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DESERT ENVIRONMENTAL TEST OF GENERAL SUPPLIES AND EQUIPMENT

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13. ABSTRACT

Describes a method for evaluation of general supplies and equipment operational and functional performance characteristics. Discusses preliminary operations, facilites, and equipment required. Provides procedures for exposure, performance, security from detection, maintenance evaluation, safety, and human factors. Appendixes define classes of supplies.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Environmental Control System						
Optical Instruments						
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Marine Equipment						
Waterway Equipment						
Desert Environmental Tests						
General Supplies and Equipment						

U. S. ARMY TEST AND EVALUATION COMMAND
ENGINEERING TEST - COMMON TEST OPERATIONS PROCEDURES

AMSTE-RP-702-109
Test Operations Procedure 10-1-004 2 October 1972

DESERT ENVIRONMENTAL TEST OF GENERAL SUPPLIES AND EQUIPMENT

SECTION I
GENERAL

1. Purpose and Scope. To describe procedures, equipment and methods for determining the capability of general supplies and equipment to withstand exposure, and subsequently function safely and efficiently in a desert environment. "General supplies and equipment" includes a wide variety of materiel types; such diverse items as combat uniforms, drafting equipment, electric fans, steam boilers, cameras, body armor and life rafts are included. A complete list may be found in Volume 10 of the Test Operations Procedures. For this document, a desert environment is defined as Climatic Category 4 or 5 in AR 70-38, "RDT&E of Materiel for Extreme Climatic Conditions," 5 May 1969; these are hot-dry and intermediate hot-dry climates.

Because of the variety of materiel included under the broad term "general supplies and equipment," two approaches are taken to the testing procedures. Exposure tests are approached from the material standpoint - textile, plastic, rubber, glass, metal and similar basic materials. Functioning tests are based on the item or system.

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The test procedures permit evaluations of the technical, engineering characteristics of the material or item from the Army-use viewpoint, as the material or item is affected by the desert environment. The procedures are designed to obtain quantitative data using identifiable and, where possible, controllable and reproducible parameters. They are designed to reveal deficiencies and will usually identify the cause of the deficiency.

2. Background. Materiel deployed or intended for combat use or combat support in desert areas may be uniquely stressed by the environment. The stress may be so extensive that dependability, serviceability, safety, maintainability and ultimately the success of a military operation may be jeopardized. The materials of manufacture and the resulting items must be chosen and designed to withstand desert environmental stresses whenever they are designated for use on a worldwide basis. Although many of these stresses are known in advance and can be reproduced in the laboratory, it is difficult to impossible to reproduce them all simultaneously, therefore testing in the natural desert environment is necessary to provide assurance that the materiel will function as intended during desert operations.

Field environmental test costs may be reduced by requiring that the item indicate a reasonable possibility for successful operation under hot-dry laboratory conditions prior to the desert field tests. The test of an individual piece of equipment may often be advantageously conducted as part of the test of a complete system.

Some of the test procedures detailed in this document duplicate, under hot-dry conditions, the tests performed in intermediate climates. The basic procedures are set out in common TOPs/MTPs, and in established procedures used in industry. The observations and data gained from desert field tests are not always directly comparable with observations and data gained from intermediate-climate or simulated-environment tests. An interaction of desert environmental factors may affect materials and materiel in ways that are not predictable.

The guidance contained in this TOP does not constitute a complete and detailed test plan. A test plan for desert field testing of a specific item may be developed from this TOP; the test planner must make his own judgment as to the applicability of each procedure, and must determine how best to obtain the required data for his particular materiel.

3. Equipment and Facilities. In addition to equipment and instruments required for testing the commodity item under standard or normal climate conditions, the following special equipment is required:

a. Temperature measuring and recording devices.

b. Sunlight intensity meters.

c. Solar radiation measuring equipment.

d. Dust sampling and analyzing equipment. The instruments for analysis should be capable of chemical and physical property determinations, plus measurements of dust concentration in milligrams per cubic meter. The sampling procedure, frequency and sample size must be determined from the exposure conditions the item will experience in its life cycle.

If the materiel is susceptible to degradation by the action of microorganisms, a biological examination of the sample must be considered.

Yuma Proving Ground (YPG) has been designated the U.S. Army desert climate proving ground. Yuma Proving Ground provides roads, test areas, terrain, climate, vegetation, and insect and animal life similar to those found in the other hot-dry desert areas of the world and the special facilities required for desert environmental testing.

SECTION II
TEST PROCEDURES

4. Pretest. In the evaluation and reporting of test results, it is important to know when a failure occurred. In some cases, a failure may occur prior to receipt of the test items at the TECOM test installation. The "as received" condition of the test items must be determined and made part of the technical record before testing begins. Pretest procedures include determination of sample sizes, the initial inspection, and identification of the test items. Because physical characteristics can economically be determined concurrently with the initial inspection, these procedures are included in this phase of the test.

a. Sample Size. Two factors are of particular importance:

(1) Each sample must contain a statistically significant number of items.

