Statement of Objectives

On-Board Vehicle Power

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1. SCOPE

1.1 Introduction. A need exists for an On-Board Vehicle Power (OBVP) system that will address the performance objectives set forth in this document. This Statement of Objectives (SOO) defines the effort and desired attributes for procurement and delivery of OBVP systems to be installed on Government Furnished High Mobility Multi-Purpose Wheeled Vehicles (HMMWV). Additionally, the contractor shall provide the requisite program management and logistics support to ensure that delivery, performance requirements, and overall supportability of the OBVP is accomplished as set forth in the subsequent contract. This program will be executed in a stepped fashion in order to refine the concept, layout, and eventual configuration while reducing risk.

1.2 Guidance. This acquisition embraces the use of the contractors configuration controlled item to the maximum extent possible, along with the vendor's product information, documentation, and manuals to the greatest extent possible. This program is funded by America Recovery and Reinvestment Act (ARRA) funding, and will carry with it special reporting requirements.

1.3 Requirements. The contractor will be responsible to establish, maintain, and deliver a configuration item that has been proposed, accepted, and verified by the Government. The contractor's Product Specification will be the binding configuration document of OBVP. Government objectives (Section 3) are initially provided to set objective criteria, which will support contractor development of concepts, that will lead up to the Product Specification, and ultimately to the configuration item. With the exception of Critical Performance Parameters (CPP) specified that are non-tradable, all other requirements are tradable within the construct of best value approach to meeting the highest level of system capability. Failure to satisfy ALL CPPs will render a proposed solution unacceptable.

1.4 Technical Approach. This program commences with the premise of preliminary technical demonstration of an offerors solution has already taken place. Although not yet a commercial or non-developmental item, this program is not a developmental contract that initiates with a clean-sheet-of-paper design. Technical compliance shall be based upon evidence (e.g., commercial specifications, test or performance data, etc.) of the OBVP to meet the performance standards set forth in the Product Specification, as well as conformance to the delivery schedule. The contractor will be responsible to verify that all delivered items can meet the approved Product Specification. Government testing may be performed at the Government's discretion. It is anticipated that proposed solutions would engage a phased development approach as detailed below:

1.4.1 Phase 0 - Proposal Submission with Product Sample: As part of each responsive offeror to the Governments Request for Proposal, the offeror shall provide a Product Sample for Government evaluation (in addition to full proposal requirements defined in the Solicitation). The Product Sample should represent the offerors starting-point for an OBVP system that will be successively refined in subsequent program phases. Government evaluation is defined in the Solicitation and this document. Each offeror

shall propose total program cost for all phases. The Government may award multiple contracts going into Phase 1.

1.4.2 Phase 1 - Base Contract: The first contracted phase of the program is anticipated to be 5 months in duration and will consist of risk reduction, performance mapping, sizing, component selection and final design of the vendors OBVP system required to achieve the proposed capabilities. Feasibility of the proposed system that will take place during Phase 2 should be supported by available data from Phase 1. Potential implications to cost and logistics to the design selected should be provided. Any potential safety hazard with the system should be addressed. At 3 months after award in Phase 1, the contractor shall present a system design. At 5 months after award, and the contractor shall conduct a final review, demonstrate the technology on the provided GFE vehicle, provide all final data deliverables for the Phase and may provide an updated cost estimate for Phase 2. Following completion of Phase 1 efforts, the Government will down-select within 30-60 days and proceed into Phase 2. During Phase 1, one Government Furnished HMMWV will be provided to each awarded contractor.

1.4.3 Phase 2 – Contract Option: The second phase of the program is anticipated to be no longer than 12 months in duration from start of work of Phase 2, and will consist of tasks required to build, test, and demonstrate five (5) prototype systems at Technology Readiness Level (TRL) 7 suitable for rugged field testing. Program documentation shall be completed and delivered to support testing. The contractor shall propose and deliver a defined configuration OBVP system compliant with their Government approved Product Specification. The contractor shall accomplish delivery of the OBVP as set forth in the contract and contract options. During Phase 2, five Government Furnished HMMWVs will be provided to the contractor. Phase 2 will also include an option for the purchase of additional kits to be installed by the contractor on additional Government Furnished vehicles

1.4.3.1 Training. The contractor shall develop a training program that shall consist of, at a minimum: setup, takedown, operations, and maintenance for Organization and Maintenance personnel. The scope of instruction shall include: all required courseware and materials; certification standards for instructors, operators and maintainers; and sufficient “hands-on” time with all pieces of equipment (to be provided by the Government) to ensure compliance with operational safety goals. Training materials, in Microsoft Office format (PowerPoint, Word, Publisher, etc) shall be delivered on a CD-ROM in accordance with a vendor provided schedule. This shall be provided during Phase 2 efforts, with no less than 3 training sessions to military and civilian audience (10 persons per session). Delivery shall be Aberdeen Test Center, Aberdeen, MD.

1.4.3.2 Additional Vehicles. The contractor, upon receipt of a Government Furnished HMMWV, shall install an OBVP kit. Up to ten occurrences may be exercised.

1.4.3.3 Technical Support. The contractor shall propose and provide labor categories to support the level-of-effort listed in Section B. This shall be at fixed hourly rates, with individual tasking to be determined at a later date on an “as needed” basis. Such support might include assistance

with refining mission roles, additional/surge field support for test and evaluation, detailed performance analysis; resolution of unique technical problems; or providing remedies for unwarranted failures

1.5 System Safety. The contractor shall consider and implement safety engineering principles in the system design and fabrication. System design and operational procedures developed by the contractor shall identify hazards associated with the system by conducting safety analyses and hazard evaluations. Analysis shall include both operational and maintenance aspects of the system along with potential interface problems with planned subsystems.

1.6 Technical Data

1.6.1 Product Specification. The contractor shall develop, maintain, update (as required), and deliver a Product Specification that describes the technical and functional performance of the OBVP. The Draft Product Specification shall be delivered at conclusion of Phase 1, a Final Review Copy prior to delivery of any OBVP fitted vehicles, and the Final Version at end of Phase 2.

1.6.2 Technical Data - Operations and Maintenance Manual. This manual shall be one document. The manual shall contain installation, operation, troubleshooting and maintenance instructions at the Organizational and Intermediate Levels. The manual shall include a complete repair parts list, which includes expanded schematic views of all assemblies and subassemblies, and a list of all special tools required by the system. The repair parts list shall include, as a minimum, the following associated data elements: Complete item nomenclature, estimated unit price, unit of issue, Source of Supply. Repair parts list will include Original Equipment Manufacturer's (OEM) part numbers. Delivery timetable and revision control shall be proposed by the offeror. This document shall be delivered concurrent with first OBVP fitted vehicle delivery. A draft manual shall be delivered 60 days prior to first vehicle delivery. Based on Government comments to be returned within 30 days, an updated draft manual shall be delivered no later than delivery of first vehicle with OBVP.

1.6.3 Technical Data - Safety Assessment Report. The contractor shall provide a Safety Assessment Report (SAR) that documents the Safety Assessment and clearly identifies any residual risks of the OBVP. The SAR shall include a signed statement that all identified hazards have been eliminated, or their associated risks controlled to acceptable levels and that the OBVP is ready to test, field or operate. Delivery schedule shall be 60 days prior to first OBVP delivery to the Government during Phase 2.

1.6.4 Technical Data – Monthly Progress Reports. The contractor shall provide monthly progress reports detailing technical progress and cost obligation/expenditure reporting throughout all contract phases. Due to the ARRA nature of the program and statutory requirements for transparency and reporting, contractors will also be required to provide a stand-along, monthly technical/cost/labor/job creations report as part of the contract.

1.6.5 Technical Data – End of Phase Reports. The contractor shall provide detailed Final Reports of efforts accomplished during each program phase. Deliverables shall be made during Phase 1 and 2.

1.7 Meetings. The contractor shall attend or host meetings no less than prescribed below:

Purpose	Frequency	Locations
Phase 1 - Start of work / Requirements Review	Once	Quantico VA
Phase 1 - In-Process Review	Once	Contractor facility
Phase 1 - Final Review	Once	Aberdeen, MD
Phase 2 - Start of work	Once	Quantico VA
Phase 2 - Test Readiness Review	Once	Vendor facility
Phase 2 - In-Process Reviews	Quarterly	Alternate between VA and Vendor facility

2.0 APPLICABLE DOCUMENTS

This document is subject to all applicable laws and regulations in effect, unless specifically exempted by the Government.

The following Government and Non-government documents form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement. In the event the listed documents have been superceded, the most current version or replacement document shall be used.

Number	Title	Revision
IEC 60309	International Electrotechnical Commission - Plugs, Socket-Outlets And Couplers For Industrial Purposes	
IEC 60529	International Electrotechnical Commission - Degrees Of Protection Provided By Enclosures	
IEEE STD-315-1975	IEEE Standard Graphic Symbols For Electrical And Electronics Diagrams	
MEP-STD-001	Export Power, Vehicle Mounted, Tactical, Alternating Current Up To 30 Kilowatts	31-Jan-03
MIL-HDBK-1857	Grounding, Bonding, Shielding Design Guidelines	
MIL-HDBK-419	Grounding, Bonding And Shielding For Electronic Equipment And Facilities, Volumes 1 & 2	A
MIL-HDBK 633	Handbook For Mobile Electric Power Engine Generator Standard Family, General Characteristics	F
MIL-HDBK-454	General Guidelines For Electronic Equipment	A
MIL-HDBK-705	Generator Sets, Electrical, Measurement And Instrumentation Methods	C
MIL-STD-810	Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests	F
MIL-STD-1275	Characteristics Of 28 Volt DC Electrical Systems In Military Vehicles	D
MIL-STD-1332	Definitions Of Tactical, Prime, Precise, And Utility Terminologies For Classification Of The DOD Mobile Electric Power Engine Generator Set Family	B
MIL-STD-461	Requirements For The Control Of Electromagnetic Interference Characteristics Of Subsystems And Equipment	E
NFPA 70	National Electrical Code	2005
SAE J163	Low Tension Wiring And Cable Terminals And Splice Clips (DOD Adopted)	28-Dec-01
SAE J560	Seven Conductor Electrical Connector For Truck-Trailer Jumper Cable (DOD Adopted)	21-Apr-04
STANAG 2601	NATO Standardization Agreement - Standardization Of	

3.0 SYSTEM PERFORMANCE

With the exception of Critical Performance Parameters (CPP), which cannot be violated, all other requirements herein are tradable, but only with Government concurrence:

3.1 MEP-STD-001. The requirements of MEP-STD-001, Appendix A, shall be followed.

3.1.1 Under paragraph 1.2 and all subsequent references to "Auxiliary Power Distribution System", this refers to the AC power producing components of this program.

3.1.2 Under paragraph 1.2, there exists no requirement for 400 Hz electrical power.

3.1.3 Under paragraph 1.2, the requirement is for Utility Class 2B (threshold).

3.1.4 Under paragraph 1.2, the requirement is for Utility Class 2A (objective).

3.1.5 Under paragraph 1.3.2, Configuration II, the electrical configuration is: 120/208-volt, 3-phase, 5-wire, WYE configuration.

3.1.6 Under paragraph 3.3.2, there exists no requirement for Parallel operation.

3.1.7 Under paragraph 3.5.1, the Starting and Operating Environmental Requirement is -25 to 125 degrees Fahrenheit (threshold).

3.1.8 Under paragraph 3.5.1, the Starting and Operating Environmental Requirement is -40 and 131 degrees Fahrenheit (objective).

3.1.9 Under paragraph 3.10, Endurance of 750 hours is required without Critical Failure.

3.1.10 From MEP-STD-001, the following requirements are CPPs.

3.1.10.1 Paragraph 1.2 Classification at Utility Class 2B is a **Critical Performance Parameters (CPP)**

3.1.10.2 Paragraph 1.3 Power Rating is a **Critical Performance Parameters (CPP)**

3.1.10.3 Paragraph 3.2.6 Transportability is a **Critical Performance Parameters (CPP)**

3.1.10.4 Paragraph 3.3.1 Starting operating and Stopping is a **Critical Performance Parameters (CPP)**

3.1.10.5 Paragraph 3.5 Environmental Requirements at -25 to 125 degrees Fahrenheit is a

Critical Performance Parameters (CPP)

3.1.10.6 Paragraph 3.10 Endurance is a **Critical Performance Parameters (CPP)**

3.2 PHYSICAL CHARACTERISTICS

3.2.1 Dimensions. The OBVP shall not exceed the maximum length, height, and width dimensions of the host HMMWV platform.

3.2.2 Volume Infringement. Any OBVP components in the occupied crew or cargo spaces of the HMMWV shall be relocatable, based on integration needs of the platform.

3.2.3 Power Density. The system, as installed, shall weigh no more than 25 pounds per delivered kilowatt

3.2.4 Weight. The system, as installed, shall increase the platform weight no more than 825 lbs. **Critical Performance Parameters (CPP)**

3.3 ELECTRICAL REQUIREMENTS

3.3.1 Power Output. The system, as installed, shall deliver for export power 20 kilowatts continuous (threshold) at 208 VAC, 3-phase, 60 Hz. **Critical Performance Parameters (CPP)**

3.3.2 Power Output. The system, as installed, shall deliver for export power 30 kilowatts continuous (objective) at 208 VAC, 3-phase, 60 Hz.

3.3.3 Power On-The-Move. The system, as installed, shall deliver at least 25% of rated power while the vehicle is in motion, without detriment to vehicle operation. **Critical Performance Parameters (CPP)**

3.3.4 Power On-The-Move. It is desired that the system, as installed, shall deliver at least 33% of rated power while the vehicle is in motion, without detriment to vehicle operation.

3.3.5 Synchronization. The system shall have frequency adjustment to allow synchronization with a Tactical Quiet Generator or USMC MMG25 generator via an external synchronization box. Technical data on the USMC model unit is available at http://www.marcorsyscom.usmc.mil/sites/pmeps/SynchronizerBox.asp

3.4 CONFIGURATION

3.4.1 The GFE vehicles to be provided will have a 400 Amp, 28/14 VDC (nominal) alternators installed: this program does not need to provide DC power, nor should this program affect the inherent DC power capability of the vehicle.

3.4.2 Configuration II power output shall be via Series 16 CAM-LOCK receptacles (5 separate, color coded).

3.4.3 Water Fording. The OBVP when mounted shall be capable of shallow water fording in conformance with MIL-STD-810F Method 512.4, paragraph 2.3.2.4.a(3) up to a depth of 30 inches without preparation. The system shall be capable of fording hard-bottomed crossings of fresh or salt water including wave height, without requiring the addition of special equipment or adjustments and without damage to the system. If the OBVP components are inactive during fording, then the system shall be capable to be energized within 1 minute of completion of fording operations. **Critical Performance Parameters (CPP)**

3.4.4 Water Fording. The OBVP when mounted shall be capable of shallow water fording in conformance with MIL-STD-810F Method 512.4, paragraph 2.3.2.4.a(3) up to a depth of 60 inches with preparation. If the OBVP components are inactive during fording, then the system shall be capable to be energized within 1 minute of completion of fording operations.

3.4.5 Road Profile. OBVP components when mounted shall be capable of operating over the mission profile of 60% on-road and 40% off-road as defined below. **Critical Performance Parameters (CPP)**

Terrain	% Operation	Roughness
Primary Roads	30	0.1" - 0.3" RMS
Secondary Roads	30	0.3" - 1.0" RMS
Trails	20	1.0" - 3.4" RMS
Cross country	20	1.5" - 4.8" RMS

3.5 SAFETY

3.5.1 The OBVP shall be designed so that under all conditions of normal use (installation, operation, and maintenance) and under a likely fault condition (including human error), it protects against the risk of electric shock and other hazards.

3.5.2 All hazards shall be eliminated or reduced to the lowest risk level practicable using methods in the following order of precedence: design; incorporation of safety devices; incorporation of warning devices; and procedures/training.

3.5.3 Catastrophic or critical hazards shall not rely solely on warnings, cautions, or procedures/training for control of risk.

3.5.4 All safety hazards not eliminated through design shall be addressed in the appropriate technical manuals.

3.5.5 Information regarding hazard-avoiding procedures and safety warning labels on equipment shall be included in all manuals.

3.5.6 The OBVP operator shall not be exposed to components with voltages exceeding 30V.

3.5.7 The OBVP operator shall not be exposed to stored energy shock at the main power connector.

3.5.8 Protection shall be provided to personnel during maintenance and repair to prevent unintentional contact with voltages exceeding 70V.

3.5.9 System capacitors shall be discharged to less than 30V and 20 Watt-seconds prior to maintainer access.

3.5.10 Equipment leakage current to ground shall not exceed 3.5 milli-ampere (mA), when tested IAW ANSI C101.1. Redundant equipment grounding conductors shall be required where currents exceed 3.5 mA as per Government approval.

3.5.11 Noise: The system as installed shall not exceed 70 dBA at 7 meters from the host vehicle, or host vehicle noise signature whichever is higher.

3.5.12 Equipment grounding shall comply with the requirements of National Fire Protection Agency (NFPA) 70-93, article 250, and the requirements of Underwriters Laboratories (UL) 1950, paragraph 1.6.3 and section 2.5 for Class I equipment. 1.

3.5.13 The OBVP shall provide maximum access and safety to personnel during installation, operation, and maintenance.

3.5.14 All rotating or reciprocating parts and parts subject to high operational temperatures that are of such nature or so located as to be a hazard to operating personnel, shall be guarded or insulated to the extent necessary to eliminate the hazard.

3.5.15 The OBVP safety critical controls and indicators shall be YELLOW for caution, ORANGE for warning and RED for danger. Any color is permitted on functional controls or indicators provided it is clear that safety is not involved.

3.6 MARKING AND LABELING

3.6.1 The OBVP markings shall be as permanent as the normal life expectancy of the marked item, and shall be capable of withstanding the environmental conditions and cleaning procedures for the marked item.

3.6.2 The method of marking shall be such that it will not adversely affect the life and utility of the marked item.

3.6.3 The markings shall be capital letters with letter height of at least 0.16 inch, except as specified herein, or shall be easily interpretable icons. Numerals shall be Arabic, except when Roman numerals are used for type designation in specifications or standards. Text type shall be Gothic No. 2 or equivalent.

3.6.4 The variable controls, such as temperature controls, shall be labeled with a symbol for a continuously variable control conforming to Society of Automotive Engineers (SAE) J1362, symbol 8.18. Thermostatic control color code shall conform to paragraph 5.5 of SAE J1362.

3.6.5 Any marking materials creating hazardous conditions shall not be used.

3.6.6 Safety markings and labels shall be provided identifying any potential hazards to personnel.

3.6.7 Safety markings and labels shall comply with ANSI Z535.4, UL 1950, or UL 969.

3.6.8 Voltages in excess of 70V shall use the signal word “WARNING”. Voltages in excess of 220V shall use the signal word “DANGER”.

3.6.9 Safety labels shall not be placed on the barrier or access doors, shall be readily visible and shall not be covered/removed when a barrier or access door is opened/removed.

