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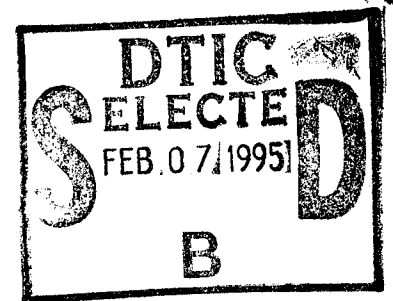


NBC Contamination Survivability
(NBCCS) of AVENGER

John D. Majeski

ARL-TR-660

November 1994



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NBC CONTAMINATION SURVIVABILITY (NBCCS) OF AVENGER

1. INTRODUCTION

This is a status report and addresses FY 94 efforts of a 2-year (FY94/95) study.

2. BACKGROUND

The Survivability-Lethality Analysis Directorate (SLAD), Chemical-Biological and Nuclear Effects Division (CBNED), of the U.S. Army Research Laboratory (ARL) has been tasked by the Project Manager (PM) AVENGER office to perform a nuclear-biological-chemical contamination survivability (NBCCS) analysis of the AVENGER system with recommendations concerning a suitable decontamination plan and cost-effective alternatives, when applicable. The PM has provided approximately 4000 component/assembly drawings to CBNED for related material evaluation. Other additional publications, such as AVENGER operational and maintenance manuals have been made available for this analysis.

Previous efforts conducted by the U.S. Army Dugway Proving Ground (DPG) are the following:

a) NBCCS analysis of the pedestal-mounted stinger (PMS) (see paragraph 4). This study, conducted during October 1989, provides an overall evaluation of the PMS turret, high mobility multipurpose wheeled vehicle (HMMWV) platform, and system interior, with anticipated problem areas discussed briefly. However, this analysis was conducted without the benefit of a technical data package (TDP). The lack of specific component/material information precluded an in-depth NBCCS analysis. Current availability of a fairly comprehensive TDP will enhance SLAD FY95 efforts to provide a more comprehensive analysis with recommendations to the PM.

b) Paper study of the HMMWV heavy variant (see paragraph 5). This study was fairly comprehensive and considered significantly noteworthy for review and inclusion in this status report. Many of the NBCCS problem areas discussed in the DPG study are probably still prevalent in the various HMMWV configurations currently used. However, the HMMWV modifications made in the Stinger product improvement to achieve the AVENGER configuration should be evaluated with the benefit of material/configuration specifics. Availability of TDP information will allow SLAD to provide value added considerations which will be reported during FY 95.

3. SCHEDULE

TASK	1994					1995			
	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR
Initiate review of data	x								
Visit PM/contractor (Boeing) to gather information and become further familiarized with the system			x						
Proceed with analysis (screen materials chemical data bases, past test results, etc.) *A task order contract will provide support services in this area.			x-----						
Visit PM/Boeing (coordination, additional information gathering)						x			
Prepare preliminary report						x---			
Coordinate report								x--x	
Finalize report									x--x

4. SYSTEM DESCRIPTION (see Figure 1)

The AVENGER air defense weapon system is a lightweight, day/night, limited adverse weather fire unit for countering the threat of low altitude, high speed, fixed wing or rotary wing aircraft, and moving or stationary ground targets. The fire unit consists of two turret-mounted Stinger missile pods, a .50-caliber machine gun, a forward-looking infrared receiver (FLIR) system, a laser range finder (LRF), and an identification friend or foe (IFF) system. The fully rotatable turret is mounted on the HMMWV. The sensor components and armament system are gyro stabilized so that the gunner can shoot while the vehicle is moving. The unit can fire a missile or machine gun while moving or from a stationary position. The gunner can operate the system from the turret or from a remote location. On-board communications equipment provides for radio and intercom operations.

