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**BODY ARMOR**

Army Test and Evaluation Command  
Aberdeen Proving Ground, Maryland

18 July 1972

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<p>Describes a method for evaluation of body armor functional performance characteristics. Identifies supporting test facilities, and equipment required. Provides procedures for preoperational inspection, physical characteristics, safety, personnel training, sizing, fitting, compatibility with combat tasks, durability, reliability, care, maintenance, human factors, and value analysis. Appreciable to body armor designed for protection of selected areas from the neck to the ankles. <u>Excludes</u> head armor, foot armor, and ballistic testing.</p>		

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U. S. ARMY TEST AND EVALUATION COMMAND  
EXPANDED SERVICE TEST - SYSTEM TEST OPERATIONS PROCEDURES

AMSTE-RP-702-109

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Test Operations Procedure 10-3-022

BODY ARMOR

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SECTION I  
GENERAL

1. Purpose and Scope.

a. This document provides procedures for testing body armor. It establishes test methods and techniques to determine if the tested body armor meets the criteria described in applicable requirements documents and is suitable for use by the U.S. Army.

b. This procedure is limited to evaluation of body armor designed to protect the soldier in selected areas from the neck to the ankles. Included is the armored vest, protection for the groin, leg armor, explosive handler's coveralls, and the armored coat and trousers for mine clearance. Head and foot armor is excluded.

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c. These procedures do not include ballistic testing. The evaluation of the resistance to penetration by projectile fragments and small arms ammunition is normally accomplished during engineering tests, in accordance with TOP 10-2-506, Ballistic Testing of Personnel Armor Materials.

## 2. Background.

a. Under the provisions of the Department of the Army Qualitative Materiel Requirement (QMR), the development of a system of Lightweight Individual Clothing and Equipment (LINCLOE) is required to conserve the energy of the individual soldier and to increase his effectiveness. Individual body armor is a part of this system.

b. Protective armor for the soldier in recent history may be considered to have started with the steel helmet of World War I. Efforts since then to provide him with protection against shell and grenade fragments, and small arms fire, have shown limited results because of excessive weight, discomfort, and degradation of combat efficiency. With recent technological advances in ballistic materials, including metals, textiles, plastics, and ceramics, it may be possible to produce elements that can defeat both fragments and small arms projectiles and still be light enough to be worn comfortably by military personnel. The degree of ballistic protection afforded is a direct function of the material employed. Similarly, the total garment weight is directly related to area coverage and area density.

c. Since the modern soldier may be exposed to a broad range of ballistic hazards (fragmentation hazards and small arms fire, including armor piercing projectiles), a variable armor system may be required. Such a system may be adapted to a particular tactical need by allowing a selection of the level of protection required for a particular combat situation. Variability of protection might be achieved by adding appropriate ballistic elements or modules in the anatomical regions of the vital organs, specifically, the thoracic and abdominal cavities which include the heart, great blood vessels, lungs, liver, kidneys, spleen, and spinal column. This concept would provide maximum protection to the vital body organs with decreasing protection to the peripheral areas or non-vital organs. Both rigid and flexible materials encompassing a broad range of areal densities may be employed to accomplish variability.

d. There is a continuing need to improve body armor by incorporating modern materials to give the soldier the best protection possible considering weight and functional suitability.

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3. Equipment and Facilities.

a. Equipment.

- (1) Test item.
- (2) Control item, if applicable.
- (3) Test troop unit, with TOE weapons and equipment and standard combat uniforms.
- (4) Photographic equipment, still and motion.
- (5) Linear and weight measurement tools.
- (6) Thermometers.
- (7) Safety and first-aid kits.
- (8) Communications equipment.
- (9) Tactical vehicles, ground and air.
- (10) Parachutes and related equipment.
- (11) Stopwatches.
- (12) Administrative materials (data forms, rating questionnaires, pencils, marking pens, etc.)

b. Facilities.

- (1) Firing ranges.
- (2) Field training areas.
- (3) Classroom, storage area, and office space.
- (4) Instrumented test facilities, if available.

