, test simulations are conducted to ensure that the proper fatigue is induced during the simulation. The BCS control system is capable of adjusting the drive file by a selected load factor such that all actuator loads are adjusted throughout the simulated crossing by the given factor. In this manner the drive files can be "fine tuned"; this method is used to match fatigue life due to the strains from the simulation with those from the live crossing. The fatigue life analysis is performed using external fatigue life analysis tools.

4. BCS Drive File Selection. Instrumented data from live field crossings of rated MLC tracked and wheeled vehicles acquired for the various dynamic conditions tested are employed. Only date files with a complete set of data (all load actuator strain channels functional) are selected. The crossings are segregated into categories, with each category corresponding to vehicle type and gap/embankment geometry. The data is provided to U.S. Army Materiel Systems Analysis Activity (AMSAA) for further analysis and selection of representative data runs. The AMSAA analysis consists of plotting the data from each category in the format of fatigue life of the most critical location versus vehicle crossing speed. Clusters of data are identified on the plots and the crossings that correspond to the average fatigue life of the regime are identified within the cluster. Each cluster is represented by the single crossing that coincided with the average of the fatigue lives repeated for as many times as there are runs in the cluster. The net effect of the grouping is to reduce the number of individual drive files executed during the simulation. The same procedure is repeated for each vehicle type and gap/embankment geometry. A distribution of simulated bridge crossings by vehicle type and crossing conditions are proposed to the AST in the form of a matrix. The matrix is used to define the number of iterations to perform each selected crossing during the simulation.

APPENDIX B. DATA FORMS

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

Evaluated By (Name): ______________________ (First) (M.I.) (Last)   Date: ________________ (Day) (Mo) (Yr)

Rank/Grade: _______   MOS/Job Title: ____________   Experience: ______________ (Yr) - (Mo)

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.

APPENDIX C. GLOSSARY.

Term	Definition
BCS	Simulates the rolling loads applied by a moving vehicle with a system of hydraulic actuators and loading fixtures.
Metacentric height	The vertical distance between the CG of the floating bridge section or assembly and the metacenter of the section or assembly. The metacenter is the point about which the assembly's center of buoyancy rotates about the roll axis for small angles (0 to 4^{o}).
MLC	A standard system in which a bridge or raft is assigned class number(s) representing the load it can carry. Vehicles are also assigned number(s) indicating the minimum class of route, bridge, or raft they are authorized to use.
MLC load simulator	A steel box mounted on I-beams to simulate the footprint of a tank. The curb weight of the box is 16,020 kg (35,320 lb). The mass of the simulator is increased by adding water. Two large drains can be manually opened to disperse the water in the event the test system stability or structure is compromised.
Reserve buoyancy	That part of the volume of a floating bridge section or assembly which is above the water surface and is watertight, so that it will increase buoyancy (upward pressure on a floating object) if the section or assembly sinks deeper into the water.
Span	The design span is the distance between the reaction point of the bank seats at each support of the bridge. The clear span is the gap to be bridged.
Trim	The angle of inclination of a floating assembly in the water by the arrangement of cargo.

APPENDIX D. ABBREVIATIONS.

3-D	three-dimensional
ADACS	Automated Data Collection System
ADMAS	Advanced Distributed Modular Acquisition System
AMSAA	US Army Material Systems Analysis Activity
AR	Army Regulation
AST	Acquisition Support Team
ASTM	American Standard Test Method
ATC	US Army Aberdeen Test Center
BCS	bridge crossing simulator
BEB	bridge erection boat
BII	basic issue items
CBR	chemical, biological, and radiological
CBRCS	chemical, biological, and radiological contamination survivability
CBRCSA	CBRCS assessment
CG	center of gravity
CWK	cold weather kit
DA	Department of the Army
DAQ	data acquisition
DPG	US Army Dugway Proving Ground
DSB	Dry Support Bridge
DTC	US Army Development Test Command
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EMITF	Electromagnetic Interference Test Facility
ESD	electrostatic discharge
FM	Field Manual
GPS	Global Positioning System
HEMP	high-altitude electromagnetic pulse
HFE	human factors engineering
HSL	helicopter sling load
ILS	integrated logistic supportability
ISO	International Standards Organization
JHA	job hazard analysis
LHS	load-handling system
LVDT	linear vertical displacement transducer
MBT	main battle tank
MCRP	Marine Corps Reference Publication
MHE	material-handling equipment
MLC	military load classification
MOPP	mission-oriented protective posture
MSDS	Material Safety Data Sheet
NATO	North Atlantic Treaty Organization

ABBREVIATIONS CONT'D

NAWC	Naval Air Warfare Center
NBC	nuclear, biological, and chemical
NDT	nondestructive test
NET	new equipment training
NSL	near strike lightning
ODIN	Observer Data Input Nexus
OMS/MP	Operational Mode Summary/Mission Profile
pH	potential of hydrogen
PLS	palletized loading system
PPE	personal protective equipment
PS	Performance Specification
RFTS	Request for Test Services
RH	relative humidity
SAR	Safety Assessment Report
SEP	System Evaluation Plan
STANAG	Standardization Agreement
TACOM	US Army Tank-automotive and Armaments Command
TARDEC	US Army Tank-Automotive Research, Development and Engineering Center
TD/EP	technical data/equipment publication
TDTC	Trilateral Test and Design Code
TIR	Test Incident Report
TM	Technical Manual
TOP	Test Operations Procedure
TSP	test support package
TTP	Techniques, Tactics and Procedures
USANCA	US Army Nuclear and Combating Weapons of Mass Destruction Agency
USMC	US 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.

Note: The references listed herein were the most recent versions prior to publishing this TOP. The most recent version should be employed unless superseded by test item requirement documents.

1. MIL-STD-810G, Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests, 31 October 2008.

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7. Trilateral Design and Test Code for Military Bridging and Gap Crossing Equipment, January 2005.

8. FM 5-34/MCRP 3-17A, Engineer Field Data, July 2005.

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10. TOP 2-2-800, Center of Gravity, 26 September 2006.

11. TOP 2-2-801, Weight Distribution and Ground Pressure (Wheeled and Tracked Vehicles), 26 September 2006.

12. TOP 1-1-060, System Safety Engineering, 7 April 1986 (change 1, 12 September 1986).

13. TOP 10-2-508, Safety and Health Hazard Evaluation - General Equipment, 6 May 1980.

14. MIL-STD-1472F, Department of Defense Design Criteria Standard Human Engineering, 23 August 1999.

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27. MIL-STD-464, Department of Defense Interface Standard, Electromagnetic Environmental Effects Requirements for Systems, 18 march 1997.

28. Department of the Army (DA)-Approved NBC Contamination Survivability Criteria for Army Materiel, U.S. Army Nuclear and Combating Weapons of Mass Destruction Agency (USANCA), 30 May 2005.

29. AR 70-75, Survivability of Army Personnel and Materiel, 10 February 1995.

30. TOP 8-2-111, Nuclear, Biological and Chemical (NBC) Contamination Survivability, Small Items of Equipment, 24 April 1998.

31. TOP 8-2-510, NBC Contamination Survivability, Large Item Exteriors, 17 April 1998.

32. TOP 8-2-061, Decontaminating Apparatus, Portable, 19 November 2002.

REFERENCE FOR INFORMATION ONLY

a. ASTM D610-08, Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces, 2008.

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-WF-E), US Army Aberdeen Test Center, 400 Colleran Road, Aberdeen Proving Ground, MD 21005-5059. 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.