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DEPARTMENT OF DEFENSE STANDARD

OCCUPANT-CENTRIC PROTECTION FOR MILITARY GROUND VEHICLES

AMSC N/A FSC 2355

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FOREWARD

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2. For commercial products, first consider using or developing a non-Government standard or including DoD requirements in an existing non-Government standard. If that will not meet the need, consider developing or revising a commercial item description.

3. The specification preparing activity should maintain a carefully documented, permanent record of the source and reason behind particular requirements and changes to requirements. Issues and controversial areas during the coordination process should be noted, and it may be desirable to summarize these issues and areas in the "Notes" section of the document and solicit feedback as experience develops. This record should provide a basis for related application guidance and a history useful in future document revisions.

4. Wherever possible, state requirements in terms of performance or form, fit, and function, as opposed to providing details on "how to" achieve the desired result.

5. Try to make use of commercial products, processes, or practices when setting requirements or tests.

6. Make a distinction between requirements portions and guidance portions of documents. Careful attention to use of the words "should" (guidance language) and "shall" (requirement language) is important.

7. Use Section 6 "Notes" to provide users with guidance information that should be considered for inclusion in the contract, how to apply the document to different contract types and different program phases, lessons learned, relationship to other documents, tailoring guidance, and any other information that is not suitable for inclusion as a requirement or test.

8. This is not intended to be a stand-alone document at this time.

9. Comments, suggestions, or questions on this document should be addressed to U.S. Army RDECOM, Tank Automotive Research Development and Engineering Center, ATTN: RDTA-SIE-ES-PLE, MS #268, 6501 E. 11 Mile Road, Warren, MI 48397-5000 or sent by email to usarmy.detroit.rdecom.mbx.tardec-standardization@mail.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil.

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1. SCOPE

1.1 Scope. This standard establishes general occupant-centric design and underbody blast protection criteria for Military ground vehicles.

1.2 Purpose. The purpose of this standard is to present occupant-centric design and underbody blast protection criteria, principles, and practices to optimize system performance with full consideration given to the target population and their defined equipment as part of the total system design trade space to achieve mission success and to mitigate the risk of occupant injury.

1.3 Application. This standard is applicable to the design of all ground vehicle systems, subsystems, and components. Unless otherwise stated in specific provisions, this standard applies to design of all ground vehicle systems, subsystems, and components for use by both male and female occupants. While this standard provides design criteria with respect to human capabilities and limitations, it is not intended to limit innovation in the design or selection of specific hardware, software, materials, and processes. This standard should be tailored by the Government as part of the contract. If it is not tailored by the Government, the contractor should determine any appropriate tailoring for the applicability to the system and should request approval from the Government for recommended tailoring.

1.4 Limitations. This military standard applies to occupant safety and protection in relation to underbody blast events. Side or top ballistic threats, vehicle rollover, and crash events are not included in this standard. These events should be kept in mind for future revisions to this standard.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this standard. This section does not include documents cited in other sections of this standard 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 of documents cited in sections 3, 4, or 5 of this standard, 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 cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-32518 - Performance Specification for Interior Head Impact Protection for use in US Military Ground Vehicle Interiors

MIL-PRF-32548 - Performance Specification for Occupant Seat Belt Restraint Systems for use in US Military Ground Vehicles

MIL-PRF-32558 - Performance Specification for Event Data Recorders for use in US Military Ground Vehicles
MIL-PRF-32563 - Performance Specification for Energy-Attenuating Seat Systems for use in US Military Ground Vehicles
MIL-PRF-32564 - Performance Specification for Energy-Attenuating Steering Subsystems for use in US Military Ground Vehicles
MIL-PRF-32566 - Performance Specification for Energy-Attenuating Floor Mats for use in US Military Ground Vehicles

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-1180 - Safety Standards for Military Ground Vehicles
MIL-STD-1472 - Human Engineering

DEPARTMENT OF DEFENSE DETAIL SPECIFICATIONS

MIL-DTL-7905 - Cylinders, Steel, Compressed Gas, Non-Shatterable, Seamless, 1800 PSI and 2100 PSI
MIL-DTL-62547 - Valve and Cylinder Assemblies, Halon 1301

(Copies of these documents are available online at http://quicksearch.dla.mil/).

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF THE U.S. ARMY

Pamphlet 40-501 - Army Hearing Program

(Copies of this document are available at www.med.navy.mil)

Memorandum - Noise Specification for Automatic Fire Extinguishing System (AFES)

(Copies of this document are available from the Department of the Army, 1500 Defense Pentagon, Washington D.C. 20310).