SECTION II  
TEST PROCEDURES

4. Supporting Tests.

a. The procedures outlined in this Test Operations Procedure (TOP) provide general guidance for the conduct of an Expanded Service Test. Detailed specific procedures will be dependent upon the characteristics of the body armor being tested, and the stated requirements in the applicable requirements documents.

b. In his preparations, the test officer should follow the general guidance laid down in MTP 6-3-501, Pretest Inspection for Service Test. The test officer should also conduct the necessary administrative, personnel, and supply preliminaries outlined in the appropriate test officer guides and manuals, or in units or organizational standard operating procedures, keeping in mind the fact that sufficient pretest training must be accomplished to ensure that the test soldiers are equally familiar with the test item and the control item. It is extremely important that the performance of the test item not be degraded because of its newness, or because the test troops are unfamiliar with the item.

c. During each supporting test, sufficient data to arrive at valid conclusions should be collected. To determine the best way to collect sufficient data, the test officer should realize his statistical objectives may be constrained by limited numbers of test items, limited time, limited manpower, and a limited amount of support and control equipment. The test officer will find it advantageous to consult with a statistical analyst to develop an experimental design prior to preparing his test plan, since a proper experimental design will aid in the control of the bias. The statistician can advise and assist the test officer in determining appropriate techniques for random sampling, sample size required to estimate the true performance, estimating the average performance (or variability of performance) from a sample, comparing materials or products with respect to average performance (or variability of performance), number of test soldiers needed, and the number of replications required for a specific operation. Additional statistical guidance can be found in TOP 3-1-002, Confidence Intervals and Sample Size, and in National Bureau of Standards Handbook 91, Experimental Statistics.

d. If possible, the test officer should also consult with human factors personnel for assistance in the preparation of pertinent portions of his test plan and test reports, and for the development of interview and questionnaire items.

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e. Published MTPs/TOPs and the test listed below (further defined in Section III where necessary) should be considered in formulating an Expanded Service Test plan. Additional reference material is listed in the appendix.

<u>TEST SUBJECT TITLE</u>	<u>PUBLICATION NO.</u>
(1) Preoperational Inspection and Physical Characteristics) (refer to para 5)	10-3-500
(2) Safety (refer to para 6)	10-3-507
(3) Personnel Training (refer to para 7)	10-3-501
(4) Sizing and Fitting (refer to para 8)	
(5) Compatibility with Combat Tasks (refer to para 9)	10-2-509
(6) Airdrop Operations	7-3-511
(7) Durability and Reliability (refer to para 10)	10-3-502 and 1-1-046
(8) Care and Maintenance (refer to para 11)	
(9) Human Factors Engineering (refer to para 12)	10-3-505
(10) Value Analysis (refer to para 13)	

SECTION III  
SUPPLEMENTARY INSTRUCTIONS

5. Preoperational Inspection and Physical Characteristics.

a. The objectives of this subtest are to verify completeness of the test item shipment, determine the physical characteristics of the test item and compare with those stated in applicable materiel requirements documents, and determine if the test item is in proper

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condition for operational testing. These objectives are met by accomplishing the applicable procedures of TOP 10-3-500, Preoperational Inspection and Physical Characteristics.

b. It is important that as much data as practicable concerning the test item be determined prior to the start of testing operations. In the collection of data and reporting of test results it is of utmost importance to know when and why something happens. In some cases the defect or cause of failure might occur prior to arrival of the test item at the test site, yet unrealistically be reported as a test failure. Data of this nature, in order to ensure valid reporting, must be discovered and recorded during the preoperational inspection phase of the test.

c. The physical characteristics of the test body armor, as prescribed in the requirements documents, are verified during the preoperational inspection. Some examples of characteristics that might be applicable are:

(1) Dimensions, such as length, width, and thickness of material.

(2) Weights. Total weight of test item, and the weight of separate components.

(3) Type of material. A generic description, such as metal, synthetics, rubber, or fabric might be used, as well as a more definitive description, such as steel, titanium, nylon, or cotton.

(4) Color, to include variations such as mottled and camouflage pattern.

(5) Texture and reflectance characteristics, such as smooth, rough, bright, shiny.

(6) Design features, such as layered fabric, 3/4 collar, velcro closures, laminated material.