3.6.10 Labels shall be provided to identify operator or maintainer related controls, displays, access covers, refrigerant lines, and cable connectors, except where it is obvious to the operator what an item is and its function and operation. Controls shall be labeled to indicate functional result of control movement (e.g., “ON”, “OFF”, “INCREASE”, etc.).

3.6.11 All labels shall be capital letters with letter height of at least 0.16 inch or shall be easily interpretable icons.

3.6.12 Labeling shall be accomplished by marking directly on the item itself, or by mounting of a label with the pertinent information.

3.6.13 All instructions printed on the external surface of the OBVP sub-assemblies shall be stenciled letters and numerals that are 1 inch high with a 1/4 inch line width and shall be lusterless white 37875, in accordance with FED-STD-595.

3.6.14 The OBVP shall have an updated shipping data plate, conforming to A-A-50271, and shall show a silhouette of the main unit or modules in each of their transport configurations indicating the dimensions, weight, center of gravity and the location and capacity of the lifting and tie-down provisions.

3.6.15 An updated shipping data plates shall be permanently attached in a location that is visible and accessible but protected from damage during movement and handling (ATPD 2219,

paragraph 3.3.5.6).

3.6.16 Identification markings of control devices and connections shall be shown on all diagrams and shall coincide with markings on all items, which are identified in the applicable schematic or wiring diagram.

3.6.17 Electrical Components. At a minimum, electrical components shall be labeled with identification marking correlating to the electrical schematic and wiring diagram. They shall also be labeled with the component's vendor information and electrical characteristics to the extent that it is practicable.

3.6.18 Altered Items. The contractor shall label the item with, at a minimum, a contractor unique part number for use in obtaining spare and repair parts. The item shall also be labeled with the component's mechanical and electrical characteristics to the extent that it is practical. The item vendor's information shall not be removed.

3.6.19 Repairable and Replaceable Components. Other repairable and replaceable components shall be labeled with unique part numbers for use in obtaining spare and repair parts.

3.6.20 All OBVPs delivered shall be provided with a label that meets the requirements for DOD Item Unique Identification.

3.7 ENGINEERING

3.7.1 Human Factors Engineering. System design shall comply with established practices described in MIL-STD-1472.

3.7.2 Fungus-Resistance. Materials that are nutrients for fungi shall not be used where it is practical to avoid. Where used and not hermetically sealed, they shall be treated with a fungicidal agent. However, if they will be used in a hermetically sealed enclosure, fungicidal treatment shall not be necessary.

3.7.3 Cables. Marking of cables and wires shall be provided for ease of trouble-shooting and maintenance as appropriate.

3.7.4 Connectors. All connectors shall be keyed and marked/labeled.

3.7.5 All connectors exposed to the weather shall be corrosion resistant and waterproof.

3.7.6 All connector covers shall be supplied and attached to the units in the area of the connector to be covered.

3.7.7 Corrosion Control. All external OBVP parts and materials subject to corrosion shall be provided with anti-corrosion treatments.

3.7.8 Materials used in the OBVP assembly shall be selected to avoid contact between dissimilar metals that could contribute to corrosion.

3.7.9 All metals used shall be of the corrosion-resistant type or treated to resist corrosion due to fuels, salt fog, or atmospheric conditions likely to be met in storage or normal service.

3.7.10 Cadmium plating/plated items shall not be used.

3.7.11 Treatment and Painting. The system shall be painted using a Type II water-reducible Chemical Agent Resistant Coating (CARC) paint in accordance with MIL-P-64159. Suitable color is Green 383, FS 595, Color No. 34094.

3.7.12 All external surfaces and parts shall be cleaned, treated, and painted, with these exceptions: Internal components previously painted by the manufacture need not be repainted when they conform to the salt fog requirements; Components whose operation will be impaired by painting shall not be painted; Internal panel surfaces shall be cleaned and treated but not top coated.

4.0 ADDITIONAL INFORMATION

4.1 Government Furnished Information

None

4.2 Government Furnished Equipment

During Phase 1, each awarded contractor will be provided on Expanded Capacity Variant (ECV) of the High Mobility Multi-Purpose Wheeled Vehicle (HMMWV). The M-1152 A1 HMMWV with Integrated Armor Protection (IAP). This will be the target chassis for OBVP. At the completion of Phase 1, the HMMWV must be returnable to the Government in as-provided condition.

During Phase 2, each awarded contractor will be provided five (5) M-1152 A1 HMMWVs with Integrated Armor Protection (IAP). These will be the modified vehicles to receive OBVP. All parts removed from the vehicles remain Government property and shall be delivered with each vehicle at time of delivery.

4.3 Product Sample Testing During Phase 0

Product Samples will be tested to Test Procedures 608 of Mil-Std-705 for rated capacity of export power while stationary (requirement 3.3.1, CPP), and 25% of rated export stationary power while the vehicle is moving (requirement 3.3.3, CPP).

Appendix A
Transportation Criteria

Vibration. Conduct of test as specified in MIL-STD-810 to the following conditions:

A. General

1. Category: Test item shall be categorized as equipment installed in ground vehicles/trailers.
2. Apparatus: Any vibration inducing equipment with required instrumentation capable of satisfying the test conditions is acceptable.
3. Applicable test: See Sinusoidal Vibration Test (below)
4. Test time schedule (per axis):
   a. Sinusoidal cycling time – 240 minutes (min) per axis.
   b. Sweep time 30 min, range 5 1000 5 hertz (Hz).
   c. Sweep time shall be increased by 3 min if test frequency goes to 2 Hz.
5. Test level curve: See Figure A3.
6. Components of the system shall not be operated during this test and shall be mounted by bolts using the mounting plates provided. Auxiliary braces, straps, or other tie-down devices, other than those specified herein, shall not be employed to secure the components to the test apparatus. No blocking or tie down of internal components shall be employed. Removable panels and access doors shall be in place during all testing. There shall be no resonance inherent in the test apparatus at the frequencies and acceleration levels specified for this test. During the test, the base of the system shall remain in a horizontal plane. Accelerometers shall be mounted on the test apparatus immediately adjacent to the four corners of the system. The four accelerometers shall be connected into an electric or electronic network which shall average the accelerometers' output signals into a single indicated "g" level of the magnitude specified for this test. After completion of each test axis, conduct the visual inspection and the run test under 70% load for 20 minutes.

B. Sinusoidal Vibration Test.

The vibration shall be applied along each of the three mutually perpendicular axis of the test item in accordance with the test level, frequency range, and times specified above. The frequency of applied vibration shall be swept over the specified range logarithmically in accordance with the worst-case scenario for the following family of curves in Figure A3. The specified sweep time is that of an ascending plus a descending sweep and is twice the ascending sweep time shown on Figure A3 for the specified range. The vibratory accelerator level or double amplitude of the test curve shall be maintained at the test item mounting points.

C. Basis of Failure. Any of the following shall constitute failure of this test.

1. Non-conformance.
2. Evidence of structural damage, misalignment or malfunction of components, leaks, fractures, abnormal vibration, or any other irregular operation.

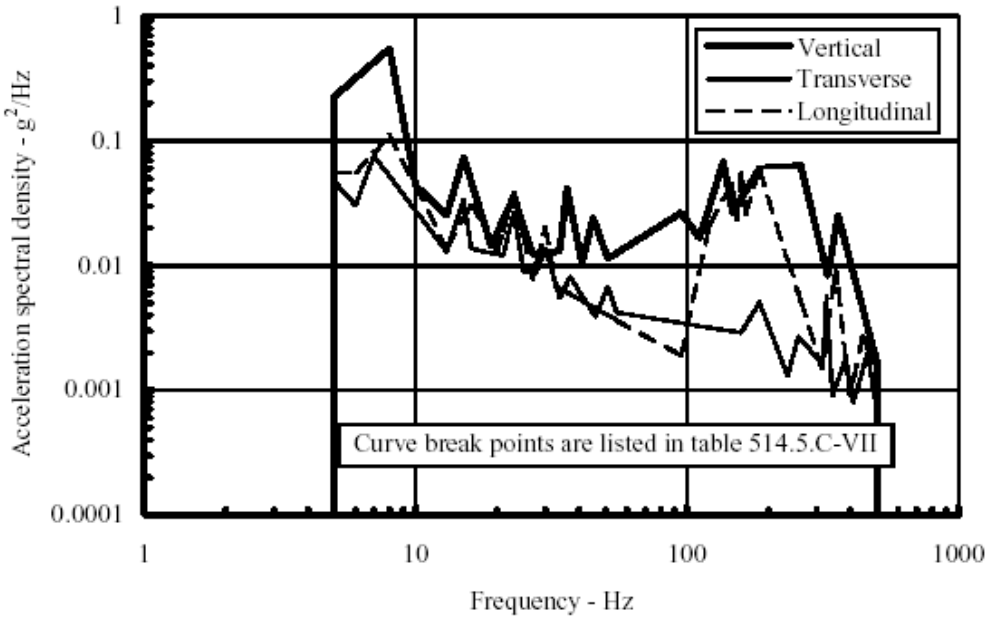

FIGURE A1 – Vibration Exposure
(ref MIL-STD-810, figure 514.5C-1)

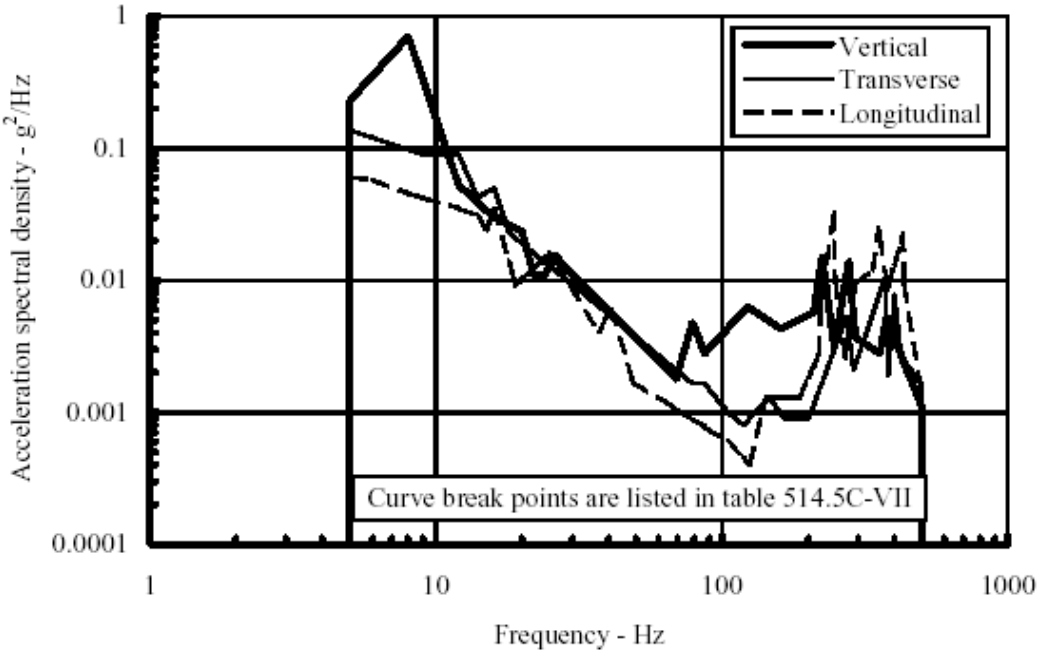

FIGURE A2 – Vibration Exposure

(ref MIL-STD-810, figure 514.5C-3)

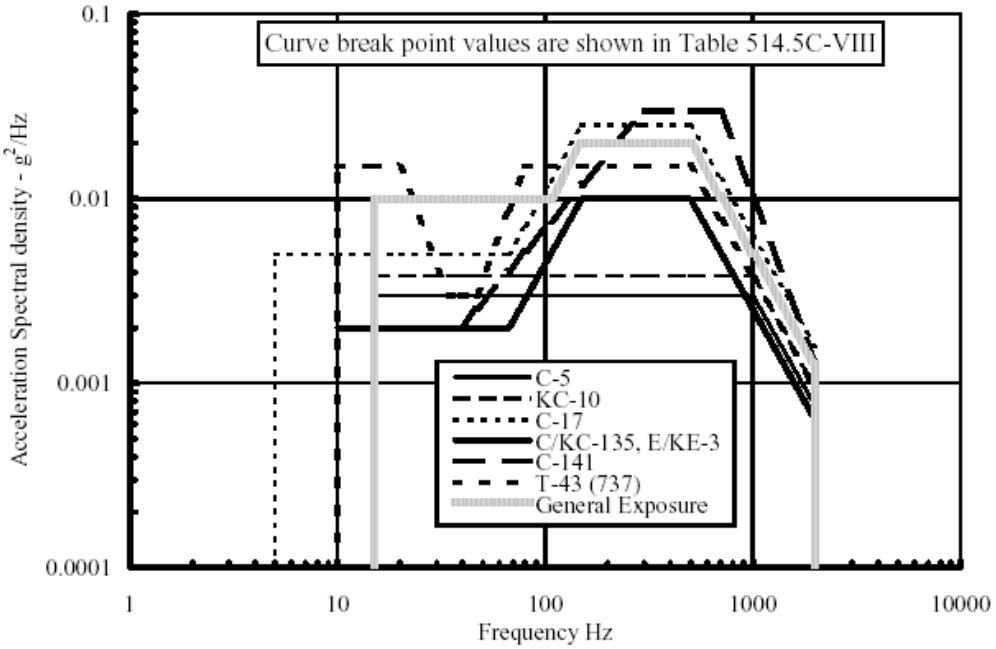

FIGURE A3 – Vibration Exposure
(ref MIL-STD-810, figure 514.5C-6)

C-5			KC-10			C/KC-135, E/KE-3			C-17		
Hz	g^2/Hz	dB/Oct	Hz	g^2/Hz	dB/Oct	Hz	g^2/Hz	dB/Oct	Hz	g^2/Hz	dB/Oct
15	0.003		15	0.0038		10	0.002		5	0.005	
1000	0.003		1000	0.0038		66.897	0.002		66.897	0.005	
		-6			-6			6			6
2000	7.5E-4		2000	9.5E-4		150	0.01		150	0.025	
rms = 2.11 g			rms = 2.38 g			500	0.01		500	0.025	
								-6			-6
						2000	6.3E-4				
						rms = 2.80 g			2000	1.6E-3	
									rms = 4.43 g		

C-141			T-43 (737)			General Exposure		
Hz	g^2/Hz	dB/Oct	Hz	g^2/Hz	dB/Oct	Hz	g^2/Hz	dB/Oct
15	0.002		10	0.015		15		
39.086	0.002		20	0.015		105.94	0.01	
		4			-9			6
300	0.03		34.263	0.003		150	0.02	
700	0.03		46.698	0.003		500	0.02	
		-9			9			-6
2000	0.0013		80	0.015		2000	1.3E-3	
rms = 5.01 g			500	0.015		rms = 3.54 g		
					-6			
			2000	9.5E-4				
			rms = 3.54 g					

Note: C-17 levels apply to the primary cargo floor. Levels for items carried on the aft ramp are higher.

TABLE A1 – Breakout Points for Figure A3
(ref MIL-STD-810, figure 514.5C-VIII)

U. S. highway truck vibration exposures
figure 514.5C-1

vertical		transverse		longitudinal	
Hz	g^2/Hz	Hz	g^2/Hz	Hz	g^2/Hz
10	0.01500	10	0.00013	10	0.00650
40	0.01500	20	0.00065	20	0.00650
500	0.00015	30	0.00065	120	0.00020
1.04	g rms	78	0.00002	121	0.00300
		79	0.00019	200	0.00300
		120	0.00019	240	0.00150
		500	0.00001	340	0.00003
		0.204	g rms	500	0.00015
				0.740	g rms

Composite wheeled vehicle vibration exposures
figure 514.5C-3

vertical		transverse		longitudinal	
Hz	g^2/Hz	Hz	g^2/Hz	Hz	g^2/Hz
5	0.2308	5	0.1373	5	0.0605
8	0.7041	9	0.0900	6	0.0577
12	0.0527	12	0.0902	8	0.0455
16	0.0300	14	0.0427	12	0.0351
20	0.0235	16	0.0496	15	0.0241
22	0.0109	18	0.0229	16	0.0350
24	0.0109	119	0.0008	19	0.0092
26	0.0154	146	0.0013	25	0.0159
69	0.0018	166	0.0009	37	0.0041
79	0.0048	201	0.0009	41	0.0060
87	0.0028	273	0.0053	49	0.0017
123	0.0063	289	0.0021	105	0.0006
161	0.0043	371	0.0104	125	0.0004
209	0.0057	382	0.0019	143	0.0013
224	0.0150	402	0.0077	187	0.0013
247	0.0031	422	0.0027	219	0.0028
278	0.0139	500	0.0016	221	0.0068
293	0.0037	1.60	g rms	247	0.0325
357	0.0028			249	0.0098
375	0.0052			270	0.0026
500	0.0011			293	0.0094
2.18	g rms			336	0.0120
				353	0.0247
				379	0.0085
				431	0.0224
				433	0.0092
				500	0.0014
				1.96	g rms

Composite two-wheeled trailer vibration exposures
figure 514.5C-2

vertical		transverse		longitudinal	
Hz	g^2/Hz	Hz	g^2/Hz	Hz	g^2/Hz
5	0.2252	5	0.0474	5	0.0563
8	0.5508	6	0.0303	6	0.0563
10	0.0437	7	0.0761	8	0.1102
13	0.0253	13	0.0130	13	0.0140
15	0.0735	15	0.0335	16	0.0303
19	0.0143	16	0.0137	20	0.0130
23	0.0358	21	0.0120	23	0.0378
27	0.0123	23	0.0268	27	0.0079
30	0.0286	25	0.0090	30	0.0200
34	0.0133	28	0.0090	33	0.0068
36	0.0416	30	0.0137	95	0.0019
41	0.0103	34	0.0055	121	0.0214
45	0.0241	37	0.0081	146	0.0450
51	0.0114	46	0.0039	153	0.0236
95	0.0266	51	0.0068	158	0.0549
111	0.0166	55	0.0042	164	0.0261
136	0.0683	158	0.0029	185	0.0577
147	0.0266	235	0.0013	314	0.0015
185	0.0603	257	0.0027	353	0.0096
262	0.0634	317	0.0016	398	0.0009
330	0.0083	326	0.0057	444	0.0027
360	0.0253	343	0.0009	500	0.0014
500	0.0017	384	0.0018	2.40	g rms
3.85	g rms	410	0.0008		
		462	0.0020		
		500	0.0007		
		1.28	g rms		

TABLE A2 – Breakout Points for Figure A1 & A2
(ref MIL-STD-810, figure 514.5C-VII)

MEP-STD-001
31 January 2003
USED IN LIEU OF
MIL-DTL-0053133B(ME)
13 September 1996
and MIL-G-53133
30 August 1993

GENERAL SPECIFICATION FOR

EXPORT POWER, VEHICLE MOUNTED, TACTICAL,

ALTERNATING CURRENT UP TO 30 KILOWATTS

1. SCOPE

1.1 Scope. This specification covers the general requirements for export power generated by vehicle mounted, tactical, alternating current systems in sizes up to 30 kilowatts. Export power devices will be referred to as Auxiliary Power Distribution System (APDS) in this document.