Location of Major Components	Equipment Data
	<p>a. <u>Weight with Vehicle</u></p> <ol style="list-style-type: none"> 1. Loaded 8513 lbs 2. Empty 7447 lbs 3. GVW 8660 lbs
	<p>b. <u>Avenger (Turret)</u></p> <ol style="list-style-type: none"> 1. Loaded 2568 2. Empty 2025
	<p>c. <u>Power</u>- Two 12V, 100 amp, 6 TN lead-acid batteries</p>
	<p>d. <u>Heater/Ventilator</u></p> <ol style="list-style-type: none"> 1. Full capacity 1.5 gals 2. Approximate operating time (full) 8 hrs 3. Temperature range 60 degrees to 90 degrees F
	<p>e. <u>Turret</u></p> <ol style="list-style-type: none"> 1. Elevation -10 degrees to +68 degrees 2. Azimuth rotates 360 degrees, rotation rate 60 degrees per sec with missiles caged
	<p>f. <u>HMMWV Avenger Modifications</u></p> <ol style="list-style-type: none"> 1. Hard cab 2. Doors 3. 100 amp generator 4. Non-skid surfaces 5. Aluminum airlift bumper 6. Blast deflectors

Figure 1. AVENGER components.

Equipment Data (Continued)

g. FLJR

1. WFOV, 1.8
2. NFOV, 7.2
3. Rain, 3.17

h. Machinegun

1. Weight, 76 lbs
2. Basic Load, 200 rounds
3. Rounds per minute, 1100 high rate
4. Remotely charged
5. Type ammo, .50 cal

i. Grade Operation

1. 60% ascent at 4 mph
2. Stop on 60% grade for 1 minute; then continue

j. Side Slope Operation - Traverse side slopes up to 40% from either side of vehicle

Equipment Data (Concluded)

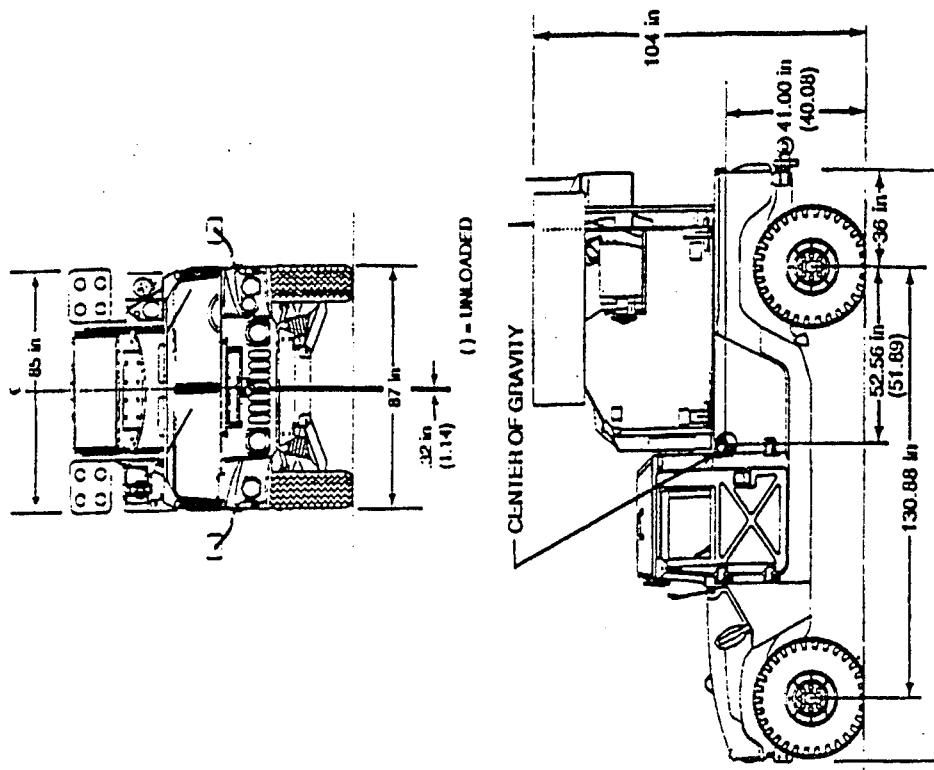


Figure 1 (continued)

The AVENGER consists of the following systems:

- Power distribution
- Slipring/azimuth encoder
- Armament
- Crew accommodations
- Azimuth/elevation drive
- Sensor
- Identification friend or foe (IFF)
- AVENGER control electronics (ACE)
- Communications
- Remote control unit (RCU)