## 6. Safety.

a. Accomplish the applicable procedures of TOP 10-3-507, Safety. Perform safety confirmation in accordance with USATECOM Regulation 385-6, Verification of Safety of Materiel During Testing.

b. These procedures are accomplished to determine if the specific safety requirements have been met, and whether the test item is safe for its intended use. To be safe for troop use, equipment must be

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free of those conditions that can cause personal injury or property damage. The safety area of concern applies not only to real and potential hazards in the test item itself, but also in its relation to any combination of items with which it may be used. This safety evaluation does not involve protection from enemy weapons.

c. Safety determination is a continuing process throughout the entire service test and, to the extent practicable, should be conducted concurrently with, or as an adjunct to other subtests.

d. The referenced TOP is designed for use in evaluating the safety aspects of different commodity items. In preparing a plan of test, use only the portions that are applicable to the test item. Those portions of the TOP pertaining to mechanical hazards, individual items, and miscellaneous hazards will usually be applicable to body armor.

#### 7. Personnel Training.

a. The objectives of this subtest are to familiarize test soldiers with all aspects of wearing and using the test item, to ensure that everyone understands what is to be accomplished by the testing, and to assess the adequacy of the training package if one has been developed for the test item.

b. Review TOP 10-3-501, Operator Training and Familiarization, and accomplish those procedures which can be applied to the test item.

c. When control items are provided, accomplish sufficient pretest training to ensure that test soldiers are equally familiar with the test item and the control item.

#### 8. Sizing and Fitting.

##### a. Objectives.

(1) To determine if the test item is provided in tariff sizes sufficient to accommodate the intended users.

(2) To determine if the size of body armor for proper fit of the test soldiers can readily be predicted from body measurements taken of the individuals.

(3) To apply identification markings to test items, and to issue items of assigned sizes to test soldiers for prescribed wear periods.

## b. Method.

(1) The test items will be arranged by model, component, and size and displayed in some logical order of storage for easy and quick selection of sizes during the fitting of personnel. Each separate part or component of the test item will be marked for identification, and a record will be maintained to show which test item is issued to each test soldier.

(2) Test soldiers will be processed through a series of measuring and fitting stations to obtain information regarding the ability to fit properly the available body sizes. Each participant will be measured to obtain the body dimensions applicable to the test item, e.g., height, chest girth, arm length, waist, and inseam length. Procedures for obtaining these measurements are found in TM 10-227, Fitting of Man's Uniforms.

(3) Using the body measurements taken and the size prediction tables in TM 10-227, an initial selection of try-on sizes will be made in each component of the test item. Test soldiers will don the selected size garment and secure the closures as for wear. If, in the opinions of test supervisory personnel, an acceptable fit is not obtained with the initial try-on size, alternate sizes will be selected for try-on until an acceptable fit is obtained for each component, or it is determined that the individual test soldiers cannot be fitted in the available sizes. Information as to the predicted and alternate try-on sizes, reasons for predicted size not being acceptable, and ratings of the adequacy of final fit will be recorded.

(4) A test item (or control item) will be issued to each test soldier who should retain that particular item throughout all test procedures.

(5) Each test soldier, while wearing his assigned test item will be inspected and judged for proper fit and adjustment. To assist in doing this, each test soldier should be exercised through the range of motions which includes various modes of bending, reaching, and firing, to cover the range of motions normally required of a soldier in combat.

(6) Photographs showing appropriate front, rear, and side views will be made of test soldiers wearing each type of item being tested. For photograph identification, record each test soldier's name, and the test item identification code number or letter.

c. Data Required. Name of each test soldier, applicable body measurements, predicted and fitted test item sizes, reasons for predicted size not being acceptable, adequacy of final fit, and identification number or marking of body armor issued to each test soldier.

d. Analytical Plan.

(1) The test data will be summarized and grouped by test item component and size to determine the number of test soldiers who could not be fitted properly with available sizes, and the number whose body armor sizes could not readily be predicted by use of body measurements.

(2) Test results will be analyzed subjectively to determine if the test objectives have been met.