(2) Control items are used to aid in identifying and isolating factors.

Other factors in sample size determination are the cost of the item and the time required for the various tests. Methods to be used, data requirements and an analytical plan are presented in appendix A of MTP 4-4-001. The plan for exposure and performance tests (number of items and procession) should be established.

b. Identification of Test Items.

(1) Objective: Proper sample identification. This identification is an important factor in reducing the error of misidentification during testing; it facilitates control of the samples during the life of the test.

(2) Method: A system should be devised and the identifier applied to each item as it is selected at random from the total sample. The identifier should be selected and applied before the initial inspection. Each item should have a unique identifier, usually letters, number, colors or some combination. Do not, for example, merely paint all the control items green. Overpacks and containers should be identified, and this mark transferred to the contents of the container when it is opened. Markings must be legible and permanent.

(3) Data required at this point is a permanent log of the identifiers against the sampling plan.

(4) No analytical plan is required for these data.

c. Initial Inspection and Physical Characteristics

(1) Objectives:

(a) To determine the condition of the items as received.

(b) To determine that all the items, ancillary equipment, publications and maintenance packages (as required) are present.

(c) To determine that all test and related items are correctly assembled, properly labeled, and ready for test.

(d) To determine that physical dimensions and characteristics conform to the applicable military specifications.

(2) Method (accomplished in sequence):

(a) Mark the overpack with the proper identifier.

(b) Inspect the overpacks in accordance with appendix B of MTP 4-4-001, and MTP 10-3-500.

(c) Uncrate the overpacks in accordance with MTP 10-3-500.

(d) Mark individual containers with the proper identifier. If individual containers are not used, proceed to step (g).

(e) Inspect the individual containers in accordance with appendix B of MTP 4-4-001. Record defects and photograph them to supplement the record.

(f) Remove the item from its individual container and mark it with the proper identifier. If containers are secured with an irreplaceable seal, remove only the control samples and those items which will be instrumented for exposure tests.

(g) Inspect the items in accordance with the applicable commodity TOP/MTP. Record defects and photograph them to supplement the record.

(h) Correct defects, if possible. If a defect is considered critical and cannot be remedied, remove the item from the test. Clean the item and lubricate or add preservatives as specified in the maintenance instructions. Note: Items removed should be held for disposal as directed by the responsible agency.

(i) Repack items in accordance with the planned exposure tests (para 5). Do not repack items which will be instrumented for exposure tests; these items will be used for determining physical characteristics. To determine physical characteristics: (1) measure and record pertinent exterior and interior dimensions, such as length, width, diameter, cavity depths, etc; (2) weigh and record weights of the complete test item and major components; (3) record the color and surface finish of the various components of the item; (4) any other physical measurements which may assist in the evaluation of the item should be made at this time, such as center of gravity, and (5) any characteristics specified in the required document.
Note: Photographs, preferably in color, should be taken at this time with corresponding color from the federal standard color chart or other acceptable standard.

(3) Data Required.

(a) Packing. Record the data in accordance with MTP 10-3-500, paragraph 6.3, and include the test item identifier.

(b) Test Item. Record the data in accordance with MTP 10-3-500, paragraph 6.3, and include the test item identifier.

(4) Analytical Plan. The data should be summarized to simplify analysis upon completion of the test. Presentation should include the percentage of packages and items which had no defects, minor defects, and major defects. Corrective measures which were applied should be clearly noted. Impact on failure to meet specified characteristics or overall suitability will be evaluated.

5. <u>Exposure Tests</u>.

a. Objective: To determine the ability of general supplies and equipment to withstand exposure to the desert environment.

b. Method: Because there is no standard for these tests, the test planner must exercise judgment for their scope and severity based on Army use of the item. One approach is the "stockpile-to-use" flow outlined in figure 1. This TOP will not consider the temperature or maritime environments of the CONUS Depot, Ocean Transportation, or Communication Zone Depot (CZD). The exposure tests will begin with road transportation on the premise that this type of exposure will be the first experienced by the materiel in a hot-dry climate. At least one test item (non-control sample) should be properly instrumented for each exposure mode. An item may be instrumented to furnish both transportation and storage data; that is, both temperature and shock measuring devices may be attached.

(1) Road Transportation Exposure. All items will be moved by wheeled cargo carriers over paved and secondary unpaved roads. Packing modes for vehicle loading will be consistent with normal practice for the commodity involved. Minimum mileages recommended: 150 miles on paved roads, 450 miles on secondary roads. The following procedures should be followed:

(a) Transport the test items over the primary and secondary roads until minimum mileages have been accumulated.

(b) Unload the test items from the transport vehicle and remove from containers, if applicable.

(c) Inspect the containers and the items in the manner indicated in paragraph 4.3.b.

(d) Remove items damaged during transportation which are unfit for further testing.

(e) Maintain critical observation of handling experiences occurring during loading, transporting, unloading and unpacking. Evaluate circumstances in the procedures which may result in damage to the test items.

(f) Photograph all damaged packages or test items.