U.S. ARMY TANK-AUTOMOTIVE RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER (TARDEC) TECHNICAL REPORTS (TR)

TR-27709 - Laboratory Test Procedure for Occupant Protection Lab Subsystem Drop Tower

(Copies of this document are available online at http://www.dtic.mil).

U.S. ARMY TEST AND EVALUATION COMMAND (ATEC)

Test Operations Procedure (TOP) 10-3-001 - Performance and Vulnerability Testing of Automatic Fire Extinguishing Systems (AFES) Used on Combat and Tactical Vehicles

(Copies of this document are available from https://www.atec.army.mil/publications/topsindex.aspx).

WALTER REED ARMY INSTITUTE OF RESEARCH (WRAIR)

WRAIR AD-A233058 - Medical Evaluation of Non-fragment Injury Effects In Armored Vehicle Live Fire Tests, Instrumentation Requirements and Injury Criteria

(Copies of this document are available from http://www.dtic.mil/dtic/tr/fulltext/u2/a233058.pdf).

WARFIGHTER SURVIVABILITY BRANCH (WSB) U.S. ARMY RESEARCH LABORATORY (ARL) SURVIVABILITY/LETHALITY ANALYSIS DIRECTORATE (SLAD) TECHNICAL REPORTS

BRIEF - ARL SLAD WSB, Injury Criteria for the Analysis of Soldier Survivability in Accelerative Events, April 2012, DIST D

(Copies of this brief are available from RDECOM-ARL-SLAD-WSB, Attn: RDRL-SL-E, 328 Hopkins Road, APG MD, 21005).

U.S. ARMY SURGEON GENERAL

MEMORANDUM - Fire Survivability Parameters for Combat Vehicle Crewmen

(Copies of this memorandum are available from Department of the Army, Office of the Surgeon General, 5111 Leesburg Pike, Falls Church, VA 22041-3258).

2.3 Order of precedence. Unless otherwise noted herein or in the contract, 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. DEFINITIONS

3.1 Anthropomorphic test device (ATD). A test device that simulates the dimensions, weight proportions and articulation of the human body. The anthropomorphic test device or ATD is typically instrumented to record a wide variety data in dynamic events such as vehicle impacts or rollovers.

3.2 Drop tower. A testing device designed to simulate the acceleration involved in an impact event.

3.3 Energy-attenuating (EA) materials. A class of materials intended to reduce or redirect energy away from the occupant. Also known as energy-absorbing materials.

3.4 Enhanced injury assessment reference values (e-IARV). See definition for injury assessment reference value (IARV). Also, term used to describe injury criteria used for the Occupant-Centric Platform Technology-Enabled Capability Demonstration (OCP TECD) program during an underbody blast, crash and rollover event. These values result from existing biomedical research and the expansion of the current use of Anthropomorphic Test Device (ATD) testing from average male to the small female and large male ATDs.

3.5 Injury assessment reserve value (IARV). Threshold level below which a specified significant injury is considered unlikely to occur for a given individual.

3.6 Injury criterion. A physical parameter or a function of several physical parameters that correlates well with the injury (probability and/or) severity of the body region under consideration.

3.7 Military ground vehicle. General term for vehicles used in a military context. Military ground vehicles are usually categorized as tactical, which are generally used in a supporting context, or combat, which are used in direct or indirect contact with enemy forces.

3.8 Occupant-centric. Designing Military vehicles around the occupant requirements for accommodation, operability, and underbody blast force protection to achieve a reduction in Soldier injuries

3.9 Restraint system. A safety system designed to secure the occupant against harmful movement that may result from an impact or sudden deceleration event.

3.10 User evaluation. A means of assessment involving the target audience using the system.

3.11 Acronyms used in this standard. The acronyms used in this standard are as follows:

a. AEC	-	Army Evaluation Command
b. AFES	-	Automatic Fire Extinguishing System
c. ARL	-	U.S. Army Research Laboratory
d. ATD	-	Anthropomorphic Test Device
e. DoD	-	Department of Defense
f. DOT&E	-	The Office of the Director, Operational Test & Evaluation
g. EA	-	Energy-Attenuating
h. e-IARV	-	Enhanced Injury Assessment Reference Value

i. IARV	-	Injury Assessment Reference Value
j. LFT&E	-	Live Fire Testing & Evaluation
k. MOS	-	Military Occupation Specialty
l. NSRDEC	-	U.S. Army Natick Soldier Research, Development and Engineering Center
m. OCP TECD	-	Occupant-Centric Platform Technology-Enabled Capability Demonstration
n. PEO	-	Program Executive Office
o. PM	-	Program Manager
p. RDEC	-	Research, Development, and Engineering Center
q. SLAD	-	Survivability/Lethality Analysis Directorate
r. SNAP	-	Significant New Alternatives Policy
s. TARDEC	-	U.S. Army Tank-Automotive Research, Development, and Engineering Center
t. TOP	-	Test Operations Procedure
u. USAARL	-	U.S. Army Aeromedical Research Laboratory
v. WRAIR	-	Walter Reed Army Institute of Research
w. WSB	-	Warfighter Survivability Branch

4. GENERAL REQUIREMENTS

4.1 Accommodate the equipped target design population. The vehicle shall accommodate the equipped target design population in accordance with MIL-STD-1472.