9. Compatibility with Combat Tasks.

a. Many applicable procedures that may be accomplished to evaluate the effects of the test item on the individual soldier's combat effectiveness are described in MTP/TOP 10-2-509, Combat Effectiveness Test Facility. An instrumented clothing and equipment test facility located at Fort Benning facilitates the collection of this type performance data. The procedures described in MTP/TOP 10-2-509 are adaptable to other test sites if access to Fort Benning facilities is impractical.

b. Accomplish practical and realistic procedures to determine how the test item affects the individual soldier's ability to perform normal combat tasks, such as loading, firing, and reloading a weapon; performing crew-served weapons drill; using fire control equipment; operating military vehicles; observing, detecting, location, and identifying hostile targets; maneuvering; marching; throwing hand grenades; digging hasty fighting positions; preparing and using cover, camouflage and concealment; using communications equipment; and other activities related to combat tasks.

c. Test soldiers equipped with fighting and existence loads, as appropriate, will perform these combat tasks under simulated combat conditions, with and without the test item, to obtain comparative data. When control items are provided, comparative data for the control item and test item will be obtained.

d. Test soldiers wearing the test and control items should be observed by test supervisory personnel from distances of 50, 100, 200 and 300 meters, using the unaided eye, binoculars, Starlight Scope, Metascope, and Radar AN/PPS-4, in order to evaluate the camouflage aspects. The test soldiers should also be observed visually from the air.

## 10. Durability and Reliability.

a. Accomplish the applicable procedures of TOP 10-3-502, Durability. Throughout the conduct of all other subtests, note all failures and occurrences which pertain to durability and reliability, and integrate the data with this subtest.

b. TOP 10-3-502 is a basic guide to examining durability during testing of general equipment. A careful review of all requirements documents and test directives should be made to ensure that specific requirements which relate to durability of the test item are thoroughly examined. Tactical field exercises to evaluate durability should be of sufficient length to determine if the life expectancy of the test item, as stated in applicable requirements documents, has been met. The procedures prescribed in TOP 1-1-046, Field Combat Test Exercises, may be used as a guide.

c. Durability is related both to physical condition and performance. It is a function of both design and workmanship. Design includes the selection of materials, machine process, size and shape of components, etc. Workmanship is the quality measure of effort put forth to produce the item. If either of these aspects receives improper or inefficient effort, the result is that the end item may have poor durability characteristics.

d. Most of the factors affecting durability are part of the operating environment in which test item will be used. The test item should be subjected to the type of handling and use that it would normally encounter from a typical soldier in the field (e.g., worn while crawling through rocks, sand, mud, and brush; carried in the cargo compartment or under the seats of tactical vehicles; used as a cushion or pillow; thrown out of vehicles onto the ground; soaked with water; and soiled by gasoline, oil and grease). Proper testing will ensure that the test item is exposed to all conditions which may affect its durability and that the effects on the test item are accurately determined, i.e., a clear "cause and effect" relationship is established.

## 11. Care and Maintenance.

### a. Objectives.

(1) To determine if adequate instructions for care and maintenance accompany the test item.

(2) To determine if the maintenance characteristics of the test item meet the criteria stated in applicable requirements documents.

## b. Method.

(1) The maintenance evaluation portion of the Expanded Service Test will be conducted simultaneously with other test operations to the maximum practical extent. The test item will be afforded maintenance comparable to that which it would receive in a user environment. Maintenance functions will be performed under actual or simulated field conditions by personnel with the appropriate MOS for the maintenance levels, using tools and equipment authorized for use at the maintenance level.

(2) The instructions furnished with the test item which pertain to care and maintenance will be reviewed for clarity, suitability, errors, and omissions. Discrepancies noted will be reported in accordance with TECOM Regulation 750-15, or as otherwise prescribed by the test directive.

(3) Throughout the conduct of each subtest, all maintenance, repairs, or cleaning performed on the test item (and control item when applicable) will be accomplished in accordance with the applicable operating and maintenance instructions. A record will be kept of all scheduled and unscheduled maintenance performed.

(4) The test items will be laundered and cleaned in the field in accordance with the maintenance instructions.

(5) Test soldiers will be observed while performing maintenance functions, and will be questioned to determine if maintenance required for the test item is more difficult or time-consuming than as specified in applicable testing criteria.

## c. Data Required.

(1) Adequacy, clarity, and correctness of maintenance instructions.

(2) Narrative description of maintenance or cleaning performed.

(3) Time required (in man-hours) to perform each maintenance function.