(2) Forward Depot Storage Area Exposure. Items selected for this test will be instrumented to provide the desired temperature data. Thermocouples should be located to measure the temperature of (as applicable):

Overpack skin	Container skin
Container interior air	Test item skin
Critical component skin	Explosive or toxic component

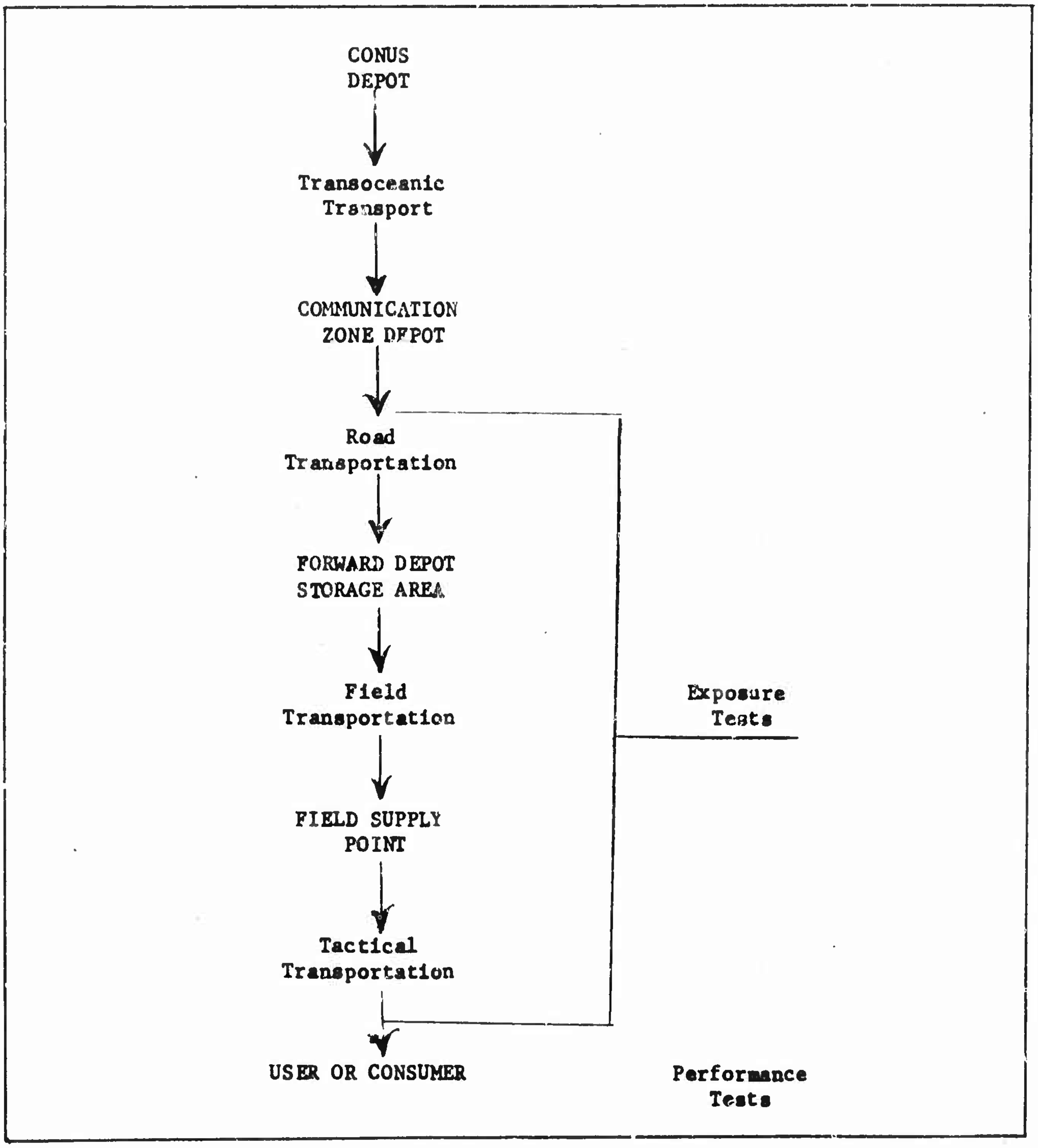

FIGURE 1. Stockpile-to-Use Flow, General Supplies and Equipment

Test items should be stored in a manner consistent with normal practices as described in applicable field manuals. This includes adequate dunnage, separated stacks, pallets, and proper shelter with provision for natural ventilation. Vehicular traffic should be routed upwind of the storage area, with a minimum of 120 vehicles passing during the storage period. The vehicular roadways should be unpaved, if possible.

(a) All test items should be exposed, if time and prevailing temperatures permit, to 9300 degree-hours over 90°F. Generally, this exposure will require about 40 to 60 days at Yuma Proving Ground during June and July. Note: An explanation of the degree-hour calculation is contained in appendix A.

(b) Upon completion of this test, visually inspect the containers and the items in the manner indicated in paragraph 4.3.b, conduct basic operational checks to verify satisfactory operation (or condition) of the test items, and photograph all damaged (deteriorated) packages and test items.