5. DEFINITIONS (see AR-70-71)

5.1 Decontaminability Capability of being rapidly decontaminated to reduce the hazard to a negligible level for unprotected personnel who operate, maintain, and resupply the materiel (equipment). The developer must consider the following:

a) Materials. Make maximum use of materials and coatings that minimally absorb NBC contamination and thereby facilitate rapid removal of contamination by means and procedures available on the battlefield.

b) Design. Construct the equipment so that exposed surfaces resist the accumulation of NBC contamination or are readily accessible for decontamination.

c) Contamination control. Employ devices that reduce the amount of contamination to be removed. Such devices may include positive overpressure for combat vehicles, packaging for supplies, and protective covers.

d) NBC equipment. Consider the requirement for NBC detection, monitoring, and contamination control devices.

5.2 Hardness Capability of withstanding the materiel-damaging effects of NBC contamination and the materials/procedures required to decontaminate the item. Decontaminability and hardness are distinct qualities. Decontaminability standards concern the residual hazard to personnel; hardness standards concern damage to materiel.

5.3 Compatibility Capability of being operated, maintained, and resupplied by persons wearing the full NBC protective ensemble, in all climatic conditions for which the item is designed and for a period specified in the requirements document. Collective protection equipment (CPE) does not provide compatibility. However, for some systems, the combat developer may substitute CPE for compatibility. In doing so, he or she accepts the possibility of diminished capability if contamination enters the CPE and the crew is forced to don the individual protective ensemble.

6. METHODOLOGY

The PM has identified a list of "mission-essential" components. Their definition of mission-essential items includes those necessary to fire a missile or the machine gun against hostile targets. This office has included several other additional items that it considers as "mission essential." These items are addressed later in this report. Concentration will be placed on the mission-essential component drawings, which will be extracted from the technical data package (TDP) provided. The design of these components will be reviewed to determine their accessibility to agents/decontaminants.

The accessibility of components to NBC contamination and decontamination will be determined by the location of the component on or in the weapon system. NBC exposure levels will be defined by their location and relative proximity to an entry pathway, hatch, or door. Components determined to be inaccessible should need no further evaluation since NBC exposure poses no threat. Exposure levels will be categorized as follows: Level 1-zero exposure; Level 2-vapor/biological aerosol exposure only; Level 3-partial liquid and/or solid fallout exposure plus total vapor/aerosol exposure; Level 4-full exterior exposure; and Level 5-exposure resulting from ingestion of exterior contamination with high flow rate, unfiltered, ventilation air.

A susceptibility analysis will be conducted on those component materials determined to be mission essential and accessible. Once a material has been determined to be susceptible, a data base search will be conducted to determine if information such as test results of the affected material against agents and decontaminants is available. If this information is not available, subsequent testing or a suitable alternate approach will probably be recommended. The "hardness" of the component is of significant importance if that item is accessible and susceptible. The identified materials are compared to susceptibility data from previous liquid, vapor, or aerosol challenge testing and decontaminating exposure. Two of the sources that will be utilized for test data are the chemical defense materials data base (CDMD) and the Chemical Warfare/Chemical/and Biological Defense Information Analysis Center (CBIAC). The analysis shall then consist of a look at

“vulnerability.” A system is considered to be vulnerable if its mission-essential components are susceptible to any contamination exposure. Also, a system is considered vulnerable if it cannot be operated, maintained, or resupplied by a soldier in mission-oriented protective posture (MOPP) IV ensemble (compatibility) or if, after exposure to contamination, the system’s contamination concentration cannot be reduced to negligible risk levels. Finally, the probability of item failure, will be categorized from very high to remote. Unknown situations will be noted as such. Failure categorization shall consider the Army Regulation (AR) 70-71 elements of hardness, decontaminability, and compatibility.

7. PREVIOUS RELATED EFFORTS

Previous efforts are described in Hansen (1989).

7.1 Purpose The U.S. Army Test and Evaluation Command (TECOM) tasked Dugway Proving Ground to perform a chemical and biological (CB) survivability analysis of the pedestal-mounted stinger (PMS). This analysis included review and design aspects that could influence the ability of the PMS to meet the criteria of AR 70-71. This analysis was conducted during production qualification testing (PQT) at the U.S. Army White Sands Missile Range.