1.2 Classification. The power generating/conditioning systems will be tactical, generating Class I-Precise Power per MIL-STD-1332B. Frequency will be 50, 60, 400 Hz, selectable at all voltage connections.

1.3 Power Rating. The power generating system will be rated 0.8 power factor (pf), lagging, and will be re-connectable for the following voltages:

1.3.1 Configuration I (0-10 kW):

- 120/240-volt, single phase, 3 wire

1.3.2 Configuration II (Above 10 kW):

- 120/208-volt, 3-phase, 4 wire, WYE configuration

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are needed to meet the requirements specified in sections 3 and 4 of this specification. This section does not include documents cited 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 and standards. The following specifications and standards 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

FEDERAL

A-A-52557	-	Fuel Oil, Diesel; for Posts, Camps and Stations.

DEPARTMENT OF DEFENSE

MIL-L-2104	-	Lubricating Oil, Internal Combustion Engine, Tactical Service.
MIL-L-2105	-	Lubricating Oil, Gear, Multipurpose.
MIL-T-5624	-	Turbine Fuels, Aviation, Grades JP-4 and JP-5.
MIL-G-10924	-	Grease, Automotive and Artillery.
MIL-A-11755	-	Antifreeze, Arctic-type.
MIL-A-46153	-	Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package.
MIL-F-46162	-	Fuel, Diesel, Referee Grade.
MIL-L-46167	-	Lubricating Oil, Internal Combustion Engine, Arctic.
MIL-A-53009	-	Additive, Antifreeze Extender, Liquid Cooling Systems.
MIL-T-83133	-	Turbine Fuel, Aviation, Kerosene Type, Grade JP-8.
MIL-L-85762	-	Lighting, Aircraft, Interior, AN/AVS-6 Aviator's Night Vision Imaging System (ANVIS) Compatible.

(See Supplement 1 for list of associated specification sheets).

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-209	-	Slinging and Tiedown Provisions for Lifting and Tying Down Military Equipment.
MIL-STD-461	-	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference.
MIL-STD-462	-	Measurement of Electromagnetic Interference Characteristics.
MIL-STD-705	-	Generator Sets, Engine-Driven, Methods of Tests and Instructions.
MIL-STD-814	-	Requirements for Tiedown, Suspension and Extraction Provisions on Military Materiel for Airdrop.
MIL-STD-882	-	System Safety Requirements.
MIL-STD-1472	-	Human Engineering Design Criteria for Military Systems, Equipment and Facilities.
MIL-STD-1791	-	Designing for Internal Aerial Delivery in Fixed Wing Aircraft.
*(U)MIL-STD-2169	-	High Altitude Electro-Magnetic Pulse Environment (HAEMP).(u)

* (Application for copies of the above classified standard are available to personnel with the appropriate security clearance from Headquarters US Army Communications-Electronics Command, Research, Development and Engineering Center, Command/Control and Systems, Integration Directorate - South, ATTN: AMSEL-RD-C2-PD-E, 10108 Gridley Road, Ste 1, Ft Belvoir, VA 22060-5817.)

HANDBOOKS

MILITARY

MIL-HDBK-454	-	Guidelines for Electronic Equipment.
MIL-HDBK-705	-	Generator Sets, Electrical, Measurements and Instrumentation.
MIL-HDBK-784	-	Guidelines: Designs to Minimize Contamination to Facilitate Decontamination of Military Vehicles and Other Equipment.

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

2.3 Non-Government publications. The following document 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 specified in the solicitation. Unless otherwise specified, the issues of the documents not listed in the issue of the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ASQC Z 1.4 - Sampling Procedures and Tables for Inspections by Attributes.

(Application for copies should be addressed to: AMERICAN NATL STANDS INST, 1430 BROADWAY, NEW YORK NY 10018.)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

MG1 - Motors and Generators.

(Application for copies should be addressed to the National Electrical Manufacturers Association, 2101 L Street, NW, Washington DC 20037.)

UNDERWRITERS LABORATORIES INC.

UL-94 Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

(Applications for copies should be addressed to Underwriter's Laboratories Inc., 1285 Walt Whitman Road, Mellville L.I., NY 11747.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, (except for related associated specifications or specification sheets), 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 Reliability. The minimum acceptable mean time between failure (MTBF) for the APDS shall be 600 hours with an 80 % lower confidence limit.

3.2 Design.

3.2.1 Short circuit. The APDS and host prime mover, operating as a unit, shall withstand two consecutive single-phase line-to-line (>10 kW only), single-phase line-to-neutral, and symmetrical 3-phase short-circuits (>10 kW only) at 5-minute intervals at output terminals when operating at rated load and frequency without damage. The sustained short-circuit current shall not be less than 300 percent of rated output current. 3-phase short circuits shall be for 10 seconds and single phase short circuits shall be for 5 seconds.

3.2.2 Instruments, controls, and other devices. Instruments, controls, and devices shall meet all requirements specified in Appendix B (sections B.3 and B.4) with the system operating under all conditions, including storage.

3.2.3 DC control power. All DC control devices shall be suitable for operation at 20 to 32 volts. DC voltage transients resulting from operation of the AC circuit interrupter or any other mounted device shall not exceed 150 volts measured across any DC component. Total operating DC current at any one time for all devices shall not exceed 5 amps when the system is operating. When the system master switch is in the "off" position, no current drain shall be imposed, except the following:

a. Panel Lights, when associated switch is in the "on" position.

b. Malfunction Indicator Lamps, which require manual reset.

3.2.4 Protective system. The APDS shall be equipped with the protective devices specified herein. In addition to functions specified herein, activation of these devices shall cause the appropriate lamp to illuminate on the malfunction indicator panel. Each device shall be capable of performing its function independently without reference to any other protective device or indicator system.

3.2.4.1 Overvoltage device. This device shall activate in not more than 1.25 seconds after the voltage in a 120-volt output lead has risen to and remained at any value greater than 153 ±3 volts for not less than 200 milliseconds and shut down the APDS.

3.2.4.2 Undervoltage device. This device shall be connected across the same output lead as the over-voltage protective device. When the voltage drops below 48 volts this device shall activate instantaneously. In addition, the device shall activate in 6 ±2 seconds after the voltage has fallen to and remained at not more than 99 ±4 volts. The device shall open the APDS circuit interrupter upon activation.

3.2.4.3 Short-circuit device. This device shall activate within 50 milliseconds in the event output current in any output lead exceeds 425 ±25 percent for all voltage connections. The device shall open the main circuit interrupter upon activation.

3.2.4.4 Overload device. This device shall not activate when current is less than 110 percent of rated value. It shall activate within 8 ±2 minutes for 130 percent of rated current. At currents between 110 percent and 350 percent, the device shall operate on an inverse time principle with the time to trip reduced in proportion to the increase in current. The device shall open the main circuit interrupter upon activation.

3.2.4.5 Reverse power device. This device shall activate if power flow into the system exceeds 20 ±3 percent of rated value. The device shall open the main circuit interrupter upon activation.

3.2.5 Malfunction indicator. The malfunction indicator system shall cause the appropriate indicating lamp to energize under activation of the protective device.

3.2.6 Transportability. The export power system shall not be damaged by rough handling which could be encountered during: rail, truck, trailer, aircraft, or helicopter transportation as defined by the specifications governing the host vehicle.

3.3 Performance. Performance shall be as specified herein and in the applicable specification sheets.

3.3.1 Starting, operating and stopping.

3.3.1.1 Starting. The APDS shall start within 5 minutes under any individual or combination of the environmental conditions specified herein.

3.3.1.2 Operating. Immediately after starting and with a maximum warm-up period of 5 minutes, the APDS shall operate without damage or failure under all loads, continuous and intermittent, up to and including rated load as specified herein and in the applicable specification sheets.

3.3.1.3 Stopping. The APDS shall stop within 30 seconds or within the time interval specified herein after activation of any device intended to stop export power.

3.3.2 Parallel operation. The requirement for parallel operation is specified in Appendix B (section B.9).

3.3.3 Maximum power. The minimum acceptable maximum power shall be 110 percent of rated load under all operating conditions.

3.4 Audio noise. Audio noise sound-pressure levels (SPL) emanating from the system shall not exceed 70 dBA at 7 m (22.9 feet) from the perimeter of the host vehicle with all doors closed, when measured at 1.2 m (3.9 feet) above the ground. In addition, audio noise emanating from the system shall not exceed 85 dBA at the operator's station, defined to be 0.7 m (2.3 feet) from the APDS. These requirements apply under all operating conditions specified herein with the system operating at all loads from the no-load to rated load.

3.5 Environmental requirements.

3.5.1 Starting and operating. The APDS shall start and operate under each and any combination of the following operating conditions:

a. All possible relative humidities, with ambient temperatures ranging from -45 to 49 °C (-50 to 120 °F) at sea level; and from -45 to 35 °C at 1,219 m (-50 to 95 °F at 4,000 feet). The high temperature requirement remains at 35 °C (95 °F) at altitudes above 1,219 m (4,000 feet).

b. Altitudes up to and including 2,438 m (8,000 feet). Rated load may be reduced by 3.5 percent for each 305 m (1,000 feet) above 1,219 m (4,000 feet) (e.g., at 8,000 feet rated load may be reduced by 14 percent).

c. With 127 millimeters (mm) (5 inches) of rain per hour impinging on the system at angles from the vertical up to 45 degrees (Appendix C, TM 102.1).

d. With 355 British thermal units (BTUs) per square foot per hour of solar radiation (Appendix C, TM 105.1).

e. With sand and dust particle concentration of up to 1,400 milligrams per cubic meter (mg/m^3). Particle sizes shall range from less than 74 micrometers in diameter to 1,000 micrometers with the bulk of the particles ranging in size from 74 to 350 micrometers (Appendix C, TM 103.1).

f. With a steady wind speed of 22 meters per second (m/s) (73 feet per second [ft/s]) and gusts up to 29 m/s (95 ft/s) at a height of 3 m (10 feet) above ground level.

g. With accumulations of ice glaze, freezing rain and hoarfrost of up to 13 mm (0.5 inch) and up to a specific gravity of 0.9.

h. In a salt fog or sea spray environment (Appendix C, TM 104.1).

3.5.2 Storage. The APDS without packaging shall not be damaged by exposure to:

a. Storage at -51 to 71 °C (-60 to 160 °F).

b. Salt fog environment.

c. All possible relative humidities.

3.6 High altitude electromagnetic pulse (HAEMP). The APDS shall withstand the HAEMP nuclear environment as specified in MIL-STD-2169. The APDS shall meet the operational requirements specified herein within 5 minutes after being subjected to the specified HAEMP nuclear environment. The recovery may include manual or automatic correction of HAEMP induced changes to the system, to include a restart, but not the replacement of piece parts or components. The cables to the load shall be 100 feet in length and shall be configured for worst-case system response during the exposure.

3.7 Electromagnetic interference. The electromagnetic interference and susceptibility characteristics of the system shall not exceed the following limits:

a. Conducted emissions on power leads shall not exceed the applicable values shown on Figure CE102-1 of MIL-STD-461 for frequencies from 10 kHz to 10 Mhz.

b. Electric field emissions shall not be radiated in excess of those shown in Figure RE102-3 (NAVY MOBILE and ARMY limit curve) of MIL-STD-461 for frequencies 2 MHz to 1 GHz. Above 30 MHz, the limits shall be met for both horizontally and vertically polarized fields.

c. The output frequency and voltage shall remain within the 30-second short term stability bandwidth specified in the applicable specification sheets when subjected to the following:

(1). The test signal with levels as specified in Figure CS101-1 of MIL-STD-461 for frequencies from 120 Hz to 50 kHz for 50/60 Hz frequency modes and 800 Hz to 50 kHz for the 400 Hz mode.

(2). The test signal with levels as specified in Figure CS114-1 of MIL-STD-461 for frequencies from 10 kHz to 30 MHz. The appropriate limit curve in Figure CS114-1 shall be selected from table III of MIL-STD-461.

(3). The radiated electrical fields specified in Table IV of MIL-STD-461 for frequencies from 30 MHz to 18 GHz. The requirement shall be met for both horizontally and vertically polarized fields. Circular polarized fields are not acceptable.

3.8 Treatment and painting. Treatment and painting shall be in accordance with the host vehicle specifications

3.9 Maintainability. The maintenance ratio shall not exceed 0.05.

3.10 Endurance. The APDS shall operate for 6,000 hours without critical failure at all loads, continuous and intermittent, up to and including rated load under all of the individual or combination of conditions specified in section 3.5 of this document. The APDS shall be operated in accordance with MIL-STD-705, TM 690.1. The disassembly portion contained in TM 690.1 is not required. The number of operating hours at each load shall be proportional to the hours specified in the TM 690.1 cyclic load schedule.

3.11 Nuclear, Biological, and Chemical (NBC) Contamination Survivability. The APDS shall have a Chemical Agent Resistant Coating (CARC) painted as specified herein. The APDS shall be capable of being operated and serviced by personnel wearing Mission Oriented Protective Posture (MOPP) IV chemical, biological, and radiological clothing without special tools or support equipment. The APDS shall not be damaged and shall meet operational requirements specified herein, within 60 minutes after being decontaminated according to the procedure specified in Appendix C, TM-101.1. Decontamination shall be accomplished with all doors and covers closed. All instrument gauges and meters shall use glass protective lenses. Gaskets and seals used on the housing, shall be made of nonabsorbent butyl rubber or other materials resistant to Decontaminant Solution No. 2. Information regarding materials resistant to decontaminants is available from the Chemical and Biological Information Analysis Center, Edgewood, MD. The system design shall minimize the collection and retention of agents and decontaminants. Design guidance is available from MIL-HDBK-784.

3.12 Safety. The APDS shall meet the provisions of MIL-STD-882, MIL-STD-1472, and Requirement 1 of MIL-HDBK-454. Exposed parts of such nature as to be a hazard to personnel shall be insulated, enclosed or guarded without impairing the functioning of these parts.

3.13 Human factors engineering (HFE). The APDS shall be designed in accordance with accepted criteria of design for Human Factors Engineering as described in MIL-STD-1472. The APDS shall be operable and maintainable during day and night by 5th percentile female through 95th percentile male soldiers when wearing the clothing which is appropriate to the environments detailed herein.

3.14 Secure lighting. All light sources shall meet the following secure lighting (blue/green) requirements:

a. Light sources shall consist of incandescent bulbs with filters and/or light emitting diodes (LEDs).

b. 95 percent of the light energy emitted by each light source shall be at wavelengths below 700 nanometers.
c. All light sources shall be visible in bright sunlight.

4. TESTING

4.1 Test schedule. Unless otherwise specified, testing of the APDS will be governed by the test schedule shall shown in Table I.

TABLE I. Test schedule.

1 TEST	2 TEST METHOD (MIL-STD-705) AND TEST PARAGRAPH	3 BASIC REQUIREMENT PARAGRAPH
Altitude Operation	Before and after REM test. TM 720.1 at 1219 m, 35 °C; and 2438 m, 35 °C (4,000 ft, 95 °F; and 8,000 ft, 95 °F)	3.5.1
Audio Noise	Appendix C (TM 100.1)	3.4, 4.3.1
Circuit Interrupter: (Overload Current)	TM 512.2	3.2.4.4
Circuit Interrupter: (Overvoltage and Undervoltage)	TM 512.3	3.2.4.1, 3.2.4.2
Circuit Interrupter: (Short Circuit)	TM 512.1 (Use oscillograph for preproduction qualification model sets only)	3.2.4.3
DC Control	TM 655.1 (Perform at minimum and maximum settings of the battery charging voltage adjustment control.)	3.2.3
Drop (Ends)	TM 740.3	4.3.4
Electromagnetic Interference	MIL-STD-461 At all rated voltage connections at the following load conditions: a. No load b. Rated kW load at 1.0 pf c. Rated kW load at 0.8 pf lagging	3.7, 4.3.5
Endurance	TM 690.1	3.10
Extreme Cold Storage	TM 731.1	3.5.2, 4.3.13
Frequency & Voltage Regulation, Stability and Transient Response:(Short Term)	TM 608.1	Appendix B (B.7.2, B.7.5, B.8.5)

1 TEST	2 TEST METHOD (MIL-STD-705) AND TEST PARAGRAPH	3 BASIC REQUIREMENT PARAGRAPH
Frequency & Voltage Stability:(Long Term)	TM 608.2	Appendix B (B.7.3, B.7.5, B.8.6, B.8.8)
HAEMP	MIL-STD-2169	3.6, 4.3.7
HFE Exam	MIL-STD-1472, Appendix C, TM 109.1	3.13, 4.3.21
High Temperature at 49 °C (120 °F)	TM 710.1 at 49 °C (120 °F): All single and 3 phase connections at the maximum and minimum voltage adjustment range specified on the applicable specification sheets. (Also perform TM 619.1 and 619.2 at rated frequency and 3 phase volt-connections.)	3.5
Hot Storage Test	TM 732.1	3.5.2, 4.3.16
Humidity	TM 711.1	3.5.1, 4.3.17
Ice Glaze and Wind	TM 608.1	3.5.1, 4.3.12
Indicating Instrument (Electrical)	TM 513.1 (At all rated voltage connections.)	Appendix B (B.4)
Maximum Power	TM 640.1; TM 640.4	3.3.3
Motor Starting	4.3.6	4.3.6
Nuclear Biological and Chemical Test	Appendix C (TM 101.1)	3.11, 4.3.22
Parallel Operation	TM 630.1	4.3.2, Appendix B (B.9)
Phase Balance: (Voltage)	TM 508.1 (To be measured at load terminals. On individual production sets measure line-to-line and line-to-neutral at load terminals only)	Appendix B (B.8.2)
Phase Sequence: (Rotation)	TM 507.1	Appendix B (B.1.5)
Railroad Impact	Appendix C (TM 107.1)	4.3.3
Rain	Appendix C (TM 102.1)	3.5.1, 4.3.14
Reliability, Endurance, Maintainability	TM 695.1	3.10, 4.3.15
Reverse Power Protective Device	TM 516.2	3.2.4.5
Road	4.2.6, Appendix C (TM 106.1)	3.2.6, 4.3.8, 5.2.6
Salt Fog	Appendix C (TM 104.1)	3.5.1, 4.3.9
Safety Exam	Appendix C (TM 108.1)	3.12, 4.3.20
Sand and Dust	Appendix C (TM 103.1)	3.5.1, 4.3.11
Secure Lighting	MIL-L-85762	3.14, 4.3.23
Short Circuit: (Mechanical strength)	TM 625.1 (Apply single phase short circuits at each line-to-line and each line-to-neutral connection. Also apply symmetrical 3 phase short circuits at the output terminals. Single phase short circuits are for 5 seconds, 3 phase short circuits are for 10 seconds. Power input to the voltage regulator to sustain the required short circuits may be obtained from a separate source.)	3.2.1
Solar Radiation	Appendix C (TM 105.1)	3.5.1, 4.3.21
Start and Stop	TM 503.1	3.3.1.1, 3.3.1.3, 3.5.1
Voltage Dip and Rise for Rated Load	TM 619.2	Appendix B (B.8.8)

1 TEST	2 TEST METHOD (MIL-STD-705) AND TEST PARAGRAPH	3 BASIC REQUIREMENT PARAGRAPH
Voltage and Frequency Drift	TM 608.2	4.3.10, Appendix B (B.7.4, B.8.7)
Voltage Dip for Low Power Factor Load	TM 619.1	Appendix B (B.8.8)
Voltage Modulation	TM 602.1 (At all rated voltage connections.)	Appendix B (B.8.3)
Voltage Unbalance with Unbalanced Load	TM 620.2	Appendix B (B.8.9)
Voltage Waveform (Oscillographic, Harmonic Analysis)	TM 601.1 and 601.4 (At all rated voltage connections and the following loading conditions: a. No-load b. Rated kW at 0.8 pf lagging c. Rated kW at 1.0 pf)	Appendix B (B.8)

4.2 Test procedures. Tests shall be conducted in accordance with MIL-STD-705, MIL-HDBK-705, and as specified herein. Test instruments shall be of the laboratory type and shall have been calibrated within 30 days of the start of testing and at six-months periods thereafter. Instruments used in calibration should be at least five times the accuracy of the instrument being calibrated. Direct-reading instruments shall have at least 0.5 percent accuracy and shall be connected to indicate the most accurate portion of their range. On DC instruments, the readings shall not be made on the lower 15 percent of the scale. On AC instruments, the readings shall not be made on the lower one-third of the scale. Oscillograph galvanometer frequency response shall be flat (±5 percent) from DC to not less than 3,000 Hz. The voltage and frequency recording-type meters, other than oscillographs, shall have the following specifications:

a. Rise time for the frequency to be 250 ms.
b. Rise time for the voltage to be 60 ms.

c. Input to be up to 500 volts RMS.

d. Output to be ±5 volts DC maximum.

e. The signal input(s) and output(s) shall be ungrounded.