(3) Field Transportation Exposure Test. All items will be moved by wheeled cargo carriers over tertiary (unpaved, single lane) roads or trails. Vehicle speed will be restricted to that safe for the operating crew. Packing will be as for the road transportation exposure test (above), with a minimum of 70 miles travelled. The test will be conducted as shown in paragraph 5.b(1), except for road class and mileage.

(4) Field Supply Point Exposure Test. This test should be accomplished in the same manner as the forward depot storage area exposure test (para 5.b(2)), except that 4450 degree-hours of exposure in 15 to 30 days should be the desired goal. At Yuma Proving Ground, this temperature stress can be expected to be reached during August.

(5) Tactical Transportation Exposure Test. This portion of the exposure tests is done on cross-country trails from point to point, and the items are carried in the type of vehicles organic to the using unit. For this reason, the tactical transportation test varies in the carrier used. Light tactical vehicles may be used for most Class I items (reference appendix B for classification categories): individual or lightweight, unit-issue Class II items; and limited quantities of Class III material. Heavy tactical or utility vehicles may be used for heavy, unit-issue Class II items; bulk quantities of Class III items; and most Class IV items. Combat vehicles may be used for transporting Class I and II items such as are issued for crew members, and supplementary quantities of Class III supplies. A recommended vehicle utilization is shown in table 1. The actual vehicle selected must be

determined by the type of the test item, its physical dimensions, and the availability of vehicle types. An integral sample should not be divided between vehicles or between missions. Packing modes should follow Army-use practices for combat zones. Recommended minimum mileages are shown in table 2.

Upon completion of this test, perform the same post-test procedures as shown in paragraph 5.b(2).

(6) Air Transportation and Delivery. If required, air transportability and air delivery tests will be conducted in accordance with MTPs 7-2-506 and 7-2-509. Tests should be conducted on a separate sample, independent of the exposure tests described above. Air delivery samples, may, however, be subjected to the Forward Supply Point exposure tests prior to their air drop.

TABLE 1. RECOMMENDED VEHICLES FOR TACTICAL TRANSPORTATION TEST

Class of Item* and Type	LTU** (1) (up to 1-1/2 T)	HTU** (over 1-1/2 T)	CV**
Class I	X	X	X (2) (3)
Class II	X	X	X (2) (3)
Class III			
up to 5-gallon units	X	X	X (2) (3)
over 5-gallon units	-	X	-
Class IV	(4)	X	X (2) (3)
Class V	X	X	X (2) (3)
Class VI	X	X	-
Class VII	(4)	X	-
Class VIII	X	X	-
Class IX	X	X	X (2) (3)
Class X	X	X	-

*See Appendix B for definition of Supply Classes
**LTU - Light/Tactical Utility, generally wheeled
HTU - Heavy/Tactical Utility, generally wheeled or tracked
CV - Combat Vehicles (tanks, SP guns, APC), generally tracked

NOTES: (1) Includes SP vehicles, which should be used only when designed for the commodity under test.
(2) Used only if commodity design for use with combat vehicles.
(3) If samples available, consider conduct in conjunction with other tests.
(4) If probable transport under combat zone conditions is by this vehicle type, use in lieu of others.

TABLE 2. MINIMUM MILEAGES FOR TACTICAL TRANSPORTATION TEST

	Type of Vehicle (2)								
	Light Tactical/ Utility			Heavy Tactical/ Utility			Combat		
Desert Type (1)	S	G	N	S	G	N	S	G	N
Terrain									
Mountain/Hills	20	20	--	10	10	--	10	10	--
Flats/Washes	15	20	15	10	15	10	5	10	5
Dune Fields	--	--	20	--	--	10	--	--	10
Dust Course	--	--	5	--	--	5	--	--	5
Total	35	40	40	20	25	25	15	20	20

NOTES: (1) S-Stony, G-Gravelly, N-Sandy. Ref. MTP 10-1-003.
(2) If racks provided on the vehicle, place items in their individual containers in the racks.

c. Data Required.

(1) Initial Inspection and Physical Characteristics.

(a) Packing: Data in accordance with MTP 10-3-500, paragraph 6.3.2.

(b) Test Item:

Test item identifier (control numbers).

Description of any discrepancies for each test item. Take photographs as required.

Adequacy of instructions for unpacking and assembling.

Adequacy of tools.

Condition, legibility, and adequacy of markings.

Time and location of inspection.

(c) Maintenance accomplished.

(d) Physical characteristics data to include exterior and interior dimensions, weights of the test item and major components, and color of test item.

(2) Exposure Tests.

(a) Transportation: Data at 15-minute intervals during testing to include:

Ambient air temperature (±2°F.).

Thermocouple readings (±2°F.).

Vehicle mileage.

Shock environment to which the test item is exposed (0-20 g, ±0.2 g) whether as a count of the times certain levels are exceeded, or a continuous record of the shock/vibration.

Course description (nomenclature plus topographic details from maps or surveys).