7.2 Findings

7.2.1 Decontaminability

a) PMS Turret. The primary reasons for failure of the PMS turret to meet the decontaminability requirements are

- The carbon composite turret structure, although painted with chemical agent resistant coating (CARC), probably has too many cracks and seams to be readily decontaminated.
- The hardened Plexiglas™ canopy will probably absorb agent and will be extremely difficult to decontaminate.
- The electrical connectors were fabricated with a variety of plastic and rubber, coupled with plugs and wire bundles. This composite of materials readily absorbs agents but desorbs agents very slowly, making effective decontamination impossible.

- The external insulation on the exhaust system cannot be readily decontaminated.
- The .50-caliber machine gun and allied equipment will be difficult to decontaminate.

b) HMMWV Platform The primary reasons for failure of the HMMWV platform to meet the decontaminability requirements are

- Wood and rubber chocks carried in the HMMWV bed are nearly impossible to decontaminate.
- Fiberglas utility cans and equipment cases are difficult to decontaminate.
- Tires, windshield wipers and moldings, hood latches, and nonskid materials all present materials or surfaces that are difficult to decontaminate.

c) System Interior The interiors of the system (turret and platform) have diverse electrical equipment, seats, floor mats, and controls. Many of these items are made of materials that readily absorb chemical agents and present many cracks and crevices in which NBC agents may collect, making decontamination difficult. Most of the surfaces are not chemically resistant or coated with chemically resistant coatings (e.g., CARC paint). Because the interiors are somewhat protected (inside the platform or the turret), contamination avoidance can be practiced to reduce the decontamination problems for the interiors (e.g., keep doors, windows, and canopy closed).

7.2.2 Hardness. The PMS system will probably fail the hardness requirements for the three areas considered. The standard decontamination method for nuclear and biological agents (hot soapy water or bleach) is generally milder than for chemical agents. Therefore, chemical decontamination with DS2 is the only method considered in detail in this report.

a) PMS Turret An integral part of the PMS operation is the target acquisition and range equipment. This sighting and acquisition equipment requires windows made of quartz and germanium. These windows must maintain accurate transmission properties for proper tracking. DS2 and bleach (and possibly hot soapy water) will alter the transmission properties, even if small quantities of the decontaminant are allowed to contact the windows. Any decontamination procedure that uses DS2 and bleach (and possible hot soapy water) on the windows will cause the entire tracking system to fail.

- The .50-caliber machine gun will likely fail to function after five decontamination cycles.

- In summary, decontamination of the turret with DS2 and bleach will probably result in system failure. If care is taken, and mild decontaminants are used, the operational characteristics can probably be maintained. However, extra decontamination time and training will be required, and the decontamination will not be as effective. Hot soapy water might be used (for nuclear and biological agents) with little or no adverse effect on the equipment.

b) HMMWV Platform The major difficulty of the HMMWV platform would be to maintain the electrical integrity of the engine with successive decontamination cycles.

c) System Interior Any attempt to decontaminate the interior with DS2 will probably result in a system failure.

7.2.3 Compatibility. The compatibility requirement can probably be met, depending on level of training of the operators. When operating in a contaminated environment, MOPP IV gear will be required. As long as the crew can maintain the suit integrity, there should be no extreme degradation in performance. The crew will need relief from MOPP IV gear periodically to respond to personal needs (eating, drinking, etc.). All typical problems associated with MOPP IV operations will be encountered. However, no additional problems are anticipated.

8. REPORT FOR NBC CONTAMINATION SURVIVABILITY OF THE HMMWV HEAVY VARIANT, TECOM PROJECT NO. 1-VG-120-HMV-058, JANUARY 1991

8.1 Background

The U.S. Army Test and Evaluation Command (TECOM), Aberdeen Proving Ground, Maryland, tasked U.S. Army Dugway Proving Ground (DPG), Utah, to perform a U.S. Army Regulation (AR) 70-71 nuclear, biological, and chemical (NBC) survivability paper study on the M1037 and heavy variant HMMWV. This task consisted of a design and materials study to determine whether these vehicles can be expected to perform their mission-essential functions in a chemically contaminated battlefield environment.

