

INCH-POUND

MIL-PRF-46103E
6 January 1998
SUPERSEDING
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23 June 1989

PERFORMANCE SPECIFICATION

ARMOR: LIGHTWEIGHT, COMPOSITE

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the performance requirements for lightweight composite armor (see 6.1).

1.2 Classification. The composite armor should be classified into these types and classes according to its ballistic protection limit (ballistic resistance):

Type I 5.56 mm

Class 1 - M855 lead ball with steel tip projectile at muzzle velocity (3100 ft (945 m) per second).

Type II 7.62 mm (0.30 caliber)

Class 1 - Lead or mild steel core ball projectile at muzzle velocity (2850 ft (869 m) per second).

Class 2 - Hard steel core armor piercing (AP) projectile at muzzle velocity (2850 ft (869 m) per second).

Class 3 - Heavy density core sabot launched armor piercing (SLAP) projectile at muzzle velocity (4000 ft (1219 m) per second).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, ATTN: AMSRL-WM-M, APG, MD 21005-5069 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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- Type III 12.7 mm (0.50 caliber)
- Class 1A - Mild steel core ball projectile at 1000 meters range (1600 ft (487 m) per second).
- Class 1B - Mild steel core ball projectile at 500 meters range (2000 ft (610 m) per second).
- Class 1C - Mild steel core ball projectile at muzzle velocity (2850 ft (869 m) per second).
- Class 2A - Hard steel core armor piercing (AP) projectile at 1000 meters range (1600 ft (487 m) per second).
- Class 2B - Hard steel core armor piercing (AP) projectile at 500 meters range (2000 ft (610 m) per second).
- Class 2C - Hard steel core armor piercing (AP) projectile at muzzle velocity (2850 ft (869 m) per second).
- Class 3 - Heavy density core sabot launched armor piercing (SLAP) projectile at muzzle velocity (4000 ft (1219 m) per second).
- Type IV 14.5 mm
- Class 1 - Hard steel core armor piercing incendiary (API) B32 projectile at muzzle velocity (3250 ft (991 m) per second).
- Class 2 - Hard steel core armor piercing incendiary (API) BS-41 projectile at muzzle velocity (3250 ft (991 m) per second).

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

DEPARTMENT OF DEFENSE

MIL-PRF-5624 - Turbine Fuel, Aviation, Grades JP-4, JP-5, And JP-5/JP-8 ST

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STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-662 - V₅₀ Ballistic Test For Armor
 MIL-STD-810 - Environmental Test Methods And Engineering Guidelines

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094).

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D792 - Density and Specific Gravity (Relative Density) of Plastics by Displacement

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428).

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified in the contract or purchase order, a sample shall be subjected to first article inspection (see 4.2.1 and 6.2).

3.2 Materials. Unless otherwise specified (see 6.2), the materials are the prerogative of the contractor as long as all the operating, environmental and identification marking requirements are fully met.

3.3 Construction. The contractor shall select the methodology of construction provided these methods are capable of yielding uniform properties in the completed structure and that all structural interfaces have no unbounded areas.

3.3.1 Molding. If the process of molding is used then the material shall be molded into the required configuration without breaking or damaging the material. Such procedures and methods shall be capable of yielding uniform properties in the completed structure.

3.3.2 Spall cover and edge strip. If a spall cover is used then the spall cover shall be of such a configuration as to cover the entire outer surface. The edge strip shall be cut to go around the entire periphery of the composite armor and extend beyond the inner edges 0.50-0.75 inches (12.7-19.0 mm). The edges shall not fray before application to the composite armor.

3.3.3 Assembly of components by bonding. All components required to be assembled by bonding shall be thoroughly cleaned of all foreign matter.

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Surfaces to be bonded shall be properly prepared in a manner which will insure a proper bond capable of meeting the applicable performance requirements specified in 3.4. The required adhesive shall be applied uniformly over the entire contact areas of the components to be joined. When bonding components, uniform pressure shall be applied over the entire surface area in order to obtain intimate contact of all components.