4.2 Protect the vehicle occupants during an underbody blast event. The vehicle shall protect the occupants.

5. DETAILED REQUIREMENTS

5.1 Protect the equipped target population during an underbody blast event.

5.1.1 Injury criteria. The vehicle shall protect the target population. Refer to “ARL SLAD WSB, Injury Criteria for the Analysis of Soldier Survivability in Accelerative Events” for the injury criteria. See Notes 6.1 and 6.2. Refer to Appendix A for test methods and information.

5.2 Other protection requirements.

5.2.1 MIL-STD-1180 Department of Defense Interface Standard - Safety Standards for Military Ground Vehicles. Vehicle systems shall comply with the applicable safety standard paragraphs of MIL-STD-1180.

5.3 Performance specifications and requirements. If the ground vehicle system includes the technologies listed below, the technology shall be designed to meet the requirements of the associated performance specification or performance requirement.

5.3.1 MIL-PRF-32548 Performance Specification for Occupant Seat Belt Restraints for Use in US Military Ground Vehicles.

5.3.2 MIL-PRF-32563 Performance Specification for Energy-Attenuating Seat Systems for use in US Military Ground Vehicles.

5.3.3 MIL-PRF-32566 Performance Specification for Energy-Attenuating Floor Mats for use in US Military Ground Vehicles.

5.3.4 MIL-PRF-32518 Performance Specification for Protective Trim for use in US Military Ground Vehicles.

5.3.5 MIL-PRF-32564 Performance Specification for Energy-Attenuating Steering Systems for use in US Military Ground Vehicles.

5.3.6 MIL-PRF-32558 Performance Specification for Blast Sensing and Blast Data Recording Systems for use in US Military Ground Vehicles.

5.3.7 Performance requirements for cargo and equipment retention.

5.3.7.1 Retain cargo and equipment. Retain cargo and equipment during an underbody blast event to prevent occupant injuries from secondary projectiles.

5.3.7.1.1 Verification method. The cargo and equipment, upon impulse of 100G for 10 milliseconds at the mounting location, shall not become unrestrained during or after an underbody blast event. Evaluate in accordance with TR-27709 “Laboratory Test Procedure for Occupant Protection Lab Subsystem Drop Tower.”

5.3.8 Performance requirements for automatic fire extinguishing systems (AFES).

5.3.8.1 Durability. The AFES shall function correctly during and following an underbody blast event that is conducted with a threat that the vehicle is required to survive.

5.3.8.1.1 Verification method. Verify requirement per "Test Operations Procedure (TOP) 10-3-001 Performance and Vulnerability Testing of Automatic Fire Extinguishing Systems (AFES) Used on Combat and Tactical Vehicles."

5.3.8.2 Protection. The fire suppression system shall automatically protect the occupants from incapacitation for a minimum of 5 minutes per US Army Surgeon General Requirements, including “Medical Evaluation of Non-fragment Injury Effects in Armored Vehicle Live Fire Tests (Walter Reed Army Institute of Research, 1989),” against fast growth petroleum hydraulic fluid and other hydrocarbon fires.

5.3.8.2.1 Verification method. Verify by system test per "Test Operations Procedure (TOP) 10-3-001 Performance and Vulnerability Testing of Automatic Fire Extinguishing Systems (AFES) Used on Combat and Tactical Vehicles."

5.3.8.3 Nozzle placement. AFES discharge nozzles shall be at least 12 inches away from any body part.

5.3.8.3.1 Verification method. Verify by analysis of the CAD model and/or physical inspection.

5.3.8.4 Nozzle discharge acceleration. The AFES nozzle discharge acceleration measured at normally occupied crew positions shall be 8 g (derived from 57 N-m neck injury assessment) or less for no more than 30 ms.

5.3.8.4.1 Verification method. Verify by system test per "Neck injury assessment," in “Medical Evaluation of Nonfragment Injury Effects in Armored Vehicle Live Fire Tests,” (Walter Reed Army Institute of Research, 1989).