Time (±1 minute).

Vehicle speed (±5 miles per hour).

(b) Storage. Record the following:

Description of the test site.

Evidences of deterioration, including location on test item, probable effects of deterioration on test item performance, and action taken to alleviate the condition.

Deficiencies attributable to exposure.

Environmental data at hourly intervals throughout the storage and emplacement subtests to include ambient air temperature (±2°F.); ground temperature (5 cm below surface; ±2°F.); thermocouple readings (±2°F.); and relative humidity (±5 percent).

Environmental data continuously throughout the storage and emplace subtests, to include precipitation (±0.01 inch); wind speed (±5 miles per hour); wind direction (±10°); and solar radiation (±1.0 gm cal/cm^2).

(1) Marking test data for identification and correlation.

(2) Organizing data into tabular and graphical form.

(3) Modifying data to correct for nonstandard conditions.

(4) Determining the statistical variation of the results in terms of the average value and standard deviation of the particular quantities, the correlation among two or more quantities, etc.

(5) Converting units of measured parameters to units of measure as expressed in applicable criteria or test item specifications.

It is noted that the requirements document serves to define the types and characteristics of the raw test data, and the ultimate objective of the test program defines the form of the test data desired. Specific instructions for the reduction and presentation of individual subtest data are outlined in subsequent paragraphs.

Storage Exposure Tests.

(a) Data from thermocouple and meteorological instrumentation shall be summarized graphically for the total test period as follows:

Monthly summaries of ambient air temperature and ground temperature, wind velocity and direction, relative humidity, and solar radiation.

The data stated above at hourly intervals for a 24-hour period, showing most extreme and mildest days and representative day during the exposure period.

Test item thermocouple readings, keyed to ambient air temperature and ground temperature and plotted in the manner of the monthly and daily presentations.

NOTE. Wind measurements are specified at 300 cm as being most applicable for this class of military item. Use of this criteria will correlate directly with ambient temperature measurements. However, if a requirement exists for conformance to AR 70-38 or MIL STD 210, criteria for a wind measured 10 feet above the surface, the following conversions must be made:

surface, the following conversions must be made:

Height:	Ft	2		5	10		15
	cm		100		300	400	
Ratio to 10 ft							
wind		0.71	0.81	0.89	1.00	1.05	1.07

(b) In addition to the above, presentations will be prepared as required to illustrate circumstances relating to malfunctions or failures attributable to particular environmental stresses.

Transportation Exposure Tests.

Climatic data shall be presented as discussed above. Shock and route data will be summarized graphically to show the shock environment, test item temperature and air temperature as a function of mileage. The counts/traces will be annotated to show time of day and start and finish of the various terrain courses.

6. Performance Tests.

a. Objective. To assess the effects of desert exposure and transportation on the test items. To determine the level of performance of the test items after exposure to the desert climate, and transportation over desert terrain.

b. Method.

(1) Items which have been left in sealed containers will be removed and identified. Bulk items (lubricants, rations, fuels, etc.) will be broken down to the quantities for individual performance tests, and their containers identified.

(2) Physical measurements of selected samples may be made to determine changes resulting from exposure tests.

(3) Items which are component parts will be assembled to form the major item. Items requiring other operations for use will be prepared according to the operation manuals. Other preparatory steps, as specified in the commodity MTP/TOP, will be accomplished. Photographs of the item, ready for performance tests, will be taken.

(4) The procedures for testing are identical with those used in engineering tests covered in the basic commodity MTPs/TOPs. Addi-

tional data accumulated to determine environmental factors should be included in the technical report.

(5) The particular tests applicable to the specific item under investigation, which have been set out in the test plan, should be followed to yield a complete and comprehensive evaluation.

c. Data Required. The same type of data required for the test and evaluation of the basic commodity (MTPs/TOPs will apply) are to be reported, augmented by the special environmental information.

d. Analytical Plan. The performance characteristics of the item under desert environmental conditions will be compared directly to the characteristics under temperate conditions. Variations in performance (if any) will be traced, where possible, to the particular environmental factor or factors which caused the variation.

7. Security from Detection.

a. Objective. To determine the capability of the materiel to be stored and to be operated in typical desert terrain without detection; to determine the detection distance.

b. Method. This test is limited to emplaced items and may be conducted during storage exposure testing. The procedures should be as follows:

(1) Select test sites providing suitable background conditions, reference MTP 10-1-003.

(2) Site or emplace the test item(s) as applicable.

(3) Replace or remove all displaced natural material.

(4) With the test equipment sited or emplaced, remove any sand or other displaced natural material and observe the camouflage and concealment qualities of the test equipment as situated in the following terrain types.

(a) Open desert pavement, no cover.

(b) Rocky or boulder strewn desert, no vegetation.

(c) Terrain having xerophyte vegetation (non-succulent).

(d) Surfaces composed of loose or drifted sand.

(5) Observe the extent to which blowing sand and terrain surface degrade or improve concealment in the above locations.