The HMMWV was undergoing preproduction qualification (PPQ) testing at the U.S. Army Combat Systems Test Activity (CSTA), Aberdeen Proving Ground (APG), Maryland, and the Yuma Proving Ground (YPG), Arizona. The DPG analyst visited APG from 21 to 23 August 1990 to evaluate the HMMWV during testing.

Addressed in this analysis were the three constituent factors of AR 70-71, decontaminability, hardness, and compatibility.

8.2 System Description

At the time of this study, there were five body styles and 16 configurations comprising the HMMWV family. These included transports for hauling cargo, troops, and towing the 105-mm howitzer; armament carriers for combat support; communication shelter carriers; missile carriers; and ambulances.

The existing HMMWV chassis had been contractor modified to produce a heavy variant with a gross vehicle weight of 10,000 pounds. This had been accomplished with a minimum of changes in the chassis and minor body reinforcements. This vehicle was painted with CARC to protect it from the effects of contamination and subsequent decontamination procedures.

8.3 Objective

Determine whether the HMMWV complies with AR 70-71 and related Army approved NBC contamination survivability criteria.

8.4 Findings

The visual inspection of the HMMWV listed the following concerns:

- The windshield and hood sealing gaskets, side door moldings, windshield wiper blades, hood closure strips, and exposed rubber tubing and belts in the engine compartment will absorb and retain chemical agents.
- Seat covers and seat belts will absorb and retain chemical agents. Retention of agents within the seat covering material, in particular, could pose substantial transfer hazards to passengers.

- Floor covering material and joints where the floor covering is joined to the sides of the cab interior will entrap contaminants.

- The existing design of the gas and brake pedals will entrap contaminants.

- The recessed well housing the fuel filler cap will entrap contaminants.

- Grease coating the rear towing pintle and chassis lubrication points will absorb chemical agents.

- Exposed cables and wiring harnesses in the engine compartment and on the underside of the frame will trap contaminants.

- It may be difficult to read the level of coolant in its plastic reservoir when wearing an NBC protective mask.

- The nearly horizontal configuration of the radiator, coupled with large exterior hood vents, makes this a particularly vulnerable area to NBC contamination. This design almost guarantees contamination of the intricate radiator fins unless the exterior hood vents are covered before exposure to NBC agents. Once contaminated, the heat emitted from the radiator will present a contact and vapor hazard, especially to personnel riding down wind in the passenger compartment. This hazard will probably decrease as the radiator emits enough heat to decontaminate itself by burning off any residual contamination after the use of conventional decontamination.

- Several other areas, by virtue of their design, will entrap contaminants. These areas include front and rear parking and turn signal light assemblies, tires, wheels, side view mirror support assemblies, air intake housing, and front towing shackles.

A number of recommendations were made by the DPG analyst. However, they are not listed in this report, since HMMWV modifications made or in process since the study discussed may have corrected some of the then-existing problems. The current ARL effort described in Paragraph 2 will culminate in a report that will address the AVENGER HMMWV configuration.

9. CONCLUSIONS

9.1 Progress to Date

The ARL/CBNED analyst has

- Initiated a review/screening of the TDP provided by the PM, separating the PM-designated mission-essential components (see Table 1).
- Initiated screening of critical materials against the chemical defense materials data base (CDMD).
- Prepared and submitted a scope of work to ARL procurement for obtaining contractor support services for this project.
- Made several information-gathering visits to the PM AVENGER and contractor (Boeing) facilities. (Requested from the PM and not received of this date is TDP information relative to the launch pods, missile, and machine gun components.)

9.2 Major Issues Requiring Addressal

Decontamination of Contaminated Ammunition The Army does not have any formulated policy for this issue. Action is being taken by the U.S. Army Nuclear Chemical Regulatory Agency to establish a policy for this area.

Cost-effective alternate approaches for improving vulnerable components/areas such as the HMMWV. It is anticipated that this study will result in the recommendation of suitable corrective measures.

(The following is a PM AVENGER compilation of components considered as constituting a “minimum mission-essential” equipment list. The items necessary to fire a missile or the machine gun against a known hostile target are identified as YES in the mission-essential column.)