5.3.8.5 Noise levels. During extinguishing discharge at any normally occupied crew or passenger position, the noise level shall be less than 140 dB without hearing protection; or less than 165 dB with single hearing protection level. Refer to “Army Hearing Program,” US Army Pamphlet 40-501, found at www.med.navy.mil.

5.3.8.5.1 Verification method. Verify by system testing per “Hearing Conservation Program,” (US Army Pamphlet 40-501, 1998).

5.3.8.6 Prevent second degree burns. The fire suppression system shall prevent second degree skin burns per “Medical Evaluation of Non-fragment Injury Effects in Armored Vehicle Live Fire Tests” (Walter Reed Army Institute of Research, 1989).

5.3.8.6.1 Verification method. Verify in fuel fire tests "Test Operations Procedure (TOP) 10-3-001 Performance and Vulnerability Testing of Automatic Fire Extinguishing Systems (AFES) Used on Combat and Tactical Vehicles.

5.3.8.7 Prevent lung and ear damage due to overpressure. The fire suppression system shall prevent lung and ear damage due to blast overpressure per "Fire Survivability Parameters for Combat Vehicle Crewmen," (Swanson, G., Memo to the US Army Surgeon General, 1987)

and "Noise Specification for Automatic Fire Extinguishing Systems (AFES)," (Rice, W. A, Dept. of the Army Memorandum, 2013).

5.3.8.7.1 Verification method. Verify in fuel fire tests "Test Operations Procedure (TOP) 10-3-001 Performance and Vulnerability Testing of Automatic Fire Extinguishing Systems (AFES) Used on Combat and Tactical Vehicles."

5.3.8.8 Limit toxic gas levels. The fire suppression system shall limit toxic gas levels per “Medical Evaluation of Non-fragment Injury Effects in Armored Vehicle Live Fire Tests” (Walter Reed Army Institute of Research, 1989).

5.3.8.8.1 Verification method. Verify in fuel fire tests "Test Operations Procedure (TOP) 10-3-001 Performance and Vulnerability Testing of Automatic Fire Extinguishing Systems (AFES) Used on Combat and Tactical Vehicles."

5.3.8.9 Maintain oxygen levels. The fire suppression system shall maintain oxygen levels at 16% or higher per "Fire Survivability Parameters for Combat Vehicle Crewmen," (Swanson, G., Memo to the US Army Surgeon General, 1987).

5.3.8.9.1 Verification method. Verify in fuel fire tests "Test Operations Procedure (TOP) 10-3-001 Performance and Vulnerability Testing of Automatic Fire Extinguishing Systems (AFES) Used on Combat and Tactical Vehicles."

5.3.8.10 Compressed gas cylinder rating. Compressed gas cylinders used in the fire suppression system shall be rated NONSHAT per Section 3.3.9 in MIL-DTL-7905, "Detail Specification - Cylinders, Steel, Compressed Gas, Non-Shatterable, Seamless, 1800 Psi and 2100 Psi."

5.3.8.10.1 Verification method. Verify by comparing cylinder certification documents to cylinder markings.

5.3.8.11 Prevent fragment discharge. The fire suppression system shall not discharge fragments per Section 3.4.1.3 in MIL- DTL-62547, "Detail Specification - Valve and Cylinder Assemblies, Halon 1301."

5.3.8.11.1 Verification method. Verify by discharge test or review of supplier certification.

5.3.8.12 Non-ozone depleting substance. The fire suppression system shall utilize a non-ozone depleting substance that is approved by the USA Surgeon General and Significant New Alternatives Policy (SNAP) listed by the EPA.

5.3.8.12.1 Verification method. Verify USA Surgeon General approval and EPA SNAP listing.

6. NOTES

6.1 Protect the equipped target population during an underbody blast event. The OCP TECD Report TR-27790 "Enhanced Injury Assessment Reference Values" was created to meet the OCP TECD program challenge statement of "designing for and protecting the Soldier population". The OCP Enhanced IARVs (e-IARVs) have not been adopted by US Department of Defense (DoD) Live Fire Testing & Evaluation (LFT&E), Army Evaluation Command (AEC), nor The Office of the Director, Operational Test & Evaluation (DOT&E), as of publication of this Military Standard, for use in current and/or new acquisition programs. As described in the report, the injury criteria developed for the OCP TECD program utilized existing biomedical research. This report recommends that program executive offices (PEOs), program managers (PMs), and research, development, and engineering centers (RDECs) may integrate these e-IARVs or extract information into contracting documents as appropriate in conjunction with the currently accepted injury criteria. These values are to be utilized for informational and developmental purposes only.