3.4 Operating requirements.

3.4.1 V₅₀ ballistic limit protection. The V₅₀ ballistic limit protection, as defined by MIL-STD-662, shall be the following for the types and classes of armor:

- Type I, Class 1 - Not less than 3100 ft (945 m) per second against 5.56 mm M855 lead ball with steel tip projectiles at zero degrees obliquity.
- Type II, Class 1 - Not less than 2850 ft (869 m) per second against 7.62 mm (0.30 caliber) lead or mild steel core ball projectile at zero degrees obliquity.
- Type II, Class 2 - Not less than 2850 ft (869 m) per second against 7.62 mm (0.30 caliber) hard steel core armor piercing (AP) projectile at zero degrees obliquity.
- Type II, Class 3 - Not less than 4000 ft (1219 m) per second against 7.62 mm (0.30 caliber) heavy density core sabot launched armor piercing (SLAP) projectile at zero degrees obliquity.
- Type III, Class 1A - Not less than 1600 ft (487 m) per second against 12.7 mm (0.50 caliber) mild steel core ball projectile at 1000 meters range at zero degrees obliquity.
- Type III, Class 1B - Not less than 2000 ft (610 m) per second against 12.7 mm (0.50 caliber) mild steel core ball projectile at 500 meters range at zero degrees obliquity.
- Type III, Class 1C - Not less than 2850 ft (869 m) per second against 12.7 mm (0.50 caliber) mild steel core ball projectile at zero degrees obliquity.
- Type III, Class 2A - Not less than 1600 ft (487 m) per second against 12.7 mm (0.50 caliber) hard steel core armor piercing (AP) projectile at 1000 meters range at zero degrees obliquity.
- Type III, Class 2B - Not less than 2000 ft (610 m) per second against 12.7 mm (0.50 caliber) hard steel core armor piercing (AP) projectile at 500 meters range at zero degrees obliquity.
- Type III, Class 2C - Not less than 2850 ft (869 m) per second against 12.7 mm (0.50 caliber) hard steel core armor piercing (AP) projectile at zero degrees obliquity.
- Type III, Class 3 - Not less than 4000 ft (1219 m) per second against 12.7 mm (0.50 caliber) heavy density core sabot launched armor piercing (SLAP) projectile at zero degrees obliquity.

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Type IV, Class 1 - Not less than 3250 ft (991 m) per second against 14.5 mm hard steel core armor piercing incendiary (API) B32 projectile at zero degrees obliquity.

Type IV, Class 2 - Not less than 3250 ft (991 m) per second against 14.5 mm hard steel core armor piercing incendiary (API) BS-41 projectile at zero degrees obliquity.

3.4.2 Ballistic deformation. Unless otherwise specified in the contract or purchase order (see 6.2), the ballistic deformation of the back surface of the armor test specimen shall not exceed 1.73 in. (44 mm).

3.4.3 Areal density. The areal density or armor assembly weight shall be as specified by the procuring activity (see 6.2).

3.5 Environmental requirements.

3.5.1 Vibration. The composite armor shall withstand expected dynamic vibrational stresses encountered in the service environment.

3.5.2 Temperature. The composite armor shall be both structurally and ballistically (see 3.4.1) functional within the temperature range -60°F to 160°F (-51°C to 71°C). Composite armor intended for use around hot components such as engines and transmissions shall also be functional at temperatures up to 320°F (160°C).

3.5.3 Acceleration. The composite armor shall maintain structural integrity without degradation and shall sustain no physical damage when exposed to acceleration levels up to 12g.

3.5.4 Fluid resistance. The composite armor shall maintain structural and ballistic integrity after immersion in jet fuel, oil, and water.

3.5.5 Humidity. The composite armor shall maintain structural integrity without degradation when exposed to 95% relative humidity.

3.5.6 Adhesion of the spall cover. If a spall cover is to be used there shall be no visible peeling of the tab formed on the spall cover.

3.6 Identification marking. The manufacturer's code (part) number, contract number, serial number, date of manufacture, national stock number, type and class of material, and the number of this specification shall be permanently marked in the location specified by the procuring activity (see 6.2).

4. VERIFICATION

4.1 Verification alternatives. Alternative test methods, techniques, or equipment, including the application of statistical process control, tool control, or cost effective sampling procedures may be proposed by the contractor. Acceptable alternative verification approaches shall be identified in the contract.