(6) Observe signature effects such as tracks, operational noise, dust clouds, flash, smoke, electromagnetic radiation, shadows, etc., during emplacement and actual use of the items under test.

NOTE: Observations concerning camouflage and concealment shall be made with observers positioned at ranges of 500, 1000, and 3000 meters within line of sight. In cases of test item emplacements greater than 4 square yards, observations shall be made from ground and from elevated positions.

(7) Monitor visibility conditions such as the following:

(a) Atmospheric clarity (freedom from dust and haze).

(b) Sky conditions (cloud cover).

(c) Elevation of the sun (time of day and date).

(d) Atmospheric turbulence (heat boil, mirage, etc.).

NOTE: Observations taken during this test will be made utilizing color film and suitable still photographs, if possible. Both ground and air photographs should be taken.

c. Data Required. Record observations of camouflage and concealment qualities of the emplaced item. Include information of sky conditions, time of day, and observation positions. Photographs of the site provide excellent visual data displays. Observation intervals should be equally divided in time throughout the duration of exposure and functioning tests.

d. Analytical Plan. Use a narrative statement of results of the observations related to security from detection. Augment the narrative with photographs and tabular data.

8. Maintenance Evaluation.

a. Objective. To determine the maintenance requirement for the test item in a desert environment.

b. Method. Record the actions taken to ensure serviceability of the test item, and comments regarding the following aspects of maintenance: ease of performing required maintenance; special tools or skills required; interchangeability of components; adequacy of instruction manuals and other publications related to the item.

(1) Refer to MTP 6-2-504 for the detailed procedures to accomplish maintenance evaluation and TOP 1-1-007 for desert maintenance considerations. TECOM Reg 750-15 provides basic directions for these actions.

(2) The environmental parameters which affect the time required for maintenance as well as requiring special maintenance considerations for particular components. For example, air filters require extra maintenance effort.

c. Analytical Plan.

(1) From raw data collected, purge nonchargeable data such as failures during a "burn-in" or "debugging" period. Annotate particular or peculiar data bits as an aid in the evaluation of maintenance characteristics.

(2) Perform the standard calculations for maintenance parameters as defined in TECOM Reg 750-15.

(3) Compare the maintenance data from the desert environmental test directly to the data from temperate environmental tests.

9. Safety.

a. Objective. To determine the safety characteristics of the items undergoing test, whether the test item is safe for its intended use after desert exposure, and if specific safety requirements of the Materiel Needs (MN) documents are met.

b. Method.

(1) Review the safety requirements for the test item, and the safety statements and safety release for the item based on previous tests.

(2) Inspect the "as received" item for conformance to safety requirements and the presence of any hazard. Refer to applicable MTPs/TOPs for these procedures, and prepare a safety checklist for use throughout the test program.

(3) Continual observation of the test item during transportation exposure and functioning tests, and regular observation during storage exposure is required. Attention to potential hazards and alertness for newly-developing hazards is mandatory.

(4) Photograph, as applicable, the item or item components which may present a hazard, which are hazardous, or which develop a safety hazard.

(5) If during testing, the item becomes unsafe to either personnel or property, notify proper authorities and restrict approach to the item. A decision must be made on the proper procedure for rendering the item safe, or for allowing its destruction.

c. Data Required.

(1) Record all observations regarding safety of the item; especially note those conditions which may be aggravated by the desert environment.

(2) Measure, where possible, the factors which contribute to a safety hazard, especially temperatures.

d. Analytical Plan. Present the safety data in narrative and tabular format, augmented by photographs, drawings, and charts. Make direct comparison to data collected during temperate environment testing. Safety hazards will be identified in accordance with MIL-STD-882.

10. Human Factors.

a. Objective. To determine the degree to which the test item meets the human factors requirements stated in Materiel Needs (MN) documents and whether the specific test item is suitable for Army use (from the standpoint of human factors principles) after exposure and functioning in the desert environment.

b. Method.

(1) Review the specific and common MTPs/TOPs related to the test item to determine areas of human factors interest, and particular situations where problems in the man-machine combination may arise. Consider the desert climatic, terrain, atmospheric, and vegetation parameters which may adversely affect human operations.

(2) Based on the common engineering and common service test procedures (MTPs 10-2-505 and 10-3-505), prepare a checklist for the systematic recording of human factors data for the test item, throughout the desert testing procedures. The checklist should be for both engineering and operating personnel, and may consist of a series of pertinent questions and remarks regarding both the tasks performed and item itself in handling, storaging, transporting, and function-testing. Be alert for "fallout" information which may have no direct bearing on the item under test, but may be of Command interest in other areas. Example: the fuel used in a gasoline engine is contaminated -- proper filtering techniques were not used at the dispensing point due to lack of operator training.

(3) The procedures suggested in MTP 10-4-003 offer excellent guidance for the human factors evaluation methods. Although the procedure was prepared for tropical testing, the information is pertinent for testing in all climates.

c. Data Required. Complete the task/item checklist by answers to the pertinent questions and appropriate remarks regarding the human factors investigated.

d. Analytical Plan. The answers to the checklist questions, and the remarks, should be arranged in the order of their importance. The analysis of this data then rests on the reasonable judgment of the project engineer.