In addition, if an analog signal is digitized for the purpose of automation, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal; (i.e. The sampling frequency for voltage waveforms acquired using the above oscillograph is 7.5 kHz; 3.75 MHz for the oscilloscope aforementioned table I (Note 7) and the voltage waveform, of the specification sheet. The sampling frequency for any waveforms acquired using the above voltage and frequency recording-type meter shall be at least 100 Hz. The data shall be saved on 3½-inch or 5¼-inch floppy disks and in ASCII text file. Exhaust smoke conditions shall be measured during all altitude testing.

4.3 Government performed tests. Maintainability demonstration, road and HAEMP tests will be accomplished by the Government, at Government expense, at a Government installation

4.3.1 Audio noise test. Instrumentation and procedures for the audio noise test shall conform to Appendix C, TM 100.1. Measure audio noise sound pressure level at no-load and rated load. The microphone(s) shall be located at 7 m (22.9 feet) from the perimeter of the APDS and 1.2 m above the ground. Measure audio noise sound pressure levels at 0.7 m from the control panel, at a height equal to the control panel and with the APDS control panel.

4.3.2 Parallel operation test. Two APDSs of each size and mode shall be tested in accordance with method 630.1 of MIL-STD-705. For individual APDS verification testing, each production APDS shall be tested in parallel with the first APDS of same production lot. Each APDS selected as the test unit shall be tested with the next test APDS selected from the next lot. The APDS selected as the paralleling master per lot, shall not be the quality control sample of that same lot. Testing shall be in accordance with method 630.1 of MIL-STD-705 with the following changes:

a. Control panel instrumentation on the sets shall be used.

b. Load connections shall be no-load, half-load, and rated load.

c. Where 1 hour of operation is referenced, substitute 15 minutes of operation.

4.3.3 Railroad impact test. The railroad impact test shall be performed in accordance with TM 107.1, with the following conditions:

a. Two APDSs shall be used.

b. The two APDSs shall be mounted in opposite direction to each other.

c. The APDSs shall be mounted in accordance with set rail tiedown procedures.

d. The systems shall not require any type of packaging for the test.

4.3.4 Drop test. The drop test shall be performed in accordance with TM 740.3 of MIL-STD-705 at a height of 9 inches.

4.3.5 Electromagnetic interference test. The electromagnetic interference test shall be performed in accordance with MIL-STD-462 with the following frequency ranges:

a. Method CE 102: 10 khz to 10 Mhz

b. Method RE 102: 2 Mhz to 1 Ghz

c. Method CS 101: 120 Hz to 50 kHz for 50/60 Hz frequency selection; 800 Hz to 50 kHz for 400 Hz frequency selection

d. Method CS 114: 10 kHz to 30 Mhz

e. Method RS 103: 30 Mhz to 18 GHz

4.3.6 Motor starting test. The motor starting test shall be performed by use of a motor rated NEMA Code F, in accordance with MG-1. The motor shall be loaded with a flywheel or equivalent having an inertia equal to that of the motor rotor. Satisfactory starting is defined as acceleration of the motor to rated speed without tripping any generator set protective devices.

4.3.7 HAEMP tests and analyses. This test shall be conducted in accordance with the applicable tests as specified in (U)MIL-STD-2169(u).

4.3.8 Road test. Each configuration as defined on the Government-furnished property listed, shall be tested in accordance with section 5.2.6 and Appendix C, TM 106.1.

4.3.9 Salt fog test. The salt fog test shall be performed in accordance with Appendix C, TM 104.1. Two APDSs shall be subjected to two 48-hour cycles as follows: 24 hours - salt fog exposure; 24 hours - standard ambient

(drying). Salt concentration shall be a 5 ±1 percent solution. The APDSs shall be tested in their normal operating mode. TM 608.1 of MIL-STD-705 shall be performed within 4 hours before the start of the salt fog cycling. After completion of the salt fog cycling, but prior to the post-cycling TM 608.1 test, measure the insulation resistance of all circuits initially measured in accordance with TM 301.1, except that the system shall not be operated prior to this test and measured values shall not be corrected for temperature. Upon completion of the post-cycling TM 301.1 test, reconnect all circuits and perform TM 608.1 within 4 hours after removal of the APDS from the test chamber. The APDS shall be examined for corrosion or other physical damage resulting from this test.

4.3.10 Voltage and frequency drift test. Follow the same procedure in TM 608.2 of MIL-STD-705, except that the APDS is initially stabilized at an ambient temperature which differs by 33 C° (60 F°) from the final stabilization temperature and the test is conducted for 8 hours. This test may be accomplished as the environmental chamber is being warmed from a cold temperature test. Temperature change shall be less than 5.5 C° per hour (10 F° per hour).

4.3.11 Sand and dust test. The sand and dust test shall be conducted in accordance with Appendix C, TM 103.1 test with the following conditions:

a. Perform TM 608.1 of MIL-STD-705.

b. Test shall be performed at prevailing ambient temperatures and relative humidities.

c. Air velocity shall be maintained at a minimum of 32.2 km/h (20 mph).

d. Sand concentration shall be 1.4 g/m^3.

e. The test shall consist of four 90-minute intervals. The APDS shall be oriented with each side exposed to the blowing sand for one 90-minute interval. The APDS shall be operated at no load for a minimum of 10 minutes during the last half of each 90-minute interval.

f. Following completion of the four 90-minute intervals, TM 608.1 of MIL-STD-705 shall be performed.

4.3.12 Ice glaze and wind test. The APDS shall be subjected to the combined action of wind and ice as follows:

a. Perform TM 608.1 of MIL-STD-705.

b. With the ambient temperature between -23 and 0 °C (-10 and 32 °F), and with a steady wind speed of at least 22.25 m/s (73 ft/s), deliver a uniform rainspray on the non-operating set until 12.7 mm (0.5 inch) of ice glaze has accumulated on the top of the APDS.

c. After accumulation of 12.7 mm (0.5 inch) on the top of the APDS, the APDS shall be started and operated at no load for a minimum of 1 hour.

d. After 1 hour of operation at no load, TM 608.1 of MIL-STD-705 shall be performed.

4.3.13 Extreme cold storage test. The test shall be conducted in accordance with TM 731.1 of MIL-STD-705 except at an extreme cold temperature of -51 °C (-60 °F) instead of -62 °C (-80 °F).

4.3.14 Rain test. Conduct test in accordance with Appendix C, TM 102.1, at 5 inches of rain per hour.

4.3.15 Reliability, endurance, maintainability test. The reliability test shall be conducted on 3 APDSs per frequency mode, in accordance with MIL-STD-705, TM 695.1 and Table III. The disassembly portion contained in TM 695.1 is not required. The number of operating hours at each load shall be proportional to the hours specified in the TM 695.1 cyclic load schedule. One critical failure shall constitute a failure of the reliability test.

TABLE III. Reliability test schedule.

APDS Size	Mode	Relevant Failures Allowed	Test Hrs per APDS	Total Hours
0-30 kW	50 Hz	4	1345	4034
0-30 kW	60 Hz	4	1345	4034
0-30 kW	400 Hz	4	1345	4034

4.3.16 Hot storage test. Perform the hot storage test in accordance with MIL-STD-705, TM 732.1 at 71 °C (160 °F).

4.3.17 Humidity test. The humidity test shall consist of 5 consecutive 48-hour cycles as specified in MIL-STD-705, TM 711.1.

4.3.18 Maintainability demonstration. The maintainability demonstration shall consist of performance of all scheduled maintenance (PMCS and 250/300 hour servicing) per host vehicle specification. Arctic mittens and MOPP IV gear shall be used. Any item of service which cannot be performed with arctic mittens or MOPP IV gear shall constitute a failure. Item 12, tighten hardware and replace insulation (noise) shall be excluded.

4.3.19 Solar radiation test. The solar radiation test shall be in accordance with Appendix C, TM 105.1.

4.3.20 Safety. A safety examination shall be conducted in accordance with Appendix C, TM-108.1.

4.3.21 HFE. A HFE examination shall be conducted in accordance with Appendix C, TM-109.1.

4.3.22 Nuclear Biological and Chemical. An NBC test shall be conducted in accordance with Appendix C, TM-101.1.

4.3.23 Secure lighting. Testing of the light sources, with filters, if applicable, shall be in accordance with table V of MIL-L-85762. Manufacturers of LEDs shall submit certificates of compliance to ensure conformance and compliance with Army secure lighting requirements.

5. NOTES

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

5.1 Intended use. The APDS are intended to supply power for multipurpose use in military applications.

5.2 Definitions.

5.2.1 Start. A APDS is considered to have started when it is operating at rated voltage and speed without the further use of starting aids.

5.2.2 Stop. A APDS system is considered to have stopped when all rotating members are at zero rpm, with the exception of a turbo charger if used.

5.2.3 Damage. Damage is defined as any failure, temperature or humidity related, rough handling damage or degradation in life. The blowing (opening) of a replaceable fuse is not considered damage, provided it is performing its intended function.

5.2.3.1 Temperature and humidity damage. Temperature and humidity damage is defined as conditions causing malfunction of any component or part, corrosion, breakage, deformation, or reduction of insulation resistance below 50,000 ohms.

5.2.3.2 Rough handling damage. Rough handling damage is defined as any condition resulting in malfunctioning of the system, liquid leakage, deformation, loosening, breakage, or change of fit of any component or part.

5.2.4 Rated load. Rated load is rated kilowatt at rated power factor, rated frequency and rated voltage.

5.2.5 Railroad transportation. Railroad transportation will be interpreted to mean impact speeds up to and including 12.88 km/h (8 MPH) under test conditions specified by the host vehicle.

5.2.6 Truck or trailer transportation. Truck or trailer transportation is defined as the conditions encountered during four cycles of a road test, each cycle consisting of the following, with the system mounted on the host vehicle:

ROAD CONDITION	DISTANCE km (Mi)	SPEED km/h (MPH)
Paved Highway	402.3 (250)	up to 80.5 (50)
Level Cross-country	402.3 (250)	up to 32.2 (20)
Hilly Cross-country	201.1 (125)	up to 32.2 (20)
Belgian Block	24.1 (15)	up to 32.2 (20)

5.2.7 Aircraft and helicopter transportation. Aircraft and helicopter transportation will be interpreted to mean a 22.86 cm (9 inch) end drop under test conditions specified in MIL-STD-705, method 740.3.

5.2.8 Failure. A failure is defined as the inability of an item to perform within specified limits. The contracting officer will classify failures into the categories described below. The following definitions are applicable for section 3 requirements and the specification sheets.

a. Relevant failure. Any failure of an item which prevents the APDS from starting, stopping, meeting the power output requirements, meeting audio noise requirements, any failure which renders any device of the protection system inoperative, or any failure which causes a critical or catastrophic hazard to personnel or equipment. Relevant failure will be used to calculate the MTBF requirement.

b. Nonrelevant failure. Any failure of an item which is not used to compute reliability. Examples of nonrelevant failures are as follows:

- Secondary failures caused by failures in the powered equipment or other occurrences in the environment when integral APDS protection is not provided against such equipment failures of occurrence, e.g., explosion or fire.

- Failures due to characteristic of the load, e.g., waveform distortion caused by saturated inductors

- Failures resulting from operating items beyond requirement

- A failure of an item which does not prevent the system from meeting the power output requirements specified herein, e.g., a panel light burns out

- Failures due to operator error where procedures are documented in technical manuals, instruction plates mounted on the system, or both, e.g., use of improper lubricant

- Failures due to design deficiencies when subsequent testing demonstrates that the design deficiency has been corrected may be assessed and re-scored as nonrelevant if the Government determines testing has proved the design deficiency has been corrected

c. Pattern failure. The occurrence of two or more failures of the same part in the same failure mode constitutes a pattern failure. A pattern failure, whether scored relevant or nonrelevant, may be a cause for rejection of the APDSs.

d. Critical failure. A critical failure is defined as a relevant failure requiring APDS disassembly to facilitate the repair.

5.2.9 Accuracy/error. Accuracy is a ratio that defines the limit of error expressed as a percentage of full-scale value. Error is the difference between the indication and the true value of the quantity measured. It is the quantity which, when algebraically subtracted from the indication, gives the true value. A positive error denotes that the indication of the meter is greater than the true value.

5.2.10 Inspection/test. Inspection/test is the examination and testing of supplies or services including, when appropriate, raw materials, components, and intermediate assemblies to determine conformance with contract requirements.

5.2.11 First article set. First article APDSs are defined as preproduction or production models.

5.2.12 Maintenance ratio. The maintenance ratio is defined as the total maintenance man-hours per total operating hours for all scheduled and unscheduled maintenance (excluding preventive maintenance checks and services by the operator) of the system. Maintenance man-hours include any and all man-hours expended for scheduled and unscheduled man-hours (excluding preventive maintenance checks and services by the operator) before, during and after operation, including time expended for inspection, diagnosis, and adjustments of the set and repair of failed components and assemblies.

5.2.13 Defect. A defect is any nonconformance of the APDS with either the specification or drawings specified in the applicable specification sheets.

5.2.14 Mission oriented protective posture (MOPP). MOPP I protection consists of a two-piece protective overgarment and helmet. In hot weather the jacket can be open with trousers closed. MOPP IV protection consists of a two-piece protective overgarment, hood, overboots and rubber gloves with cotton liners. The overgarment is closed and hood is pulled down and adjusted (Field manual FM-3-100).

5.2.15 Inspection report. The contractor will furnish, within the time interval specified, inspection reports in accordance with MIL-STD-831 for preproduction inspection and production inspection. The inspection reports will also include the following:

a. All test data obtained from applicable tests.

b. Description of malfunction, damages, failures, and adjustments (other than adjustments permitted by this specification) which occur during inspection.

c. Causes and analysis of malfunction, damages, or failures, and reasons for adjustments.

d. Corrective actions taken or required.

5.2.16 Subject term (key word) listing.

- Noise
  - Nuclear
  - Mobile

5.2.17 Government-furnished property. The contracting officer should arrange to furnish the Government-furnished property required for testing.

APPENDIX A

GENERAL REQUIREMENTS

A.1 SCOPE

A.1.1 Scope. This appendix is a mandatory part of the specification. The information contained herein is intended for guidance only. This document clarifies the test methods to be used for testing the generator set.

A.2 APPLICABLE DOCUMENTS

A.2.1 Non-Government publications. The following document(s) 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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ISO 10012-1	-	Quality Assurance For Measuring Equipment, Part I, Meteorological Confirmation System for Measuring Equipment.
NCSL Z 540-1	-	General Requirements for Calibration Laboratories, Measuring and Test Equipment.

(Application for copies should be addressed to: AMERICAN NATL STANDS INST, 1430 BROADWAY, NEW YORK NY 10018.)

A.3 GENERAL REQUIREMENTS

A.3.1 Test conditions. Unless otherwise specified herein, measurements and tests shall be made at the following conditions:

a. Standard ambient. Ambient measurements and checks (e.g., pre- and post-test) are conducted at room ambient conditions as follows:

Temperature:	25 ±10 °C (77 ±18 °F)
Relative humidity:	Uncontrolled room ambient
Atmospheric pressure:	Site pressure

b. Controlled ambient. When the ambient conditions must be closely controlled, the following shall be maintained:

Temperature:	23 ±2 °C (73 ±3.6 °F)
Relative humidity:	50 percent ±5 percent
Atmospheric pressure:	86.45 to 103.05 kPa (655 to 775 mmHg) (25.5 to 30.5 inHg)

A.3.1.1 Tolerance for test conditions. Unless otherwise specified, tolerances for test conditions shall be as follows:

a. Temperature. The test item shall be totally surrounded by an envelope of air (except at necessary support points). The temperature of the test section measurement system and the temperature gradient throughout this envelope, which is measured close to the test item, shall be within ±2 °C (±3.6 °F) of the test temperature and shall not exceed 1 °C per meter or a maximum of 2.2 °C total (equipment non-operating).

c. Pressure. ±5% (±200 Pa).

c. Humidity. Relative humidity at the chamber control sensor shall be ±5 percent RH of the measured value.

d. Time. Elapsed time shall be measured with an accuracy of ±1 percent.

e. Air velocity. Air velocity shall be within 10 percent of the specified value.

A.3.1.2 Accuracy of test instrumentation calibration. The accuracy of instruments and test equipment used to control or monitor the test parameters shall be verified prior to and following each test and then calibrated in predetermined intervals and shall meet the requirements of ISO 10012-1 and ANSI/NCSL Z 540-1 to the satisfaction of the procuring activity. All instruments and test equipment used in conducting the tests specified herein shall:

a. Be calibrated to laboratory standards whose calibration is traceable to the National Standards via primary standards.

b. Have an accuracy of at least one-third the tolerance for the variable to be measured. In the event of conflict between this accuracy and a requirement for accuracy in any one of the test methods of this appendix, the latter shall govern. A.3.2 General test performance guidance.