4.2 Classification of inspection. The inspection requirements specified herein are classified as follows:

- a. First article inspection (see 4.2.1)
- b. Conformance inspection (see 4.2.2)

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4.2.1 First article inspection. When required (see 3.1), the first article sample shall be examined for compliance with the requirements and verifications listed in table I. All samples shall be produced with materials and processes proposed for use on production composite armor. Inspection shall be carried out by the contractor under Government surveillance, when specified (see 6.2).

4.2.2 Conformance inspection. Conformance inspection for acceptance of production composite armor shall be conducted on a recurring basis and include the examinations and tests listed in table I.

TABLE I. Requirements and verification.

Title	Requirements	Verification
Construction	3.3	4.3
V ₅₀ ballistic limit protection	3.4.1	4.4.1
Ballistic deformation	3.4.2	4.4.2
Areal density	3.4.3	4.4.3
Vibration	3.5.1	4.4.4
Temperature	3.5.2	4.4.5
Acceleration	3.5.3	4.4.6
Fluid resistance	3.5.4	4.4.7
Humidity	3.5.5	4.4.8
Adhesion of the spall cover	3.5.6	4.4.9
Identification marking	3.6	4.4.10

4.2.3 Lot formation. An inspection lot shall consist of all the composite armor of one type and part number, from an identifiable production period, from one manufacturer, submitted at one time for acceptance.

4.2.4 Initial production lot. The number of random samples selected for inspection, from each initial production lot of components, shall be defined by the procuring activity (see 6.2).

4.2.5 Production lots after initial lot. The number of random samples selected for inspection, from each production lot of components after the initial lot, shall be defined by the procuring activity (see 6.2).

4.2.6 Acceptance and rejection. The selected armor samples shall meet the requirements in table I for the represented lot to be acceptable. Failure of any test samples to meet the requirements in table I shall constitute rejection of the entire lot which they represent. Unless otherwise specified (see 6.2), the ballistic tests shall be conducted and the test results accepted prior to shipment of the lot of armor represented by the test samples.

4.3 Visual inspection. Visual inspection shall be used to verify the method of construction. Visual inspection shall also be used to verify that no unbounded areas exist for all structural interfaces.

4.4 Operating requirements verification.

4.4.1 V₅₀ ballistic limit protection. The ballistic resistance test shall be conducted in accordance with MIL-STD-662. The contractor shall supply two test samples for each three months of composite armor fabrication for ballistic acceptance testing at a Government approved facility to show conformance to the ballistic requirements in 3.4.1. The test samples shall be adequately identified

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as to contractor, contract number, manufacturer, and date. The testing facility shall report raw data, velocities, penetration observation, thickness, and the ballistic type and class (see 1.2) for each test sample.

4.4.2 Ballistic deformation. Examine the armor and the backing material to determine if the projectile made a fair hit and whether penetration occurred. If no penetration occurred and the projectile made a fair hit, measure and record the depth of the depression made in the armor backing material to determine compliance with the ballistic deformation requirement in 3.4.2. The depth of the depression is the distance from the original undisturbed surface of the backing material to the lowest point of the depression. A projectile that impacts at too high a velocity, but is otherwise a fair hit that meets the ballistic deformation requirement in 3.4.2, shall be considered a fair hit for the determination of deformation. Penetration (complete or partial) by any fair hit, not meeting the ballistic deformation requirement in 3.4.2, or penetration by a projectile at a velocity lower than the minimum required impact velocity, shall constitute failure. The testing facility shall report ballistic deformation for each test sample.

4.4.3 Areal density. The areal density shall be reported for each test sample. The areal density in pounds per square foot (lb/ft²) and in kilograms per square meter (kg/m²) of the composite armor, shall be calculated from measurements on each component. Each component shall be weighed to the nearest 0.01 lb (0.0045 kg). The thickness shall be measured to 0.001 in. (0.025 mm) at four corner locations on each component. Six measurements shall be made at each corner with the first measurement taken approximately 1 in. (25 mm) from the edge of the corner and the remaining five taken on a straight line toward the center of the armor with the measurements spaced in approximately one inch increments. A deep throat type depth gage shall be used for taking measurements. The average of the 24 readings shall be used in the calculation of the areal density for each component. The average density of each component shall be determined by using ASTM D792, except the immersed weight shall be determined to 0.01 lb (0.0045 kg) and the liquid used shall be clean tap water, containing a wetting agent if necessary, which shall be changed just prior to examination of each lot. The areal density of the composite armor, without spall cover and spall cover edge strip, shall be the cumulative areal densities of each component calculated to the nearest tolerance of 0.1 lb/ft² or (0.2 kg/m²) as follows:

$$\text{Areal density (lb/ft}^2\text{)} = 5.202 \times \text{Density (g/cm}^3\text{)} \times \text{Thickness (in.)}$$

$$\text{Areal density (kg/m}^2\text{)} = 10.000 \times \text{Density (g/cm}^3\text{)} \times \text{Thickness (cm)}$$

4.4.4 Vibration. The composite armor shall be tested for vibration in accordance with MIL-STD-810, Method 514.4 for the following vibration environment categories and meet the requirement specified in 3.5.1:

Category	Description
Loose cargo	Equipment carried on ground vehicles as unrestrained cargo
Jet aircraft	Equipment installed in jet aircraft manned and unmanned
Helicopter	Equipment installed in helicopters
Ground mobile	Equipment installed in wheeled vehicles trailers and tracked vehicles
Marine	Equipment installed in ships or other naval watercraft
Minimum integrity test	All other and vibration-isolated equipment

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4.4.5 Temperature. The composite armor shall be tested in accordance with MIL-STD-810, Methods 501.3, 502.3, and 503.3 at the temperature range specified in 3.5.2. The composite armor shall then meet the ballistic requirements in 3.4.1.

4.4.6 Acceleration. The composite armor shall be tested in accordance with MIL-STD-810, Method 513.4 and meet the requirement specified in 3.5.3.

4.4.7 Fluid resistance. The composite armor shall be immersed in jet fuel in accordance with MIL-PRF-5624, in a gas turbine engine lubricating oil primarily used for aircraft engines, which has a nominal viscosity of 5 centiStokes at 100°C, made with neopentyl polyol ester base stock, and in water for a period of twenty-four (24) hours each at $70^{\circ} \pm 10^{\circ}\text{F}$ ($21^{\circ} \pm 5^{\circ}\text{C}$). After thoroughly drying, the composite armor shall then meet the ballistic requirements in 3.4.1.

4.4.8 Humidity. The composite armor shall be tested in accordance with MIL-STD-810, Method 507.3 and meet the requirement specified in 3.5.5.

4.4.9 Adhesion of the spall cover. The sample for this test shall be made from composite armor which has been tested ballistically using an undamaged area, or a small test specimen made identically to the composite armor with respect to surface preparation, adhesion, application and bonding. Make parallel cuts through the spall cover 4 in. (102 mm) long and 1 in. (25 mm) apart. At one end of the cut, make a cut at a right angle so that a 1 in. x 2 in. (25 mm x 51 mm) tab can be peeled from the sample. Attach a 2 lb (0.9 kg) weight to this tab so that the resultant peel force is normal to the plane of the sample. Make gage marks on the sample for the measurement of the amount of peeling during the test. Allow the weight to stand for four (4) hours minimum at room temperature. Any visual peeling of the tab constitutes failure of the test.

4.4.10 Identification marking. Verify the presence of the required markings.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The lightweight composite armor covered by this specification is military unique because it is used in applications such as military personnel body armor, aircraft armor, and applique armor for tactical shelters and light vehicles when resistance to armor piercing projectiles and limited multi-hit capability are required.

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6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number, and date of the specification.
- b. Type and class of armor (see 1.2).
- c. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2 and 2.3).
- d. When first article is required (see 3.1).
- e. Whether the material is to be specified (see 3.2).
- f. Acceptable value for ballistic deformation, if different (see 3.4.2).
- g. Acceptable value for areal density or armor assembly weight (see 3.4.3).
- h. Specify location of identification markings (see 3.6).
- i. Whether inspection is carried out by the contractor under Government surveillance (see 4.2.1)
- j. Number of samples to be inspected from the initial production lot (see 4.2.4).
- k. Number of samples to be inspected from the production lots after the initial production lot (see 4.2.5).
- l. Acceptance requirements prior to shipment of the lot of armor, if different (see 4.2.6).
- m. Packaging requirements (see 5.1).