SECTION III
SUPPLEMENTARY INSTRUCTIONS

11. Storage Exposure. North American desert summertime temperatures do not consistently reach the maximums described in AR 70-38. Within the United States, the single area classified "Climate Category 4: Hot-Dry" lies along the lower Colorado River in Arizona and California, a portion of the Sonoran Desert. Yuma Proving Ground is within this area. During July, the ambient air temperatures at Yuma Proving Ground can be expected to exceed 112°F. one percent of the time, 108°F or more five percent of the time, and 106°F. or more 10 percent of the time. Diurnal temperature variation averages about 28°F.

A study by the Air Force of high temperatures throughout the world (see app A, Ref 18) has shown that in the hottest area, temperatures over 120°F. can be expected one percent of the time. The highest temperature ever recorded was 136°F. in Libya. The Air Force study also shows that during a 30-day period in extreme hot-dry areas, 8800-9000 degree-hours over 90°F. is probable. A heat stress of 8800 degree-hours is possible at Yuma Proving Ground only if exposure times are about 50 days during June and July, or July and August. The average heat stress for Yuma Proving Ground is 130 degree-hours over 90°F. per day for June, 201 for July, 171 for August, and 117 for September.

a. The convenient measure of temperature stress for comparison purposes or for engineering evaluation, is the "degree-hour." A base temperature, usually 90°F., is selected and each degree over this base for an hour is one degree-hour. For example, if the meteorological data for a day show:

Time of Day	Max Ambient Air Temp (°F.)		Degree-Hours	
	Day 1	Day 2	Day 1	Day 2
0600-0700	75	85	0	0
0700-0800	78	90	0	0
0800-0900	81	95	0	5
0900-1000	83	95	0	5
1000-1100	86	96	0	6
1100-1200	90	96	0	6
1200-1300	92	97	2	7
1300-1400	92	98	2	8
1400-1500	93	100	3	10
1500-1600	95	104	5	14
1600-1700	98	107	8	17
1700-1800	98	109	8	19
1800-1900	98	109	8	19
1900-2000	97	103	7	13
2000-2100	95	102	5	12
2100-2200	90	100	0	10
2200-2300	85	95	0	5
2300-2400	80	90	0	0
	Total degree hours over 90°F. =		48	147

The degree-hours are the cumulative figures for the day. The temperature curves for hot-dry areas indicate that, over a period of years, the following approximations can be made:

Daily Max Ambient Air Temp (°F.)	Degree-Hours Over 90°F, Per Day*
Between	
90-95	9
95-100	50
100-105	110
105-110	180
Over 110	290

*For hot-dry areas

If, therefore, materiel was in storage for 30 days and 15 of these days had temperature maxima in the range 100° to 105°F, and 15 days had maxima in the range 105° to 110°F, the approximate temperature stress due to ambient air temperature would be: (15 x 110) + (15 x 180) or 1650 + 2700 = 4350 degree-hours for the storage period.

b. Temperature stress data based on ambient air degree-hours should be reported showing both exposure time (days) and total degree-hours.

c. The added heat stress resulting from solar radiation and/or ground temperatures must be considered and evaluated by the project engineer in making decisions regarding the performance of materiel.

12. General Comments. Hot-dry climates are intrinsically favorable for the preservation of mechanical equipment. However, many natural materials, plastics, rubber and textiles are susceptible to accelerated deterioration under extreme heat, low humidity, intense solar radiation, and high ozone concentrations. Many metal components, especially those with small dimensional tolerances, are adversely affected by the rapid and extensive temperature changes experienced in the desert. All materials are susceptible to the erosive (and sometimes corrosive) effects of dust, sand and other airborne particulates. Biological agents of deterioration should not be neglected, even in the desert. The presence of insects, microorganisms, and rodent-type gnawing animals represents a hazard to many types of material.

a. The project engineer must decide which components of the test item are likely to be adversely affected by the desert environment. The materials of construction should be examined during the pretest investigations. The examination should include visual scrutiny and, as required, physical tests for such parameters as hardness, surface finish, elasticity, reflectance and pliability. Color photographs should be taken at this time of each component susceptible to change under the storage exposure, transportation, or performance tests.

b. To aid the project engineer in determining optimum testing procedures, and to indicate materials which may require special attention, eight material types will be discussed in additional detail. (Extracts from "Deterioration of Materials" by Greathouse and Wessel, Reinhold Publishing Corp., 1954).

(1) Metals. These may deteriorate by aging, fatigue, erosion, corrosion, oxidation and wear. The presence of alkalis and chemical salts plus moisture can cause severe corrosion. Items such as pumps may show impeller erosion due to solid particles in the fluid being pumped.

(2) Wood. The small amount of wood found in an Army materiel is protected by surface covering and/or chemical impregnation. Despite this protection, wood is subject to warping, cracking and splintering in hot-dry climates. Laminates such as plywood may

separate if not properly glued. Tool handles should be inspected for smoothness. Wood used in trailer beds or sideboards is subject to abrasion and rapid wear.