A.3.2.1 Pretest performance record. Before testing, the test item should be operated at standard ambient conditions to obtain and record data determining compliance with the requirements document(s) and for comparison with data obtained before, during, and after the environmental test(s). The identification and environmental test history of the specific test item(s) should be documented for failure analysis purposes. The pre-test record shall include (as applicable):

a. The functional parameters to be monitored during and after the test if not specified herein. This shall include acceptable functional limits (with permissible degradation) when operation of the test item is required.

b. Additional evaluation criteria.

A.3.2.2 Installation of test item in test facility. Unless otherwise specified, the test item shall be installed in the test facility in a manner that will simulate service usage, with connections made and instrumentation attached as necessary.

a. Plugs, covers, and inspection plates not used in operation, but used in servicing, shall remain in place.

b. Electrical connections normally used in service but not in test shall be provided with electrical connectors having dummy cables with protected terminations. Such mechanical connections shall also be protected.

c. For tests where temperature values are controlled, the test chamber shall be at standard ambient conditions when the test item is installed or as specified in the individual methods.

d. The test item shall be operated according to the applicable technical order or technical manual, when available, to determine that no malfunction or damage has resulted from faulty installation or handling. The requirement to operate the test item after its installation in the test facility applies only when the item is required to operate during the test.

e. Test items shall be positioned at least 15 cm (6 inches) from each other or from walls, floors, ceilings, etc. to allow for adequate circulation.

f. If the item to be tested consists of several separate units, these units may be tested separately provided the functional aspects are maintained as defined herein.

A.3.2.3 Interrupted tests. Unless otherwise specified in the individual methods, the following procedures shall be followed when a test is interrupted. Any deviation from this guidance shall be explained in the test report.

A.3.2.3.1 In-tolerance interruptions. Interruptions during which the prescribed test tolerances are not exceeded shall be considered as part of the total test duration. (No allowance is necessary if exposure to the proper test levels was maintained.)

A.3.2.3.2 Methods 103.1, 105.1 (See figure 1).

a. Undertest. If test tolerances have been exceeded resulting in an undertest condition, the test may be resumed from the point at which tolerances were exceeded following re-establishment of prescribed conditions (except as noted in the individual methods), and extended to ensure that the prescribed test cycle is achieved.

b. Overtest. If an overtest condition occurs, the preferable course of action is to stop the test and start over with a new test item. However, if any damage is a direct result of the overtest conditions and will not affect other test item characteristics, or if the item can be repaired, the test may be resumed and extended as in the undertest condition. If an item failure occurs during the remainder of the test, the test results shall be considered invalid.

A.3.2.3.3 Methods 104.1. Each of these methods contains guidance for handling out-of-tolerance test interruptions. Any such interruption must be carefully analyzed. If the decision is made to continue testing from the point interruption, to restart the last successfully completed test cycle, or to restart the entire test with the same test item, and a failure occurs, it is essential to consider the possible effect of the interruption or of the extended length of the test.

A.3.2.4 Post-test data. At the completion of each environmental test, the test item shall be inspected as specified herein, and the results shall be compared with the pretest data obtained in accordance with B.3.2.1. Post-test data shall include:

c. complete identification of all test equipment and accessories.

c. The actual test sequence (program) used.

c. Deviation from the planned test program.

d. The room ambient test conditions recorded periodically during the test period.

e. A signature and data block for certification of the test data by the test engineer.

f. Other data as specified in the individual methods or as specified herein.

A.3.2.5 Failure criteria. Failure of the test item to meet any one of the following conditions shall constitute a test item failure.

a. Deviation of monitored functional parameter levels beyond acceptable limits established in B.3.2.1 and specified herein.

NOTE: Certain types of equipment (e.g., propellants and electrically driven devices) are often expected to demonstrate lesser performance at an environmental extreme, particularly low temperature. A failure would occur only if degradation is more than permissible.

b. Nonfulfillment of safety requirements or the development of safety hazards.

c. Nonfulfillment of specific test item requirements.

d. Changes to the test item, which could prevent the equipment from meeting its intended service life or maintenance requirements. (For example: Corroded oil drain plug cannot be removed with specified tools.)

e. Deviation from established environmental requirements.

B.1. SCOPE

B.1.1 Scope. This Appendix covers the specific requirements for export power generated by vehicle mounted, engine driven, tactical, alternating current systems in sizes up to 30 kilowatts. Export power devices will be referred to as Auxiliary Power Distribution System (APDS) in this document.

B.1.2 Classification. The APDS will be tactical, generate Class I-Precise Power per MIL-STD-1332B.

B.1.3 Power rating. The APDS will be rated 0.8 power factor (pf), lagging, and will be re-connectable for the following voltages:

B.1.3.1 Configuration I (below 10 kW):

- 120/240 VAC, single phase, 3 wire, WYE configuration

B.1.3.2 Configuration II (above 10 kW):

- 120/208 VAC, three phase, 4 wire, WYE configuration

B.1.4 Frequency. The frequency shall be 50, 60, 400 Hz selectable at all voltage connections.

B.1.5 Phase sequence.

- Configuration I: L1, L2.

- Configuration II: L1, L2, L3.

B.2. LOAD TERMINALS AND RECEPTACLES

The APDS shall be equipped with load terminals and receptacles as follows:

B.2.1 Output terminals.

B.2.1.1 Configuration I. AC output terminals and equipment grounding terminal(s) shall be provided. They shall be conspicuously marked "L_1", "L_2", "N", and “GND”; terminal "N" being neutral and terminal “GND” being ground. The terminals shall be arranged in line in the sequence "L_1", "L_2", "N", and “GND” reading from top to bottom if mounted vertically. If mounted horizontally, the terminals may be arranged in the following sequence: "GND", "N", "L_1", "L_2" or "L_1", "L_2", "N", "GND" with the lead opening located on the side nearest the "GND" terminal. The terminals shall be mounted adjacent to a corrosion resistant ground plane, containing the "GND" terminal and permanently connected to the APDS base by means of a low resistance, corrosion-free connection. The mounting arrangement shall permit a removable, low inductance connection between "N" and "GND" terminals. Terminals shall be compatible with, and interface with the DISE and PDISE systems. Terminals shall be rigidly mounted; studs shall not twist or turn in their mountings when the hexagon bar nuts are tightened. Terminals shall be readily accessible for connection of external output wires. All terminals shall be protected to prevent accidental contact. A non-conductive wrench suitable for securing load cables to terminals shall be provided with each APDS. It shall be captive with a synthetic, non-conductive fiber rope and shall be secured inside/on the APDS housing when not in use.

The access door, which shields the load terminals, shall be permanently marked with a .75-inch minimum letter height:

“DANGER”
HIGH VOLTAGE

OUTPUT TERMINALS”

Also, the opening where the load cables exit the APDS housing, shall be marked:

“OUTPUT CABLES”
INSERT OUTPUT TERMINAL CALL OUT FOR SINGLE PHASE

B.2.1.2 Configuration II. AC output terminals and equipment grounding terminal(s) shall be provided. They shall be conspicuously marked "L_1", "L_2", "L_3", "N", and “GND”; terminal "N" being neutral and terminal “GND” being ground. The terminals shall be arranged in line in the sequence "L_1", "L_2", "L_3", "N", and “GND” reading from top to bottom if mounted vertically. If mounted horizontally, the terminals may be arranged in the following sequence: "GND", "N", "L_1", "L_2", "L_3" or "L_1", "L_2", "L_3", "N", "GND" with the lead opening located on the side nearest the "GND" terminal. The terminals shall be mounted adjacent to a corrosion resistant ground plane, containing the "GND" terminal and permanently connected to the APDS base by means of a low resistance, corrosion-free connection. The mounting arrangement shall permit a removable, low inductance connection between "N" and "GND" terminals. Terminals shall be compatible with, and interface with the DISE and PDISE systems. Terminals shall be rigidly mounted; studs shall not twist or turn in their mountings when the hexagon bar nuts are tightened. Terminals shall be readily accessible for connection of external output wires. All terminals shall be protected to prevent accidental contact. A non-conductive wrench suitable for securing load cables to terminals shall be provided with each APDS. It shall be captive with a synthetic, non-conductive fiber rope and shall be secured inside/on the APDS housing when not in use.

The access door, which shields the load terminals, shall be permanently marked with a .75-inch minimum letter height:

“DANGER”
HIGH VOLTAGE
OUTPUT TERMINALS”

Also, the opening where the load cables exit the APDS housing, shall be marked:

“OUTPUT CABLES”

B.2.2 Convenience receptacle. The APDS shall be provided with a convenience receptacle used to provide 15 amps current at 120 VAC, located near the control assembly. The APDS convenience receptacle shall be a 125-volt, 15-amp, single-phase, Underwriters Laboratories Inc. (UL) listed duplex receptacle. The receptacle shall be protected by a 15-amp circuit breaker and a 15-amp Ground Fault Circuit Interrupter (GFCI) for all operating conditions specified herein. The GFCI shall be mounted adjacent to the convenience receptacle if it is not integral to the convenience receptacle. The receptacle shall be mounted on the exterior of the APDS, accessible without the opening or removal of any housing covers or access doors. If single-phase sensing is used, the receptacles shall be energized from the reference voltage of the voltage regulator system. The receptacle shall be connected in accordance with the National Electric Code. The convenience receptacle shall be equipped with separate spring-loaded, weatherproof covers.

B.3. CONTROLS

A manually activated device is required when reference to a “switch” is made in the following paragraphs:

B.3.1 Start/Stop switch. A single switch shall be provided for powering and de-energizing the APDS. When the switch is in the "OFF" position, power shall be available for control panel lights and malfunction indicators.

B.3.2.2 Emergency Stop switch. A maintaining, push-to-activate switch shall be provided to simultaneously open the APDS output contactor, de-energize the APDS, and disconnect the DC control power. There shall be no current

drain from the battery(ies) after the switch is activated, except that power can be provided to an electronic engine control system. The switch shall be red and labeled "EMERGENCY STOP" and "PUSH TO STOP".

B.3.3 Ammeter-voltmeter control.

B.3.3.1 Configuration I. A control shall be provided to display the following voltages and currents.

Voltage	Current
L1-L2	L1-L2
L2-L0	L2
L1-L0	L1

B.3.3.2 Configuration II. A control shall be provided to display the following voltages and currents.

Voltage	Current
L1-L2	None
L2-L3	None
L3-L1	None
L3-L0	L3
L2-L0	L2
L1-L0	L1

B.3.4 AC circuit interrupter actuator switch. A switch shall be provided to permit opening and closing of the ac output circuit interrupter. The upper position shall be marked "CLOSED" and the lower position shall be marked "OPEN". An amber indicator light shall be provided and connected to energize when the AC circuit interrupter switch is in the "closed" position. It shall be located directly above the AC circuit interrupter switch. It shall be possible to test the light without the need for tools or test equipment. The switch shall be labeled “AC CIRCUIT INTERRUPTER”.

B.3.5 Panel light switch. A single on/off switch shall be provided to control all instrument panel lights. The switch shall be labeled "PANEL LIGHTS".

B.3.6 Unit-parallel control. A control shall be provided to activate/deactivate all parallel circuits for the APDS. The control shall be labeled "UNIT-PARALLEL".

B.3.7 Battle short switch. A switch shall be provided and connected to prevent deenergizing the APDS and/or opening of the circuit interrupter under the action of any safety or protective device, except and short-circuit. It shall be provided with a hinged red cover that can be quickly raised to provide access to the switch and which returns the switch to "OFF" when lowered. The switch shall be labeled "BATTLE SHORT", "ON" in the up position, "OFF" in the down position. A red indicator light shall be provided and connected to energize when the battle short switch is in the “ON” position. The indicator light shall be located directly above the battle short switch. It shall be possible to test the light without the need for tools or test equipment.

B.3.8 Voltage adjust control. A control shall be provided to permit adjustment of APDS output voltage as required herein. The control shall be marked “VOLTAGE”.

B.3.9 Paralleling control. A control shall be provided to permit adjustment of division of the reactive kVA among APDS operated in parallel. The control shall be labeled "REACTIVE CURRENT ADJUST".

B.3.10 Frequency selector control. A control shall be provided to permit selection of 50 Hz, 60 Hz or 400 Hz operation. The control shall be provided with a means to prevent accidental or inadvertent activation. The control shall be labeled "FREQUENCY SELECT".

B.4. INDICATING INSTRUMENTS

B.4.1 Running-time meter. A running-time meter shall be provided to indicate total APDS operating hours. This meter shall register a minimum of 18,000 hours. The meter shall have an error not to exceed ±5 hours per 500 hours operation.

B.4.2 Voltmeter. The voltmeter shall display voltage in all line-to-line (L-L) and line-to-neutral (L-N) phases for all voltage connections. The voltmeter shall indicate voltage on the input side of the AC circuit interrupter. The voltmeter shall be capable of displaying voltages from 0-250 volts. Minimum scale divisions of 5 volts shall be provided over the full range of output. The meter shall have an error not to exceed 2.5 % of full scale, except that within the ranges of 115 to 125 and 200 to 250 volts the error shall not exceed 5 and 10 volts, respectively.

B.4.3 Ammeter. The ammeter shall display current in all phases. The ammeter shall indicate percent of rated current. The ammeter shall be capable of displaying currents from 0-133 % rated current. Minimum scale divisions of 10 % rated current shall be provided over the full range of output. The instrument shall provide an accurate display of current for both the 50 Hz and 60 Hz frequencies. The ammeter error shall not exceed 3 % of full-scale value.

B.4.4 Kilowattmeter. The kilowattmeter shall display total power in kilowatts. The kilowattmeter shall be capable of displaying power from 0-133 % of rated kW. Minimum scale divisions of 10 % rated power shall be provided over the full range of output. The kilowatt- meter system (meter and transducer) shall indicate the power output to an accuracy of 3 % of full scale value at +77 °F from APDS no load to rated load current under the following conditions:

B.4.4.1 Balanced load at any pf from unity to 0.80, lagging.

B.4.4.2 Unbalanced load, where the voltages in each leg, currents, and pf differ.

B.4.4.3 With the output of any one-phase equal to zero.

Note, the temperature error at ambient temperatures from +77 to +120 °F shall be not more than 1.5 % of full-scale value. At ambient temperatures from +120 to –25 °F and with the instrument energized at rated voltage at rated frequency and at constant loads from no-load to rated load, the kilowatt indication shall not change by more than 1 percent of full-scale value from the time the instrument is energized until it reaches a stabilized temperature or until 30 minutes has elapsed, whichever period is longer. The error due to frequency change shall be not more than one-half of 1 % of full-scale value as the frequency is varied between 48 and 62 Hz. The error due to change in pf shall be not more than 1 % of full-scale value as the pf is varied from 1.0 to 0.5 leading or lagging. The kilowattmeter system shall incorporate separate static (no moving parts) circuit elements. A separate isolated voltage and current element is required for each phase. Two-and-one-half element systems shall not be used. The meter and transducer shall be separately replaceable without exceeding accuracy limits herein. The kilowattmeter system shall not require reconnection when the APDS is changed to either of the specified voltage connections. The operation of the meter and its associated circuit element shall not be adversely affected by the following conditions:

B.4.4.4 Twice-rated voltage at zero current for 5 seconds.

B.4.4.5 Twice-rated current at normal voltage continuously.

B.4.4.6 Five times rated current at normal voltage for 5 seconds.

B.4.5 Frequency meter. The frequency meter shall display frequency in Hz. Minimum scale divisions of 0.1 Hz shall be provided. System error shall not exceed 0.5 Hz. The frequency meter system (meter and transducer) shall not be damaged by application of the following voltages:

B.4.5.1 240 volts at rated frequency for 10 seconds.

B.4.5.2 150 volts at rated frequency continuously.

B.4.5.3 120 volts at 40 % of rated frequency continuously.

B.4.5.4 120 volts at 125 % of rated frequency continuously

B.4.6 Instrument accuracy. The maximum error range of each metering system shall be as follows:

INSTRUMENT		Maximum Allowable Error Range
Voltmeter		
	115-125 volt range	± 5 V
	200-250 volt range	± 10 V
Ammeter (AC)		
	25 percent Load Current	17-33 percent Rated Current
	50 percent Load Current	42-58 percent Rated Current
	75 percent Load Current	67-83 percent Rated Current
	100 percent Load Current	92-108 percent Rated Current
Frequency meter		
	55-65 Hz range	± 0.6 Hz
	48-52 Hz range	± 0.6 Hz
	380-420 Hz range	± 4 Hz
Kilowattmeter		
	25 percent Load	12-38 percent Load
	50 percent Load	37-63 percent Load
	75 percent Load	62-88 percent Load
	100 percent Load	87-113 percent Load

B.5. CONTROL PANEL ILLUMINATION

All control panel illumination (flood and individual) shall conform to MIL-STD-1472 paragraph 5.2.1.2.1 and 5.8.2, except 600 mm shall be 600 nm. Compliance with the "Recommendations for Display Lighting" in Table XXII of MIL-STD-1472 is required.

B.6. WIRING

B.6.1 Wiring. All wires shall be secured neatly into harnesses. Wires in all harnesses shall be of the proper length and shall be so run and secured (with insulated clamps) as to protect insulation against chafing, contact with sharp corners and edges, pinching, sharp bending and twisting, abrasion because of vibration or contact with moving parts and exposure to high temperatures. Adhesive backed "Panduit" wiring mounts shall not be used. Similar mounts may be used with mechanical fastening instead of adhesive backing. Where a cable or wire is run between parts that move relative to each other (as a result of vibration, adjustment, inspection, or as a matter of normal operation), sufficient slack shall be left in the harness to allow repeated movement to take place without bending or twisting to the point of damaging the wire in any manner. Wires shall not be spliced. All wiring harnesses shall terminate in connectors or terminal lugs at each end or branch except solder connections may be made to potentiometers, resistors, semiconductors, fuse holders, capacitors, and press-to-test indicator lights. Quick-disconnect connectors are the preferred method of harness termination. A means shall be provided to prevent liquids from coming in contact with any electrical connection for all operating conditions specified herein. Not more than two terminal lugs

shall be attached with any one screw on screw type terminal boards, and not more than four terminal lugs shall be attached to any one stud on stud-type terminal boards. Terminals on electrical components shall not have more than one wire attached.

B.6.2 Wire and wire marking. Wire shall be multi-stranded copper conductor, flame retardant, moisture, heat and oil resistant in accordance with the National Electric Code. All wire shall be numbered for easy identification. The marking shall be permanently applied to the wire to withstand all specified operating conditions herein throughout the life of the APDS. Wiring shall be identified at intervals not longer than 15 inches throughout its length and with 3-inch intervals for the final 15 inches of each end. The contractor shall determine the wire-numbering scheme. Wires energized from the battery (except the battery cables) shall be marked using red characters. All other wires shall be marked using black characters. The use of colored wire coating as a marking scheme is prohibited. Wire in accordance with drawing 88-20540 may be used.