Table 1
 AVENGER Mission-essential Components

Item	Mission essential	Comments
Turret module assembly	yes	not sealed
Laser range finder	no	
FLIR	yes	sealed but lens damage probable
FLIR monitor	yes	not sealed
FLIR FOV foot SW	no	
Autotracker symbology card	yes	(for missiles only) provides driven reticles for missile lock-on validation, sealed
Control display terminal (CDT)	no	
Site electronics	no	
Site head	no	
Ace	yes	sealed
Gunner's console	yes	not sealed, front panel switches vulnerable plus lamp card 1a1 and misc. card 1a2 inside
Gunner's hand station	yes	switches not sealed
Machine gun	yes	not sealed
Gun charger	yes	not sealed
5V power supply	yes	sealed
RT 524 and antenna	no	
AM 1780	no	
CVC helmets	no	
C-2298 intercom	no	
*IFF antenna	no	
IFF interface box	no	
IFF interrogator	no	
Heater ventilator	no	
Launch pods	yes	not sealed
Launch elect assembly	yes	sealed
Interface elect assembly	yes	sealed
Electronics cont assembly	yes	sealed
Azimuth drive assembly	yes	sealed
Elevation drive assembly	yes	sealed
Azimuth encoder	no	
*Gun gyro	no	
Hull gyro	no	

Table 1 (continued)

Slip ring	yes	not sealed
HMMWV batteries	no	
System batteries	yes	not sealed
Current monitor	no	
RSO jumper at baseplate	yes	sealed
*Remote control unit	no	
RCU jumper at baseplate	yes	sealed
Terminal boards	yes	not sealed
Cables		not sealed
W12	yes	connect system batteries
W13-1,-2	yes	battery to NATO connector
W14	yes	aft video to FLIR monitor
W15	yes	28, 15, 5 volt distribution
W16	yes	IEA to right pod
W17	yes	28V through slipring to terminal BD
W18	yes	IEA to left pod
W19	yes	ACE to slipring and encoder
W20	yes	ACE to IEA and 1780
W21	yes	28V terminal BD to gunner's console
W22	yes	28V terminal BD to ECA
W23	no	aft video to slipring
W24	no	gunner's console to foot SW, heater ventilator, IFF 2298 and 1780
W25	no	RT524 antenna ground strap
W26	yes	slipring to baseplate current monitor and NATO
W27	yes	slipring to NATO
W29	yes	5, 15, 28V power distribution from gunner's console to ACE
W30	yes	gunner's console to ACE
W31	no	ACE to CDT, optical sight and LRF
W32	yes	RSO shorting plug
W34	yes	gunner's console to limit switches and W35
W35	yes	W34 to machine gun
W37	no	ACE to FLIR display and AVT
W38	yes	FLIR monitor to receiver
W41	no	wall lamp to W15
W42	yes	FLIR video to AVT
W44	no	R442 antenna ground strap
W45	yes	ACE to ECA, hand-station, W30 and W74
W46	no	IFF interface box to IFF antenna DIFF

Table 1 (continued)

W47	no	IFF interface box to IFF antenna SUM
W71	no	baseplate to RSO box
W72	no	AVDAS power
W73	no	AVDAS baseplate video and data to encoder and audio to junction panel
W74	yes	elevation drive to W45 and ECA
W75	yes	ECA to gun and hull gyros
W76	yes	azimuth drive to ECA
W77	yes	elevation drive to ECA
W78	no	IFF interrogator to IFF interface box
W80	no	RCU cable
W81	no	RCU CVC helmet extension cable
W82	no	1780 to R442
W83	no	1780 to RT524
W84	no	RT524 antenna to RT
W85	no	RT antenna to RT
W86	no	sight head to electronics
W87	no	NATO cable
W88	no	RT524 to R442
W89	no	R442 to R442 antenna
W90	no	AVDAS recorder to junction panel
W91	no	AVDAS recorder to recorder remote control
W92	no	AVDAS encoder video out to junction box
W95	no	current monitor to battery and NATO connector

*NOTE. Author comments to this table are indicated as follows. Recommend asterisk items be considered as categorized "Yes" in "Mission-Essential" column. Also, the inability to satisfactorily decontaminate the HMMWV may present significant degradation in mission capability.

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