6.2 Occupant incapacitation. Incapacitation is determined for each occupant within the vehicle, based on the vehicle mission and occupant’s Military Occupation Specialty (MOS). Incapacitation is determined by the PM in conjunction with independent evaluators.

6.3 Subject term (key word) listing.

Blast
Drop tower
Energy-attenuating
Injury
Restraint
Safety
Survivability
Underbody

APPENDIX A

OCCUPANT-CENTRIC PROTECTION UNDERBODY BLAST TEST METHODS

A.1 SCOPE

A.1.1 Scope. The following test methods are used to evaluate vehicle system response, vulnerability, and occupant survivability in an underbody blast event, based on the vehicle system mission scenario and threat definition. This testing shall be conducted IAW the applicable documents listed below for Vehicle Vulnerability, Injury Criteria, Threat Emplacement, and Soil Conditions. Occupant positioning procedures follow.

Occupant Survivability	Measure the biomechanical response of the occupant due to accelerative loading.
System Response and Vulnerability	Measure the response of structural components within the test asset due to accelerative loading, structural loading (pressure), displacement, and strain.

Injury criteria IAW the following document:

a. ARL SLAD WSB, Injury Criteria for the Analysis of Soldier Survivability in Accelerative Events

Anthropomorphic Test Device (ATD) utilization IAW the following documents:

a. TOP 2-2-640, Using Anthropomorphic Test Devices in Survivability Testing
b. ITOP 1-2-505, Testing with ATDs

Vehicle vulnerability IAW the following documents:

a. ITOP 4-2-508, Vehicle Vulnerability Tests Using Mines
b. ITOP 2-2-617, Vulnerability Testing of Combat Vehicles and their Components Subsystems
c. ITOP 2-2-722, Fragment Penetration Tests of Armor
d. TOP 4-2-840, Vehicle Vulnerability Tests Against Roadside Improvised Explosive Devises
e. TOP 4-2-842, Vehicle Vulnerability Tests Against Explosively Formed Penetrator (EFP) and Improvised Explosive Devices (IEDs)

APPENDIX A

Threat emplacement IAW the following documents:

a. STANAG 4569, Protection Levels for Occupants of Armoured Vehicles
b. AEP-55, Volume 2 (Edition 1), Procedures for Evaluating the Protection Level of Logistic and Light Armoured Vehicles, Volume 2 – For Mine Threat
c. ITOP 4-2-508, Vehicle Vulnerability Tests Using Mines

Underbody blast loading using engineered soil IAW with the following documents, as applicable:

a. ASTM D4643-08, Standard Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating
b. ASTM D2487-93, Classification of Soil for Engineering Purposes (Unified Soil Classification System)
c. American Association of State Highway and Transportation Officials (AASHTO) Soil Classification System, M-145-91
d. ASTM D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
e. ASTM D854, Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer
f. ASTM D698 (2012), Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))
g. ASTM D6938-10, Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

Occupant positioning IAW with the following procedure:

Instrumented ATDs will be used to record accelerative load effects data for each event.

1. Positioning. Each simulator will be positioned in representative personnel orientations. Measurements will be taken at multiple positions to include the H-point, knees, head, and shoulder to determine placement relative to fixed points on the seat. Adjustments will be made as needed based on the initial measurements with acceptability of final positioning determined by the test sponsor.
2. Restraints. If so equipped with a belted restraint, restraints shall be routed between the occupant gear “pouches” and as close to the torso and hips as possible. The following guidance will be followed to properly position and align restraints:
    a. If equipped with a five-point restraint system, locate the fifth-point belt/buckle and attach both lap belts and shoulder belts in the fifth point.
    b. Position the buckle at the waist (where shirt and pants meet) and remove belt slack from the fifth point belt. The left and right lap belts should be routed beneath any pouches attached to the vest and tightened.

c. Position and route the shoulder belts over or around any pouches attached on the chest. Ensure the shoulder belts are routed towards the center of the chest.
d. Conduct a visual inspection of the webbing to verify there are no twists or tears. Check belt tightness by sliding two fingers under the lap and shoulder belts to verify they are secure. If active retractors are used, cycle the left and right lap
e. belts to ensure they are locked followed by the left and right shoulder belts to ensure they are unlocked.
f. During the event, ensure that the restraint 5th point anchor (crotch strap) stays fixed relative to the horizontal plane of the H-point.

3. Follow a similar process should the simulator be equipped with other than a 5-point restraint system (e.g. 4, 3, or 2 point), with the buckle in the lowest position possible, closest to the lap.

Custodian:

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Preparing Activity:

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(Project 2355-2016-001)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.