B.7. FREQUENCY CHARACTERISTICS

B.7.1 Frequency regulation. 0.25 % of rated frequency at all loads, including rated load.

B.7.2 Short-term (30 seconds) stability. 0.5 % of rated frequency at all loads, including rated load.

B.7.3 Long term (4 hour) stability. 1% of rated frequency at all loads, including rated load.

B.7.4 Frequency drift. 0.5 % of rated frequency over an 8-hour period with a 60-degree F change in ambient temperature, under constant load and voltage.

B.7.5 Transient performance. Following application and rejection of load (up to and including rated load), stable frequency shall be established in 2 seconds. The maximum undershoot/overshoot shall not be more than 4 %

B.8. VOLTAGE CHARACTERISTICS

B.8.1 Voltage waveform. The deviation factor for L-L and L-N voltage waveform for each voltage connection shall not be more than 5 %, and no single voltage harmonic shall be more than 2 %. In addition, no evident discontinuities or spikes shall be present in the waveform.

B.8.2 Phase balance. 1% maximum difference in all L-N voltages at all loads, including rated load.

B.8.3 Voltage modulation. 1% maximum for all L-L and L-N voltages at all loads, including rated load.

B.8.4 Voltage regulation. Voltage regulation from no load to rated load and from rated load to no load shall be not more than 1 % of the rated voltage for all voltage connections.

B.8.5 Short term (30 seconds) stability. At every constant load from no load to rated load the voltage at the output terminals shall remain in a bandwidth of 1 % of rated voltage.

B.8.6 Long term (4 hour) stability. At constant load, the voltage at the output terminals shall remain in a bandwidth of 2 % of rated voltage, operating at constant ambient temperature, constant barometric pressure, constant frequency and any constant load from rated load to no load.

B.8.7 Voltage drift. 1 % of rated voltage over an 8-hour period with a 60 degree F change in ambient temperature, under constant load and frequency.

B.8.8 Transient performance. With the APDS operating at no load, rated voltage, rated frequency, the terminal voltage of the APDS shall not drop to less than 70 % of the no load voltage, when a balanced 3-phase (single phase load for Configuration I APDS), 0.4 pf (or less) lagging, static load having an impedance of 0.5 per unit is suddenly applied to the output terminals. When connected to the specified load, the output voltage shall recover to a

minimum of 95 % of rated voltage within 0.7 sec and shall stabilize at or above this voltage; With APDS operating at rated frequency, rated voltage, and following any sudden change in load from no load to rated load, the instantaneous voltage shall not drop to less than 85 % of rated voltage and shall reach stable conditions within 0.5 sec; overshoot or undershoot of the final voltage shall not exceed the initial transient in amplitude. The above requirements also apply when load is suddenly changed from rated load to no load, except that the initial voltage transient shall not exceed 112 % of rated voltage; The APDS shall be capable of across-the-line starting a motor rated at 1 hp for kW of the APDS kW rating. The starting current rating of the motor shall be NEMA Code F and the motor shall be loaded with a flywheel having inertia equal to that of the motor rotor.

B.8.9 Voltage unbalance. For Configuration II APDS, maximum difference between L-L voltages shall not be more than 5 % of rated voltage under the conditions of a single phase, L-L, unity pf load of 25 % rated current and no other load on the APDS.

B.8.10 Voltage adjustment range. For all voltage connections, voltage shall be adjustable 10 VAC above and below nominal. Note, this voltage adjustment range shall apply for all loads between no load and rated kW, rated power factor at rated frequency under all environmental conditions. It shall not be possible to adjust the voltage to a value that activates the over voltage protective device.

B.9 PARALLEL OPERATION

It shall be possible to parallel at least 3 (more than 3 desired) 30 kW APDS units. APDS operated in parallel shall divide load in accordance with the following as system load (at rated power factor) is varied between zero and 100 % (and vice versa) of the combined rating of the connected APDSs:

B.9.1 Real power division. At no time shall difference between the average individual kilowatt outputs of the APDS, when supplying the system load, be greater than 10 % of the kilowatt rating of one APDS.

B.9.2 Power exchange. At all constant system loads up to the combined rating of the APDS in parallel, power exchange between the APDS shall not exceed 10 % of the kilowatt rating of one APDS. Power exchange is the difference between the maximum and minimum power outputs delivered by one APDS for constant system load conditions, as determined from ocsillographic measurements.

B.9.3 Reactive power division. At no time shall the difference in average reactive kilowatt-ampere (kVA) supplied by any two APDS differ by more than 10 % of the reactive kVA rating of one APDS.

For the above requirements, the initial system load shall be equally divided between the APDS, both as to activate and reactivate components; thereafter, there shall be no adjustments to voltage regulators, or any other components as system load is changed.

B.9.4 Automatic paralleling. The APDS shall incorporate an automatic paralleling system, whereby two or more APDS can operate in parallel. Automatic shall be defined as a “one button” control that senses voltage and frequency phasing; closes the contacts when the voltage and frequency are in phase and zero voltage; and senses and shares the total load equally.

B.9.5 Paralleling cables. When specified, a 25-foot length of cable shall be provided with and stored within each APDS. This cable shall be labeled “PARALLELING CABLE”.

B.9.6 Paralleling receptacles. For paralleling, each APDS shall have receptacles mounted in the vicinity of the control panel. These receptacles shall be used for voltage regulator interconnection. The receptacles shall have captive caps. The receptacles shall be labeled, “PARALLELING RECEPTACLE”.

B.10. VOLTAGE RECONNECTION SYSTEM

A voltage reconnection system shall be provided for reconnecting the phases of the APDS to give all specified output voltages. In addition, reconnection of any other circuits required to convert the APDS voltage/phase output shall be accomplished at the same time and by the device, which serves to reconnect the APDS output. The reconnection device shall consist of a link panel wherein the links are permanently attached to a single insulating board in such a manner that an improper connection cannot be made. A rotary type switch shall not be used.

B.11. AC CIRCUIT INTERRUPTER

A dustproof and waterproof circuit interrupter shall be provided and connected between the voltage reconnection system and the APDS output terminals. It shall be electrically controlled from the 24 VDC system by means of a switch on the control panel. It shall be a three-pole, three-phase (single phase for configuration I APDS) device constructed such that the three sets of main contacts close and open simultaneously through action of a common mechanism. The main contacts shall all close within 50 milliseconds and shall open within 35 milliseconds when operating on the dc control voltage range. It shall not be possible for any of these main contacts to remain closed while others are open. The circuit interrupter shall be connected so that it opens automatically when either the circuit interrupter actuator switch or the master switch is placed in the "OFF" position; or the dc control circuit breaker is pulled. This shall be accomplished independently from any protective device. Interrupting capacity of the main contacts shall be not less than 10 times rated current for the contacts.

B.12. SAFETY

B.12.1 High voltages. The APDS shall be designed so that operators will not be required to access components with voltages exceeding 30 V.

B.12.2 Voltage protection. The APDS shall provide protection for personnel during maintenance and repair against unintentional contact with voltages exceeding 70 V. Current sources exceeding 25 A shall be protected from accidental short-circuiting. Capacitors shall be discharged to less than 30 V and 20 J energy prior to maintainer access. Two resistors in parallel shall be used where resistor networks discharge capacitors, or act as voltage dividers (between test point and ground). Voltage measurements required by maintainers shall not exceed 300 V. Circuits and components exceeding 500 V shall be completely enclosed or protected by non-bypassable interlocks.

B.12.3 Equipment grounding. Equipment grounding shall comply with the requirements of NFPA 70, Article 250. Hinges and slides shall not be relied upon as the sole means of grounding.

B.12.4 Equipment access. The APDS shall provide maximum access and safety to personnel during operation and maintenance.

B.12.5 Temperature limits. Operator accessible parts shall comply with the temperature limits shown in UL 1950, Table 16, Part 2. There shall be no exposed surfaces greater than +60 °C. Hot surfaces shall be clearly marked/labeled in accordance with 3.11.6.11.

B.12.6 Power switches. Power switches shall be protected from accidental shut-off, which can interrupt power output, and accidental actuation, which can pose a hazard to operators or maintainers.

B.12.7 Moving parts, edges or corners. Equipment shall additionally comply with the requirements of UL 1950, paragraphs 4.1.2 - 4.1.4.

B.12.8 Safety colors. Colors of safety critical controls and indicators shall be yellow for caution, and red for danger. Any color is permitted on functional controls or indicators provided it is clear that safety is not involved. Safety critical controls shall be readily accessible.

B.12.9 Hazard marking. Safety markings and labels shall be provided identifying any potential hazards to personnel. Safety markings and labels shall comply with the requirements of ANSI Z535.2. Voltages in excess of 70 V shall use the signal word "WARNING". Voltages in excess of 500 V shall use the signal word "DANGER".

Markings and labels shall be readily visible in accordance with ANSI Z535.2. They shall not be removed or obstructed when a barrier or access door is opened or removed.

B.12.10 Malfunction indicator. The malfunction indicator system shall cause the appropriate indicating lamp to energize under activation of the associated protective device.

B.13. DROP TEST

The drop test shall be performed in accordance with MIL-STD-705c, TM 740.3, at a height of 9 inches.

B.14. TECHNICAL MANUAL SAFETY INFORMATION

All safety hazards not eliminated through design shall be addressed in the appropriate technical manuals. Information regarding hazard-avoiding procedures and safety warning labels on equipment shall be included in all manuals. Maintenance technical manuals shall address replacement procedures for damaged or missing safety labels.

B.15. GROUNDING

All AC electrical components of the APDS shall be isolated from ground, except as otherwise specified herein. The equipment ground terminal (GND) shall be connected by a removable, solid copper bar to the neutral output terminal "N" (see 3.15.1). Neutral connection of "WYE" connected current transformer secondary leads may be connected to circuits leading to the output terminal "N". Direct current components utilizing chassis or case grounding shall not be used except for, control panel indicators. When specified either a three-section ground rod conforming to type III, class B of A-A-55804 or a surface wire ground system conforming to DL SC-B-681610 shall be provided for each APDS. Provisions shall be made for storage of ground rods with the APDS. If the ground rods are stored within the APDS, door(s) through which ground rods are accessed shall be marked “GROUND ROD” on the outside.

B.16 I.D. MARKING AND INFORMATION

The APDS shall be permanently identified and marked and have information and instruction plates as specified herein.

B.16.1 Parts identification. Parts shall be identified in accordance with MIL-STD-130.

B.16.2 Identification plates. The following identification plates shall be permanently affixed to the APDS. Plates shall be photosensitive aluminum, 0.020-0.032 thick, impregnated with silver compound or coated with other than silver for one side printable area. Photosensitive aluminum shall be capable of resolving not less than 25 lines per millimeter. Plates shall have natural aluminum copy on black background.

B.16.3 APDS identification plate. An identification plate containing the information on drawing 88-20063 shall be mounted in a conspicuous place on the APDS.

B.16.4 Information and instruction plates and markings. Plates specified below shall be supplied on each APDS.

B.16.5 Operating instructions. A plate or plates containing operating instructions shall be mounted in a conspicuous location visible from the operator's position. The operating instructions shall be complete and brief; shall describe procedures for starting, operating and stopping at ambient temperatures from +120 to -50 °F; shall describe procedures for paralleling; shall state information on grounding the APDS frame with a warning that this should be done to avoid shock hazard. Operating instructions shall comply with the labeling requirements.

B.16.6 Schematic and wiring diagrams. A schematic diagram(s) and a connection (wiring) diagram(s) shall be provided with the APDS. The schematic diagram shall show the complete operational and functional sequence of

the circuitry for analysis and maintenance of the APDS. The connection diagram shall show the physical location of all wiring interconnections in the same relationship as when they are installed. Identification marking of instruments, control devices, and connections shall be shown in both diagrams and shall coincide with markings on all items being identified. Electrical symbols shall be in accordance with IEEE STD-315-1975. When additional electrical symbols are used for items not in IEEE STD-315-1975, a note on the diagram shall define the meaning of the symbol.

B.16.7 Grounding stud plate. A plate at the grounding stud shall contain instructions for use of four-wire and five-wire grounding systems with a caution to ground the APDS before use.

B.16.8 Connection changeover instructions. A plate that illustrates the physical configuration for achieving each of the APDS operating connections shall be mounted on or near the voltage reconnection system. In lieu of a separate plate, the instructions may be printed directly on the reconnection system.

B.16.9 Caution plate for voltage connections. A plate shall be mounted in the vicinity of the load output terminals stating:

"TO AVOID DAMAGE
CHECK THE
VOLTAGE, FREQUENCY, AND PHASE REQUIREMENTS OF THE LOAD."

B.16.10 Convenience receptacle plate. A plate at the convenience receptacle shall be marked "15 amps, 120 volts, 60 Hz".

B.16.11 Paralleling receptacle plate. The receptacle shall have a plate marked "PARALLELING RECEPTACLE".

B.16.12 APDS rating plate. A plate(s) shall be mounted adjacent to the APDS identification plate. It shall contain the following information about the APDS:

B.16.12.1 Kilowatt capacity in different environments.

B.16.12.2 Frequency rating.

B.16.12.3 Rated voltage, current and phases available at each connection.

B.16.12.4 Voltage adjustment ranges available at each connection.

B.16.12.5 Power factor.

APPENDIX C

TEST METHODS

TEST METHOD 100.1

AUDIO NOISE TEST

100.1.1 General. The generator set must satisfy audio noise requirements.

100.1.2 Apparatus. Instrumentation for measuring load conditions and noise shall be as described and illustrated in MIL-HDBK-705.

100.1.3 Procedure.

100.1.3.1 Preparation for test. The test site shall be a uniform flat grass surface, free of ice, snow, or vegetation over 0.15 meter (5.9 inches) tall; it shall be free of reflecting surfaces such as buildings, trees, hillsides, or load bank(s) within a 50 meter (164 ft) radius. The generator set or power unit/plant shall be positioned in the center of the test site. An anechoic or hemi-anechoic chamber may be substituted for outdoor measurements. Audio Noise Sound Pressure Level (SPL) readings shall be taken with the set(s) not operating (ambient), at no-load and rated-load. The ambient noise level must be at least 10 dB below the sets for a valid test

100.1.3.2 Steady-State noise. Start and operate the set and allow it to stabilize at rated-load, rated voltage and rated frequency. Stabilization shall be considered to have occurred after the set is operated at rated-load, rated voltage and rated frequency for 10 minutes. The generator set shall be operated at rated-load, 75 percent, 50 percent, 25 percent and no-load. Measurements shall be taken at each load condition. The dB(A) SPL shall be determined by positioning microphones at an elevation above the ground and distance away from the perimeter of the generator set or power unit/plant as specified in herein. The sensing element of the microphones shall be positioned parallel to the ground. The microphone(s) shall be placed or moved in 30-degree increments around the item with the 0-degree location being the center of the operator's control panel.

100.1.3.3 Hearing protection assessment. The control panel door (if applicable) shall be opened and secured. Position the microphone at the distance from the operator's panel specified herein. The height of the microphone will be equal to the vertical center of the control panel. The generator set shall be operated at rated-load, 75 percent, 50 percent, 25 percent and no-load. Noise level measurements shall be taken at each load condition.

100.1.3.4 Data required. The following data will be included on the test data sheets for each test condition:

a. Ambient temperature, °C (°F).

b. Wind speed, km/hr (mph).

c. Barometric pressure, millimeters mercury (mmHg).

d. Relative humidity, %.

e. Ambient noise levels versus octave band center frequency (dB and dB(A))

f. A tabulation of the audio noise SPL versus octave band center frequency for rated-load and no-load operation for each measurement (dB).

g. A tabulation of the SPL at each measurement (dB(A)).

h. A measurement of the SPL at the operator's station (dB(A)).

100.1.3.5 Results. Compare the operator's control panel noise level with the 85 dB(A) criteria for personnel hearing protection.

TEST METHOD 101.1

NUCLEAR, BIOLOGICAL AND CHEMICAL CONTAMINATION SURVIVABILITY (NBCCS)

EVALUATION

101.1.1 General. The generator set must be capable of being decontaminated with no damage or deterioration in performance.

101.1.2 Apparatus. The apparatus requirements of MIL-STD-705, method 608.1 is necessary to perform this test. The decontamination systems used shall be the M17 Lightweight Decontamination System (LDS), NSN 4230-01-251-8702.

101.1.3 Procedure.

101.1.3.1 Preparation for test.

a. Place the generator set in the decontamination environment location with external connections made to simulate field installation conditions as closely as possible.

b. Connect the load and field instrumentation in accordance with TM 608.1 of MIL-STD-705.

c. The test area shall be at normal ambient temperature at the beginning of the test and no further regulation of temperature is required.

101.1.3.2 Test.

a. Within four hours of the test and at the test site, perform TM 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term), of MIL-STD-705. Color photographs shall also be taken of the exterior of the set as well as the components of the interior of the set.

b. Cycle 1. Decontaminate the exterior of the set using hot soapy water followed by water rinse using the M17 Lightweight Decontamination System. Within one hour of the test and at the test site, perform TM 608.1.

c. Cycle 2. Decontaminate the exterior of the set using hot soapy water followed by water rinse using the M17 Lightweight Decontamination System. Within one hour of the test and at the test site, perform TM 608.1. Cycle 2 shall not be conducted on the same day as cycle 1.

d. Cycle 3. Decontaminate the exterior of the set using hot soapy water followed by water rinse using the M17 Lightweight Decontamination System. Within one hour of the test and at the test site, perform TM 608.1. Cycle 3 shall not be conducted on the same day as cycle 2.

e. Cycle 4. Decontaminate the exterior of the set using hot soapy water followed by water rinse using the M17 Lightweight Decontamination System. Within one hour of the test and at the test site, perform TM 608.1. Cycle 4 shall not be conducted on the same day as cycle 3.

f. Cycle 5. Decontaminate the exterior of the set using hot soapy water followed by water rinse using the M17 Lightweight Decontamination System. Within one hour of the test and at the test site, perform TM 608.1. Cycle 5 shall not be conducted on the same day as cycle 4.

g. Wait a minimum of forty-eight hours to determine the effects of corrosion. Conduct TM 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term), of MIL-STD-705. Color photographs shall also be taken of the exterior of the set as well as the components of the interior of the set prior to proceeding to the next decontaminant.

NOTE: The maximum water pressure of the M17 Lightweight Decontamination System (LDS) shall be 100 psi. The maximum water temperature shall be 248^{o} F. Each exterior side (top, back, left and right, and the control panel) of the generator shall be washed for approximately 30 seconds. The generator shall be washed from the top down. The end of the wand shall be approximately 36 inches from the generator set surfaces. Caution should be taken when decontaminating the control panel of the set. The hot soapy water shall be rinsed from the set within 30 minutes after application. The soap used shall conform to NSN 7930-00-282-9699.

101.1.4. Results.

a. Compare the results of the test specified in 3.2a through 3.2f with the requirements of this procurement document.

TEST METHOD 102.1

RAIN TEST

102.1.1 General. Since most generator sets are expected to be operated outdoors, without shelter of any kind, this test is performed to assure proper operation during a heavy rain storm.