6.3 Definitions.

6.3.1 Areal density. A measure of the weight of armor material per unit area, usually expressed in pounds per square foot (lb/ft²) or kilograms per square meter (kg/m²) of surface area.

6.3.2 Ballistic deformation. The maximum momentary displacement of the back surface of the armor test specimen caused by a fair hit that does not penetrate the armor when the armor is in initial contact with the backing material.

6.3.3 Ballistic resistance. A measure of the capability of a material or component to stop or reduce the impact velocity and mass of an impacting projectile or fragment.

6.3.4 Complete penetration, (CP). A complete penetration occurs when the impacting projectile, or any fragment thereof, or any fragment of the test specimen perforates the witness plate, resulting in a crack or hole which permits light passage when a 60 watt, 110 volt bulb is placed proximate to the witness plate.

6.3.5 Contractor. The term "contractor" is defined as the organization having a direct contract with the procuring activity.

6.3.6 Fair hit. A bullet that impacts the armor at an angle of incidence no greater than +5° from the intended angle of incidence, no closer to the edge of the armor part than 3 in. (7.6 cm) and no closer to a prior hit than 2 in. (5 cm), at an impact velocity no more than 50 ft (15 m) per second greater than the minimum required test velocity.

6.3.7 Manufacturer. The term "manufacturer" is defined as the organization actually performing the operations covered by this specification.

6.3.8 Partial penetration, (PP). Any impact which is not a complete penetration may be considered a partial penetration.

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6.3.9 V₅₀ ballistic limit protection, (V₅₀BL(P)). The V₅₀ ballistic limit protection may be defined as the average of an equal number of highest partial penetration velocities and the lowest complete penetration velocities which occur within a specified velocity spread.

6.3.10 Witness plate. A thin sheet located behind and parallel to the ballistic test sample which is used to detect penetrating projectiles or spall.

6.4 Certification activity. Unless otherwise designated, the U.S. Army Weapons and Materials Research Directorate (WMRD), APG, MD, is responsible for the certification of ballistic testing facilities and equipment.

6.5 First-time suppliers. First-time suppliers who have not previously supplied composite armor to MIL-A-46103 and wish to have their material tested, may do so at their own expense. It is recommended that inquiries for testing be directed to Commander, U.S. Army Test and Evaluation Command, ATTN: AMSTE-TM-O, Aberdeen Proving Ground, MD 21005. Technical questions regarding testing may be directed to U.S. Army Aberdeen Test Center, ATTN: STEAC-LI, Aberdeen Proving Ground, MD 21005.

6.6 Subject term (key word) listing.

Ballistic deformation
Muzzle velocity
Projectile
Spall cover
V₅₀ ballistic limit
Witness plate

Custodians:

Army - MR
Navy - AS
Air Force - 11

Preparing activity:

Army - MR

Project No. CMPS-0137

Review activities:

Army - AR, AT, AV, IE, TE
Navy - SH
Air Force - 13
DLA - DH

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:

1. DOCUMENT NUMBER
MIL-PRF-46103E

2. DOCUMENT DATE (YYMMDD)
980106

3. DOCUMENT TITLE ARMOR: LIGHTWEIGHT, COMPOSITE

4. NATURE OF CHANGE Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)

b. ORGANIZATION

c. ADDRESS (Include Zip Code)

d. TELEPHONE (Include Area Code)
(1) Commercial
(2) AUTOVON
(if applicable)

7. DATE SUBMITTED
(YYMMDD)

8. PREPARING ACTIVITY

a. NAME

US ARMY RESEARCH LABORATORY

b. TELEPHONE Include Area Code)

(1) Commercial 410-306-0725 (2) AUTOVON 458-0725

c. ADDRESS (Include Zip Code)

WEAPONS & MATERIALS RESEARCH DIRECTORATE
ATTN: AMSRL-WM-M
ABERDEEN PROVING GROUND, MD 21005-5069

IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:
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5203 Leesburg Pike, Suite 1403, Falls Church, VA 22401-3466
Telephone (703) 756-2340 AUTOVON 289-2340