(4) Description of any difficulties encountered in performing maintenance.

## d. Analytical Plan.

(1) Based on collected test data, a subjective determination will be made as to the adequacy of maintenance instructions.

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(2) Test data pertaining to maintenance, repair, or cleaning the test item will be compared with the control item, or with other designated criteria, by use of appropriate statistical formulas to determine significant differences in maintenance requirements (see paragraph 4c, above). The results of the comparison will be analyzed subjectively to determine if applicable maintenance criteria are met.

## 12. Human Factors Engineering.

a. Accomplish the applicable procedures of TOP 10-3-505, Human Factors Evaluation, to determine if the test item is suitable for U.S. Army use from the standpoint of compliance with human factors principles. TOP 10-3-505 is intended for use in planning and conducting human factors evaluation for general supplies and equipment. Specific criteria and test procedures for the test item must be determined only after appraisal of pertinent requirements documents.

b. Review the test item's technical, operating, and maintenance characteristics to ensure that complete and realistic criteria are selected and that the methodology is in keeping with field conditions of the units affected. This evaluation can normally be carried out in conjunction with other testing. The primary objective is to obtain adequate data describing the man-item relationship while the test item is being operated, used, or worn by typical soldiers confronted with the organizational mission, and climatic conditions representing the scope of intended Army use.

c. Note any test item feature or characteristic which results in increased user fatigue, nervousness, or irritability. Heat stress is important and should be considered when the test item is worn. The armor should be worn in the rain, or be subjected to immersion during stream crossing exercises; then the water absorption should be checked for weight increase, chafing, or other human factors problems.

## 13. Value Analysis.

a. Objective. To determine if the test item has any features which might be eliminated without adversely affecting performance, durability, or safety.

b. Method. During the conduct of all tests, examine the test item from a value standpoint, and record comments concerning any features which can be eliminated without degrading the test item in performance, durability or safety. Review TECOM Regulation 700-1, Quality Assurance; Value Engineering for additional guidance.

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c. Data Required. Comments of test soldiers and test supervisory personnel will be recorded, to include description of feature, recommended change to be made, and reason for recommendation. Recorded comments will be in narrative form and will provide full details of conditions or events occurring during conduct of the test.

d. Analytical Plan. Summarize all data collected during the test and present the results in narrative form supplemented with charts and photograph as appropriate. Where opinions of test soldiers or judgements of test supervisory personnel are presented, identify these as such, and separate from factual data. Accumulated data will be subjectively analyzed to determine if appropriate criteria are met. Conclude with a recommendation of specific changes to be made to the test item.

Recommended changes to this publication should be forwarded to Commanding General, U.S. Army Test and Evaluation Command, ATTN: AMSTE-ME Aberdeen Proving Ground, Maryland 21005. Technical information related to this publication may be obtained from U.S. Army Infantry Board, ATTN: STEBC-MO-M, Fort Benning, Georgia 31905. Additional copies of this document are available from the Defense Documentation Center, Cameron Station, Alexandria, Virginia 22314. This document is identified by the accession number (AD No) printed on the first page.

**APPENDIX  
REFERENCES**

1. AR 70-10, Test and Evaluation During Development and Acquisition of Materiel.
2. DA SB 10-523, Size Tariffs for Clothing, Equipage and Footwear.
3. DA Approved QMR for a System of Lightweight Individual Clothing and Equipment (LINCLOE), date 1 Sep 65.
4. TM 10-227, Fitting of Man's Uniforms.
5. National Bureau of Standards Handbook 91, Experimental Statistics.
6. AMCP 706-110, 111, & 112 Engineering Design Handbook.
7. TECR 70-23, Equipment Performance Reports.
8. TECR 70-24, Documenting Test Plans and Reports.
9. TECR 310-3, TECOM Test Operations Procedures Style Manual.
10. TECR 310-6, TECOM Test Operations Procedures.
11. TECR 385-6, Verification of Safety of Materiel During Testing.
12. TECR 700-1, Quality Assurance; Value Engineering.
13. TECR 750-15, Maintenance Evaluation During Testing.
14. MTP/TOP 6-3-501, Pretest Inspection for Service Test.
15. MTP/TOP 3-1-002, Confidence Intervals and Sample Size.