102.1.2 Apparatus. Instrumentation for measuring load conditions and rain shall be as described and illustrated in MIL-HDBK-705. In addition, a test area capable of providing the required rainfall and wind conditions shall be provided.

102.1.3 Procedure.

102.1.3.1 Preparation for test.

a. Perform test method 608.1 of MIL-STD-705 within 4 hours before the start of the rain test.

b. Place the generator set in the rain environmental location with external connections made to simulate field installation conditions as closely as possible.

c. Connect the load instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, 205.1.10 for the voltage connection and frequency specified herein.

d. The test area shall be at normal ambient temperature (68 to 86 °F or 20 to 30 °C) at the beginning of the test and no further regulation of temperature is required.

102.1.3.2 Test.

a. A simulated rainfall of 8 ±1 inches per hour or as otherwise specified herein, shall be produced by water spray nozzles of such design that the water is emitted in the form of small droplets, rather than a fine mist. The temperature of the water shall be above 40 °F (4.44 °C). The spray nozzles shall be located so that the water drops impinge on the set at angles between 15 degrees and 45 degrees from the vertical. The water shall be dispersed as uniformly as possible over the entire area by means of a wind source producing wind velocities up and including 40 mph (18 m/s). The wind velocity shall be measured at the position of the set prior to placement of the set in the facility.

b. Open the set control panel doors, if provided. Subject the set to the water spray for 3 consecutive hours. Each side of the set shall be exposed to simulated blowing rain for 30 minutes beginning with the control panel end of the set. At the beginning of the last hour of the test, and with the simulated blowing rain on the control panel end of the set, perform TM 608.1 of MIL-STD-705. Continue operating the set during the simulated blowing rain until completion of TM 608.1 or completion of the third hours, whichever conditioner is the longer of the two.

c. Immediately after exposure to the simulated blowing rain and at the rain test site, examine the set for evidence of water penetration and damage. After completion of the examination of the set, start the set and perform TM 608.1.

102.1.4 Results. The data sheet shall indicate the length of test, quantity and incident angle of the water, wind velocity, any malfunction, water penetration, and water damage (see figure 2).

TEST METHOD 103.1

SAND AND DUST TEST

103.1.1 General. Since most generator sets are expected to be operated outdoors, without shelter of any kind, this test is performed to assure proper operation in an airborne sand and dust environment.

103.1.2 Apparatus.

103.1.2.1 Test facility.

a. The required apparatus consists of a chamber or cabinet, together with necessary air conditioning and circulation equipment with its auxiliary control instrumentation, sand storage and moving equipment, and sand concentration measuring equipment, capable of maintaining and continuously monitoring the required conditions throughout an envelope of air surrounding the test item(s). (See B.1.1.) Figures 3 and 4 are schematic diagrams of typical facilities for this test.

b. A data collection system, separate from the chamber controllers, shall be employed to measure test space conditions. Readout charts shall be readable to within at least 0.6 °C (1 °F).

c. Dehumidification, heating, and cooling of chamber test volume air for control of test conditions shall be achieved by methods that do not alter the chemical composition of the air, sand, or water vapor within the chamber test volume air.

d. Test facility design considerations.

(1) The vibratory or screw type sand feeder shall be controlled to emit the sand at the specified concentrations. The feeder shall be located in such a manner as to ensure that the sand is uniformly in suspension in the air stream when it strikes the test item, to simulate the same effects as in the field.

NOTE: Uniform sand distribution is usually easier to obtain when the sand-air mixture is directed downward, as in figure 3.

(2) Because of the extremely abrasive characteristics of blowing sand at high velocity, it is not recommended that the sand be re-circulated through the fan or air conditioning equipment. Instead, it should be separated from the air downstream from the test chamber in a sand separator, collected in a separate receiver, and reintroduced into the sand tank or hopper. The fan should re-circulate only the sand-free conditioning air.

NOTE: The sand collected in the separator may be reused for other tests if, after analysis, it still conforms to 103.1.2.2d of this method.

103.1.2.2 Controls.

a. Test parameters. Unless otherwise specified herein, temperature and relative humidity measurements made during testing shall be continuous if measurements are in analog form, or at intervals of one every 15 minutes or less if measurements are in digital form. All instrumentation used with the test chamber shall be capable of meeting the accuracies, tolerances, etc., of B.1.1 and B.1.2. Any significant change of the test item temperature or chamber conditions shall result in the test item being reestablished at the required environmental conditions before continuation.

b. Relative humidity. Relative humidity in the test section shall be less than 30 percent throughout the conduct of the test.

c. Test variables. The test variables (temperature, air velocity, and dust concentration) shall be continuously monitored during the test. Humidity shall be verified just before or during each test.

d. Sand composition Unless otherwise specified, the sand suggested to be used in the large particle test is silica sand and (at least 95 percent by weight SiO_2). The amount 1.0 percent ±0.5 percent of the sand shall be retained by a 20-mesh screen (850 mm), 1.7 percent ±0.5 percent by a 30 mesh screen (590 mm), 14.8 percent ±1 percent by a 40 mesh screen (420 mm), 37.0 percent ±1 percent by a 50 mesh screen (297 mm), 28.6 percent ±1 percent by a 70 mesh screen (210 mm), 12.7 percent ±1 percent by a 100 mesh screen (149 mm), and 5.2 percent ±1 percent shall pass a 100 mesh screen. The sand shall be of subangular structure with a mean Krumbein number (roundness factor) equal to 0.2 and a hardness factor of 7 mohs.

e. Sand concentration The sand concentrations shall be 1.4 grams per cubic meter.

f. Air velocity. An air velocity shall be maintained at a minimum of 20 mph.

103.1.2.3 Test interruption. (See B.2.3).

a. Undertest interruption. The abrasion, penetration, and collection of dust are cumulative effects that are not affected by interruption. The test item shall be reestablished at the prescribed temperature and the test continued from the point of interruption.

b. Overtest interruption. Any interruption that results in more extreme exposure of the test item than required herein should be followed by a complete physical examination and operational check (where possible) before continuation of testing. If a problem is encountered, the test should be reinitiated with a new test item.

103.1.3 Criteria. The failure of a test item to meet the requirements specified herein must be analyzed, and related information must be considered, such as:

a. Degradation allowed in operating characteristics while at the extreme conditions.

b. Necessity for use of special operating procedures or special kits during extreme conditions.

c. The test item shall be considered to have failed the large-particle test when:

(1) Abrasion of the test item exceeds the amount described herein.

(2) The test item does not perform safely or operate adequately as described herein.

NOTE: The test plan shall contain procedures for determining the test item's degradation due to abrasion. These procedures shall describe parameters (such as amount of wear or loss of weight) or observable attributes (such as change of shape) which, if not within specified limits, are indications that the test item has failed because of abrasion effects. The permissible tolerances of the parameters and attributes shall be provided.

103.1.4 Procedure.

103.1.4.1 Preparation for test. Conduct the pretest checkout as follows:

Step 1. Position the test item in the test chamber as near the center of the test sections as practicable. The test item shall have a minimum clearance of 15 cm (6 inches) from any wall of the test chamber and from any other test item (if more than one item is being tested). Orient the test item so as to expose the most critical or vulnerable parts to the sand or dust stream.

NOTE: The orientation of the test item may be changed during the test if required by the test plan.

Step 2. Prepare the test item in its operational configuration in accordance with B.2.2.

Step 3. Stabilize the test item at standard ambient conditions (see B.1a).

Step 4. Conduct a complete visual examination of the test item with special attention to sealed areas and minute of openings

Step 5. Document the results.

Step 6. Conduct an operational checkout in accordance with the approved test plan. Perform TM 608.1 of MIL-STD-705 within 4 hours before the start of the sand and dust test.

Step 7. Record results for compliance with B.2.1.

Step 8. If the test item operates satisfactorily, proceed to step 1 of the test procedure. If not, resolve the problem and restart at step 1 of pretest checkout.

103.1.4.2 Test.

Step 1. Adjust the chamber temperature to the high operating temperature of the test item and maintain until temperature stabilization of the test item is achieved.

Step 2. Adjust the air velocity to that required by the test plan.

Step 3. Adjust the sand feeder to obtain the sand concentration specified in the test plan, depending upon the application of the test item.

Step 4. Maintain the conditions of steps 1 through 3 for the duration specified in the test plan.

Step 5. If operation of the test item during the test is required, perform an operational test of the item during the last hour of the test and document the results. If not, proceed to step 6.

Step 6. Turn off all chamber controls and allow the test item to return to standard ambient conditions. Remove accumulated sand from the test unit by brushing, wiping, or shaking, taking care to avoid introduction of additional sand into the test unit.

Step 7. Conduct an operational checkout of the test item in accordance with the approved test plan. Within 4 hours after the completion of the test, perform TM 608.1 of MIL-STD-705.

Step 8. Document the results.

Step 9. Visually inspect the test item looking for abrasion and clogging effects and any evidence of sand penetration.

Step 10. Compare these data with the pretest data.

103.1.4.3 Data to be recorded.

a. Test item identification (manufacture, serial numbers, etc.).

b. Previous test methods to which the specified test item has been subjected.

c. Orientation and any change in orientation during test.

d. Results of each performance check (pretest, during test, and post-test).

e. Values of the test variables for each section of the test.

f. Results of each visual inspection.

g. Duration of each section of test.

103.1.5 Results. The results will be reviewed and compared to the criteria (see 103.1.3) for compliance. Inability to meet the voltage and frequency specified herein will constitute failure of the test.

FIGURE 3. Blowing sand test facility (vertical flow)

TEST METHOD 104.1

SALT FOG TEST

104.1.1 General. This test is performed to determine the resistance of generator set to the effects of an aqueous salt atmosphere.

104.1.2 Apparatus.

104.1.2.1 Test facility. The apparatus used in performing the salt fog test in this method shall include:

a. A test chamber with:

(1) Supporting racks designed and constructed so that they will not affect the characteristics of the salt fog mist. All parts of the test chamber and the supporting racks that come into contact with the test item shall be constructed of material or will be buffered with material that will not cause electrolytic corrosion. Condensation shall not be allowed to drip on the test item. No liquid that comes in contact with either the exposure chamber or the test item shall return to the salt solution reservoir. The exposure chamber shall be properly vented to prevent pressure buildup.

(2) The capability to maintain temperatures in the exposure zone at 35 °C (95 °F). Satisfactory methods for controlling the temperature accurately are by housing the apparatus in a properly controlled constant-temperature room, by thoroughly insulating the apparatus and preheating the air to the proper temperature before the atomization, or by jacketing the apparatus and controlling the temperature of the water or the air used in the jacket. The use of immersion heaters within the chamber exposure area for the purpose of maintaining the temperature within the exposure zone is prohibited.

b. A salt solution reservoir made of material that is non-reactive with the salt solution, e.g., glass, hard rubber, or plastic.

c. A means for injecting the salt solution into the test chamber. Caution must be exercised to prevent clogging of the nozzles from salt buildup. Atomizers used shall be of such design and construction as to produce a finely divided, wet, dense fog. Atomizing nozzles and the piping system shall be made of material that is non-reactive to the salt solution. Suitable atomization has been obtained in chambers having a volume of less than 0.34 m^3 (12 ft^3) under the following conditions:

(1) Nozzle pressure as low as practical to produce fog at the required rate.

(2) Orifices between 0.5 and 0.76 mm (0.02 and 0.03 inches) in diameter.

(3) Atomization of approximately 2.8 liters of salt solution per 0.28 m^3 (10 ft^3) of chamber volume per 24 hours. When chambers with a volume considerably in excess of 0.34 m^3 (12 ft^3), are used the conditions specified may require modification.

NOTE: A filter fabricated of noncorrosive materials similar to that shown in figure 4 shall be provided in the supply line and immersed in the salt solution reservoir as illustrated in figure 5.

d. Salt fog collection receptacles placed so that a clean receptacle at any point in the exposure zone will collect from 0.5 to 3 milliliters of solution per hour for each 80 square centimeters of horizontal collecting area (10 cm diameter) in an average test of at least 16 hours. A minimum of 2 receptacles shall be used, one placed nearest to any nozzle and one farthest from all nozzles. Receptacles shall be placed so that they are not shielded by the test item and will collect no drops of solution from the test item or other sources.

104.1.2.2 Controls.

a. Before injection into the test section, the salt solution shall be heated to within ±6 °C (±10 °F) of the test section temperature at the time of injection.

b. All water used during the salt fog tests shall be from steam or distilled, demineralized, or de-ionized water, and have a pH between 6.5 and 7.5 at 25 °C, or have a resistivity of not less than 250,000 ohms/cm at 25°C.

c. Test section air circulation: Air velocity in test chambers shall be minimal (essentially zero).

104.1.2.3 Test interruptions. (See B.2.3)

a. Undertest interruptions. If an unscheduled test interruption occurs that causes the test conditions to exceed allowable tolerances toward standard ambient conditions, the test item should be given a complete visual examination, and a technical evaluation should be made of the impact of the interruption on the test results. The test must be restarted at the point of interruption and the test item re-stabilized at the test conditions.

b. Overtest interruptions. If an unscheduled test interruption occurs that causes the test conditions to exceed allowable tolerances away from standard ambient conditions, the test conditions should be stabilized to within tolerances and held at that level until a complete visual examination and technical evaluation can be made to determine the impact of the interruption on test results. If the visual examination or technical evaluation results in a conclusion that the test interruption did not adversely affect the final test results, or if the effects of the interruption can be nullified with confidence, pre-interruption conditions should be re-established and the test continued from the point where the test tolerances were exceeded.

104.1.3 Criteria. In addition to the failure criteria of B.2.5, the following must be considered. Any corrosion must be analyzed for its immediate or potential effect on the proper functioning of the test item. Satisfactory operation following this test is not the sole criterion for pass/fail.

104.1.4 Procedure.

104.1.4.1 Preparation for test.

104.1.4.1.1 Preparation of salt solution. The salt used for this test shall be sodium chloride containing (on a dry basis) not more than 0.1 percent sodium iodide and not more than 0.5 percent total impurities. Unless otherwise specified, a 5 ±1 percent solution shall be prepared by dissolving 5 parts by weight of salt in 95 parts by weight of water. The solution shall be adjusted to, and maintained at, a specific gravity (figure 7) by using the measured temperature and density of the salt solution. Sodium tetraborate (borax) may be added to the salt solution as a pH stabilization agent in a ratio not to exceed 0.7g sodium tetraborate to 75 liters of salt solution. The pH of the salt solution, as collected as fallout in the exposure chamber, shall be maintained between 6.5 and 7.2 with the solution temperature at +35 °C (+95 °F). Only diluted chemically pure hydrochloric acid or chemically pure sodium hydroxide shall be used to adjust the pH. The pH measurement shall be made electrometically or colorimetrically.

104.1.4.1.2 Chamber operation verification. Unless the chamber has been used within five days, immediately before the test, and with the exposure chamber empty, adjust all test parameters to those required for the test. Maintain these conditions for one 24-hour period. Continuously monitor all test parameters to verify that the test chamber is operating properly.

104.1.4.1.3 Pretest standard ambient checkout. All items require a pretest checkout at room ambient conditions to provide baseline data. Conduct the checkout as follows:

Step 1. Prepare the test item in its required configuration in accordance with B.2.2.

Step 2. Record the room ambient conditions.

Step 3. Conduct a complete visual examination of the test item with attention to:

a. High-stress areas.

b. Areas where dissimilar metals are in contact.

c. Electrical and electronic components - especially those having closely spaced, unpainted, or exposed circuitry.

d. Metallic surfaces.

e. Enclosed volumes where condensation has occurred or may occur.

f. Components or surfaces provided with coatings or surface treatments for corrosion protection.

g. Cathodic protection systems; mechanical systems subject to malfunction if clogged or coated with salt deposits.

h. Electrical and thermal insulators.

NOTE: Partial or complete disassembly of the test item should be considered if a complete visual examination is required. Care must be taken not to damage any protective coatings, etc.

Step 4. Document the results. (Use photographs, if necessary.)

Step 5. Conduct an operational checkout in accordance with the approved test plan. Perform TM 608.1 of MIL-STD-705 within 4 hours before the start of the test.

Step 6. Record the results for compliance with B.2.1.

Step 7. If the test item meets General Requirements, the approved test plan, or other applicable documents, proceed to step 1 of the test procedure below. If not, resolve any problems and restart the pretest standard ambient checkout at the most reasonable step above.

104.1.4.1.4 Preparation of the test item.

a. The test item shall be given a minimum of handling, particularly on the significant surfaces, and will be prepared for test immediately before exposure. Unless otherwise specified, test items shall be free of contamination such as oil, grease, or dirt, which could cause a water break. The cleaning methods shall not include the use of corrosive solvents, solvents which deposit either corrosive or protective films, or abrasive other than a paste of pure magnesium oxide.

b. Arrange the test item configurations as specified in the test plan.

c. Insert the test item into the test chamber (see B.2.2).

104.1.4.2 Test.

Step 1. Adjust the test chamber temperature to 35 °C (95 °F) and condition the test item for at least two hours before introducing the salt fog.

Step 2. Continuously atomize a salt solution of a composition as given in 104.1.4.1.1 into the test chamber for a period of 48 hours or as specified in the test plan. (Cycling periods of 24 hours each (wet and dry) may be required instead of constant wetting for 48 hours or longer.) During the entire exposure period, the salt fog fallout rate and pH of the fallout solution shall be measured at least at 24-hour intervals. (More frequent intervals are recommended. If fallout quantity requirements are not met, that interval must be repeated.) Fallout shall be between 0.5 and 3 ml/80cm^2/hr.

Step 3. Store the test item in a standard ambient atmosphere for 48 hours, or as specified in the equipment specification, for drying.

Step 4. At the end of the drying period, unless otherwise specified, the test item shall be operated and the results documented for comparison with the pretest data. Within 4 hours after the completion of the test, perform TM 608.1 of MIL-STD-705.

Step 5. The test item shall be visually inspected in accordance with the guidelines given in 104.1.4.1.3. If necessary to aid in examination, a gentle wash in running water not warmer than 38 °C (100 °F) may be used.

104.1.4.3 Data to be recorded.

a. Test item identification (manufacturer, serial number, etc.).

b. Previous test methods to which the test item was subjected.

c. Results of each visual examination and performance checkout performed on the test item.

d. Areas of the test item visually and functionally examined and an explanation of their inclusion.

e. Areas of the test item not visually and functionally examined and an explanation of their exclusion.

f. Test chamber operational information (interruptions, time schedule. etc.).

g. Test variables:

(1) Salt solution pH.

(2) Salt solution fallout rate (ml/cm^2/hr).

(3) Resistance of initial water and type of water.

h. Preliminary failure analysis.

104.1.5 Results. The results will be reviewed and compared to the criteria (see 104.1.3) for compliance. Inability to meet the voltage and frequency specified herein will constitute failure of this test.

FIGURE 7. Variation of specific gravity of salt (NaCl) solution with temperature.