(3) Textiles. Natural and synthetic textiles (except those made of inorganic material such as glass or asbestos) are markedly temperature sensitive. Breaking and tearing strength decreases significantly with continued exposure to high (105°F.) temperatures, or to cyclic temperature changes. Sunlight is the climatic factor most responsible for nonbiological deterioration of textiles. The ultraviolet end of the sunlight spectrum is the most destructive to textiles by causing the greatest fiber breakdown. Sunlight also causes changes in the color of textiles, a bleaching or yellowing effect.

(4) Leather. Like wood, leather has a relatively small use in Army materiel. Shoes, boots, carrying cases and holsters are among the items which may be tested. Abrasive wear is the most likely deteriorating action, and one easily monitored. Leather is subject to aging with a loss of physical strength and a similar effect has been noted when metal contacts leather. Thus leather items having snaps or buckles of metal should be examined at the point where the metal touches the leather.

(5) Plastics and Rubber. Both materials are almost exclusively man-made, and their composition can be closely controlled to enhance some special property for particular applications. A designer, then, has a wide range of material choices for his item. These materials are subject to deterioration by abrasive action, temperature and ozone, manifest by a loss of strength, erosion, warpage, cracks and loss of transparency (in plastics). Rubber is especially affected by ozone and heat, which causes cracking, crazing and softening or hardening.

(6) Petroleum Products. A primary cause for the lack of effectiveness in fuel, grease, and oil is contamination by dust and sand. The result is a rapid abrasion of moving parts, loss of dimensional tolerances, or a mechanical jam. The formation of gums in stored gasoline is due to the action of atmospheric oxygen, with temperature a contributing factor. Contamination of fuel by microorganisms (fungus-type formations) is possible, resulting in a restriction of fuel flow through the filters. The test of an item, then, which uses POL products requires these products (and their containers, pipelines and valves) be closely examined before and during testing. Special attention must be paid to covers and other fittings to assure proper closure.

(7) Paint (Varnish, Enamel, Lacquer). These protective coatings suffer from all the elements present in a desert climate. Evidence of deterioration includes discoloration, cracking, peeling,

blistering, chalking and loss of adhesion. Wind-borne dust and sand will abrade and erode the coating. Symbols for identification and operation are often painted on an item and their loss through deterioration must be observed.

c. A particular problem with Army materiel is the variety of materials assembled into a single piece of equipment, and often in a very small container. For example, a radio set may contain various metals, plastics, rubber, textiles, glass, paper and ceramic materials plus their protective coatings and identifying markings. Two materiel categories representing such assembled units are discussed below.

(1) Optical Instruments. The combination of high temperatures and low humidity found in the desert will cause seals and adhesives to dry out, become soft, and lose their effectiveness. The integrity of optical assemblies may be destroyed. Blowing sand and dust will etch exposed optical surfaces; proper covers must be available and utilized. Optical equipment requires special lubricants of low volatility to prevent distillation of products onto glass surfaces at high temperatures.

(2) Electrical-Electronic Equipment. In most cases, it is a combination of factors which causes malfunction of equipment or complete failure. High temperatures and wide temperature variations are perhaps the two major causes of problems with this equipment. Heat generated by the equipment is intensified when the item is exposed and operated in the desert; component temperatures to 212°F. (100°C.) have been recorded. Dry cell batteries are especially susceptible to deterioration under these conditions. Temperature variations of 40°F. between day and night are not uncommon, and 30° variations should be expected in the desert. The differential expansion of separate elements may result in the distortion of assemblies, the rupture of seals, and the binding of movable parts. The design trend toward miniaturization, encapsulation, and hermetic sealing of units compounds the problem of proper cooling, and is therefore of particular interest in the test and evaluation of this type of equipment. Dust and sand cause binding of motor bearings and other moving parts. Airborne particulates such as chemical salts may cause corrosion and result in malfunction. Refer to MTP 6-4-001 for a more complete list of parts susceptible to failure.

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APPENDIX A
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APPENDIX B
*DEFINITION OF SUPPLY CLASSES

Class I	Subsistence including gratuitous health and welfare items. Primary rations.
Class II	Clothing, individual equipment, tentage, administrative and housekeeping supplies and equipment. Subclasses include ground support materiel (power generators), weapons, and industrial supplies (cable, block and tackle, screws and bolts).
Class III	Petroleum fuels, lubricants, hydraulic and insulating oils, liquid and compressed gases, bulk chemical products.
Class IV	Construction materials including barrier materials.
Class V	Ammunition; all types, and associated items.
Class VI	Personal items (non-military sales items).
Class VII	Major end items - tanks and other vehicles, mobile shops, launchers, missiles.
Class VIII	Medical materiel.
Class IX	Repair parts and components required for maintenance support of all equipment.
Class X	Materiel to support non-military programs (agricultural and economic development).

* From AR 310-25, "Dictionary of Army Terms," March 1969.