TEST METHOD 105.1

SOLAR RADIATION TEST

105.1.1 General. The generator sets must be capable of withstanding the effect of solar loading without physical damage or compromises in operational ability.

105.1.2 Apparatus.

105.1.2.1 Test facility.

a. The required facility consists of a chamber or cabinet, auxiliary instrumentation, and a solar lamp bank. This apparatus must be capable of maintaining and monitoring required conditions of temperature, airflow, and irradiation.

b. The possible cooling effects of airflow over the test specimens must be considered. An airflow of as little as 1 m/s can cause a reduction in temperature rise of over 20 percent. It is essential, therefore, to control and measure the rate of airflow, which should be as low as possible consistent with achieving satisfactory control of temperature. Adjustments of the temperature within the enclosure and control of chamber gradients by suitable heating and cooling of the walls of the enclosure eliminate the need for high air velocities. The air velocity shall be maintained between 0.25 and 1.5 m/s (50 to 300 ft/min).

c. The volume of the test chamber shall be a minimum of 10 times that of the envelope volume of the test item.

d. The solar radiation source area shall be such that the length and width of the test item shall be no more than one-half the same dimensions of the lamp bank and may be composed of either radiant heat-producing lamps or lamps that simulate the solar spectrum.

e. The irradiance shall have a maximum intensity of 1120 W/m^2 (±10 percent), and the radiation on the test item shall be uniform to within ±10 percent of the desired value, with the spectral distribution given in table V. Where thermal effects only are to be assessed, deviation from this spectral distribution is permitted, but the irradiance must be adjusted to give an equivalent heating effect. In order to calculate this adjustment, it is necessary to know:

(1) The spectral reflectance or transmittance of the irradiated surfaces, and,

(2) The spectral energy distribution of the particular lamps being used (and also the effect of any associated reflectors or glasses). The radiation shall be directed onto the test item and shall irradiate the entire surface of the test item facing the solar radiation source. The value of 1120 W/m^2 shall include any radiation reflected from the test chamber walls and received by the test item, but it should not include long-wave infrared radiation emitted by the chamber walls. The radiation-measuring device shall be calibrated in the wavelength range of the test source radiation.

TABLE V. Spectral energy distribution and permitted tolerance.

CHARACTERISTIC	SPECTRAL REGION			
	ULTRAVIOLET		VISIBLE	INFRARED
Bandwidth	0.28 to 0.32 mm	0.32 to 0.40 mm	0.40 to 0.78 mm	0.78 to 3.00 mm
Irradiance	5 W/m^2	63 W/m^2	517 to 604 W/m^2	492 W/m^2
Tolerance	±35%	±25%	±10%	±20%

NOTE: The amount of radiation wavelength shorter than 0.30 mm reaching the Earth's surface is insignificant.

f. The radiation source shall be located at least 76 cm (30 inches) away from any other surface of the test item.

g. Light source.

(1) Tests conducted for degradation and deterioration of materials due to actinic effects, as well as heat buildup within the test items, must satisfy the full spectrum of table I and may use one of the following acceptable radiation sources:

(a) Xenon arc or mercury xenon arc (used singularly) with suitable reflector.

(b) Combination of high pressure sodium vapor and improved mercury vapor with suitable reflectors.

(c) High-intensity multivapor, mercury vapor (with suitable reflectors), and incandescent spot lamp.

(d) Carbon arc lamp with suitable reflectors.

NOTE: Other combinations of the lamps listed above and in 105.1.2.1g(2) below may be used if it is proven that the combination produces the spectrum of table V.

(2) Tests in which it is not sought to reproduce the sun's spectrum may use the appropriate lamps from

(a) Mercury vapor lamps (internal reflector type only).

(b) Combination of incandescent spot lamps and tubular-type mercury vapor lamps with external reflectors.

(c) Combination of incandescent spot lamps and mercury vapor lamps with internal reflectors.

(d) Metal halide.

(e) Mercury xenon arc lamps with suitable reflectors.

(f) Multivapor (clear or coated bulb) with suitable reflectors.

(g) Tungsten filament lamps.

This list is not intended to exclude new lamps made available by advanced technology.

105.1.2.2 Controls.

a. Temperature. The chamber air temperature shall be within ±2 °C (±3.6 °F) of the test temperature and shall not exceed 1 °C per meter or a maximum of 2.2 °C total (equipment nonoperating) and measured (with adequate shielding from radiated heat) at a point or points in a horizontal plane 0 to 50 mm below the prescribed irradiation plane, at half the distance between the test item and the wall of the chamber or at 1m from the test item, whichever is smaller. This is one way to ensure reasonable control of the envelope of air surrounding the test item.

b. Surface contamination. Dust and other surface contamination may significantly change the absorption characteristics of irradiated surfaces. Unless otherwise required, specimens should be clean when they are tested.

c. Instrumentation.

ITEM	TOLERANCE
Pyranometer or pyrheliometer	Total irradiation (direct and scattered) to +47 W/m² (+14 Btu/ft /h)
Spectroradiometer or filtered pyranometer	+5% of reading

NOTE: Values may be assumed to represent plus or minus two standard deviations; thus, the stated tolerances should not be exceeded in more than 1 measurement out of 20. Solar radiation intensity shall be measured with a pyranometer or pyrheliometer. Spectral distribution of irradiance as a function of wavelength shall be measured with a spectral radiometer or filtered pyranometer.

d. Calibration of chamber. Because of the variety of permissible lamps and chamber designs, it is particularly important that the chamber be calibrated to assure that the proper levels of radiant infrared energy are impacting the test area when heat alone is of concern and that the proper intensity and spectral distribution of solar radiation are impacting the test area when actinic effects are of concern. Over the area covered by the test item, the radiation intensity must be within +10 percent. As the lamps age, their spectral output changes. A check on spectral distribution, intensity, and uniformity shall be performed at intervals not exceeding 500 hours of operation to ensure that the facilities continue to meet established specifications. This value is based on the manufacturer's guarantee for minimum bulb life.

105.1.2.3 Test interruptions.

a. Undertest interruptions.

(1) The test rationale is based on the total cumulative effect of the solar environment. Any undertest interruption should be followed by re-stabilization at the specified conditioning and continuation of the test from the point of the interruption.

(2) If an interruption occurs after 18 hours 20 minutes of the last cycle, the test shall be considered complete. (At least 92 percent of the test would have been completed, and the probability of a failure is low during the remaining reduced levels of temperature and solar radiation.)

b. Overtest interruption. Any overtest conditions must be followed by a thorough examination and checkout of the test item to verify the effect of the overtest. Since any failure following continuation of testing will be difficult to defend as unrelated to the overtest, a new test item should be used.

105.1.3 Criteria.

a. The set shall not be damaged (see below) or show degradation in operational performance by the effects of solar radiation with up to 355 British Thermal Units (BTUs) per square foot per hour of solar radiation.

b. The damage is defined as:

(1) Change in strength, stress, or loss of structural integrity due to differential expansion and contraction of dissimilar materials.

(2) Jamming or loosening of moving parts or linkages.

(3) Loss of seal or gasket integrity.

(4) Deteriorated electronic or electrical components or wiring.

(5) Blistering, fading, cracking, or peeling of paints.

(6) Softening or weakening of glued parts.

105.1.4 Procedure.

105.1.4.1 Preparation for test. Before the sets are placed in the solar radiation test chamber the following preparation will be made:

a. Perform test method 608.1a, of MIL-STD-705.

b. Fill the set's fuel tank and all other liquids to rated capacity.

c. Install thermocouples at the following locations:

(1) Engine compartment.

(2) Control cubicle.

(3) Fuel tank.

(4) Top, front, rear, and side surface of housing.

(5) Ambient (in accordance with 202.1.4 of MIL-HDBK-705).

d. Conduct the checkout as follows:

Step 1. Install the test item in the chamber and stabilize it at standard ambient conditions (see B.1.1a) and in a manner that will simulate service usage, unless the storage configuration is specified. Position the test item in accordance with the following:

(a) As near the center of the test chamber as practical and so that the surface of the item is not closer than 0.3m (1 foot) to any wall or 0.76m (30-inch) to the radiation source when the source is adjusted to the closest position it will assume during the test.

(b) Oriented, within realistic limits, to expose its most vulnerable parts to the solar radiation, unless a prescribed orientation sequence is to be followed.

(c) Separated from other items that are being tested simultaneously, to ensure that there is no mutual shading or blocking of airflow.

Step 2. Conduct a visual examination of the test item with special attention to stress areas, such as corners of molded cases.

Step 3. Document the results.

Step 4. Prepare the test item in accordance with B.2.2, with the temperature sensors necessary to determine test item response.

Step 5. Conduct an operational checkout in accordance with the approved test plan.

Step 6. Record results for compliance with B.2.4.

Step 7. If the test item operates satisfactorily, place it in its test configuration (if other than operational). If not, resolve the problem and restart at step 1. Position the test item in accordance with the following and proceed to the first test as specified in the test plan.

(a) As near the center of the test chamber as practical. (See 105.1.2.1c and d.)

(b) Oriented, within realistic limits, to expose its most vulnerable parts to the solar radiation, unless a prescribed orientation sequence is to be followed.

(c) Separated from other items that are being tested to ensure that there is no mutual shading or blocking of airflow.

105.1.4.2 Test.

a. Each side will singularly be exposed to four 24-hour, hot-dry test cycles described in table VI. The set will be placed in the chamber and positioned so that one vertical side and top of the set receives the greatest amount of radiation during the first 24-hour cycle so that the equal exposure to the radiation is accomplished to the entire set by the end of the test.

Step 1. Raise the chamber air temperature to the 0000-hour temperature of table VI.

Step 2. Expose the test item to continuous 24-hour cycles of controlled simulated solar radiation and dry-bulb temperature as indicated in table VI or as specified in the equipment specification. The number of cycles performed shall be whichever of the following is longer:

(a) The minimum necessary to ensure that the peak response temperature of the most critical area of the test item achieved during a cycle is within ±2 °C (±3.6 °F) of the peak response temperature achieved during the previous 24-hour cycle, or

(b) Three continuous cycles.

Increase and decrease the solar radiation intensity in a minimum of four steps up and four steps down to approximate the curve of figure 9 (table VI). The test item may or may not be operated throughout the test. When an evaluation of the heating effects is important, operation at least at peak temperature should be specified. For

certain one-shot items (e.g., rockets), thermocouples affixed to critical portions of the test item should be used to determine the time and value of peak temperature. The time of operation shall coincide with peak temperature.

TABLE VI. Temperature/solar radiation diurnal cycles.

Time	Hot-Dry		Basic Hot		Solar Radiation (see figure 8)	
	°C	°F	°C	°F	W/m^2	$Btu/ft^2/hr$
0000	37	98	33	91	0	0
0300	34	93	32	90	0	0
0600	32	90	30	86	55	18
0900	38	101	37	99	730	231
1200	44	112	42	107	1120	355
1500	48	119	43	110	915	291
1600	49	120	43	110	730	231
1800	48	118	42	107	270	85
2100	41	105	36	97	0	0
2400	37	98	33	91	0	0
Max	49	120	43	110	1120	355
Min	32	90	30	86	0	0

Step 3. Continue cycling until the peak response temperature (measured at representative locations) achieved during a cycle is within ±2 °C (±3.6 °F) of the peak response temperature achieved during the previous 24-hour cycle, or during 7 cycles, whichever comes first.

Step 4. Conduct an operational checkout of the test item as in 105.1.4.1d, step 5.

Step 5. Adjust the chamber air temperature to standard ambient conditions and maintain until temperature stabilization of the test item has been achieved.

Step 6. Conduct a complete visual examination of the test item.

Step 7. Document the results.

Step 8. Conduct an operational checkout of the test item as in 105.1.4.1d, step 5.

Step 9. Document the results.

Step 10. Compare these data with the pretest data.

b. After completion of the four cycles, thoroughly examine the set for physical damage.

c. Remove the set from the chamber and perform TM 608.1a, of MIL-STD-705.

105.1.5 Results. The results of the solar radiation test will be reviewed and compared to the criteria for compliance. Inability to meet the voltage and frequency criteria specified in the specification and applicable specification sheets, or evidence of physical damage as described above in 105.1.3, will constitute failure of this test.

FIGURE 8. Simulated solar radiation cycle.

FIGURE 9. Daily solar radiation cycle

TEST METHOD 106.1
ROAD TRANSPORTABILITY TEST

106.1.1 General. The generator set must be capable of withstanding the vibration and shock encountered during road transport. Skid mounted sets are transported either in the bed of wheeled vehicle cargo trucks or mounted on a cargo trailer either singly (power unit configuration) or two sets are configured as a power plant (with a load transfer switch).

106.1.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient temperature shall be as described and illustrated in MIL-HDBK-705. Recording meter(s) for recording voltage and frequency shall be required. A military cargo truck of size applicable to the generator set under test will be required for skid set testing. A military cargo trailer and compatible military truck will be required for power unit and power plant testing. Instrumentation for measuring and recording the truck speed and road mileage shall be required.

106.1.3 Procedure.

106.1.3.1 Power units and power plants.

106.1.3.1.1 Preparation for test.

a. The generator set(s) shall be serviced to verify that all fluids are at normal operating levels with the exception of the fuel. Unless otherwise stated, the fuel tank will be half full.

b. The positive securement of the generator(s) and associated equipment to the trailer shall be verified.

c. The trailer shall be inspected and serviced in accordance with its technical manual including the brake system, suspension, lighting, tire pressure and lubrication.

d. Ancillary equipment weight, as specified herein, shall be positively secured to the trailer. Care should be taken in the placement of the weight so that access to the generator sets is not restricted for inspections and operational tests.

106.1.3.1.2 Slope operation.

a. The theoretical tipping angles (critical angles) should be calculated for both ends and sides of the power unit or power plant before traversing the slopes to establish a rough approximation of the maximum slopes on which the trailer can safely negotiate. In theory, the critical angle is when the center of gravity (CG) of the item is located vertically above its center of rotation (the mid-point of the tire in a single-axle trailer).

b. Side slope. The power unit or power plant shall be towed in a sine wave pattern along the horizontal length of the required side slope(s). The trailer will be towed in both directions on the slope. During the traversal of a slope, the trailer shall be stopped for inspection purposes. The power unit or plant shall be inspected for any shifting of on-board equipment, and
the overflow of any fluid reservoirs. The results of the inspection shall be recorded. Power units or plants having a high vertical CG shall have their maximum side-slope ability tested with the aid of special safety precautions (i.e. a safety cable attached to the item to prevent accidental tip-over).

c. Longitudinal slope. The power unit or plant shall be towed up and down the required longitudinal slope(s). Particular attention will be given to the approach and departure of the trailer onto/from the slope. During traversal of the slope, the trailer shall be stopped for inspection purposes. The power unit or plant shall be inspected for any shifting of on-board equipment, and the overflow of any fluid reservoirs. The results of the inspection shall be recorded.

106.1.3.1.3 Road test.

a. Prior to and at the end of the last cycle of road testing, a Method 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) of MIL-STD-705, shall be conducted. At the end of each roadability cycle of table VII, Method 608.1 test (rated load only) will be repeated to verify operability of the set(s).

b. The power unit or plant shall be exposed to four cycles of the road schedule presented in table VII. At the beginning and end of each driving period (shift or day) the generator set(s) shall be started and run at no-load until stabilized to verify operability including rated voltage, frequency, and adequate oil pressure. The generator set(s), equipment and trailer shall be visually inspected several times each driving period for any evidence of structural damage, deformation or degradation that may occur during travel. The results of the inspections shall be recorded.

c. During traversal of the road courses, the trailer shall be observed for evidence of weaving, inability to successfully track behind the prime mover, interference with the prime mover, fluid reservoir overflow, or any other hazardous characteristic.

106.1.3.2 Skid-mounted sets as loose cargo.

106.1.3.2.1 Preparation for test. Service the skid-mounted set(s) as indicated in 106.1.3.1.1.a above. Unless specified herein, the skid-mounted set shall be tied down on a military cargo truck using the set lifting eyes and cargo straps.

106.1.3.2.2 Road test.

a. Prior to and at the end of the last cycle of road testing, a Method 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term), shall be conducted. At the end of each roadability cycle of table VII, Method 608.1 test (rated load only) will be repeated to verify operability of the set(s).

b. The skid-mounted set(s) shall be exposed to four cycles of the road schedule presented in table VII. At the beginning and end of each driving period (shift or day) the set(s) shall be started and run at no-load until stabilized to verify operability including rated voltage, frequency, and adequate oil pressure. The set(s) shall be visually inspected several times each driving period for any evidence of structural damage, deformation or degradation that may occur during travel. The results of the inspections shall be recorded.

TABLE VII. Road transportability test schedule.

Road Course (Aberdeen Proving Ground, Maryland)	Distance		Maximum Speed	
	mi	km	mph	km/hr
Paved highway	250	402	50	80
Level cross-country (Perryman 1)	250	402	20	32
Hilly cross-country (Churchville B)	125	201	20	32
Belgian Block	15	24	20	32
Totals	640	1029		

TEST METHOD 107.1

RAILROAD IMPACT TEST

107.1.1 General. The generator set must be capable of withstanding the vibration and shock encountered in all forms of transportation and movement. The mechanical integrity of the set is tested by means of the shock loading encountered during the railroad impact test. The test also evaluates the method of tie-down on the rail car.

107.1.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient temperature shall be as described and illustrated in MIL-HDBK-705. Recording meter(s) for recording voltage and frequency shall be required. Unless otherwise specified herein, the recording meters shall be as described and illustrated in MIL-HDBK-705, Methods 101.1 and 104.1. In addition, two railroad cars with a total standing weight of not less than 250,000 pounds, divided approximately equally between the two cars, and one standard flat railroad car (test car) all with standard draft gear couplings and conventional underframes, a means of moving the test car, an electrical or electronic device to determine the test car speed at impact, and shock measuring equipment as applicable, shall be required.

107.1.3 Procedure.

107.1.3.1 Preparation for test.

a. Unless otherwise specified, the equipment shall be mounted on the impact end of the test car in accordance with the standard loading and bracing method as shown in section 6 of the Association of American Railroads (AAR) "Rules Governing the Loading of Department of Defense Material on Open Top Cars". No exotic or unusual tiedown methods shall be used. Unless otherwise specified the longitudinal axis of the equipment shall be mounted parallel to the length of the test car.

b. Unless otherwise specified, the equipment fuel tank shall be half full of fuel. Used batteries filled with water may be installed to prevent acid damage should the set batteries fail. All liquids (except fuel) shall be at normal operating level.

c. Any load in the stationary (buffer) cars shall be secured to prevent sliding or shifting; any movement greater than two inches resulting from the test shall be justification for retest.

107.1.3.2 Test.

a. Within four hours of the test and at the test site, perform Method 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

b. The couplers between the stationary cars shall be compressed to remove the slack and all of the air and hand brakes shall be set.

c. Locate the test car between the stationary cars and the locomotive. A minimum of 200 feet of reasonably level track between the test car and stationary cars is required to achieve the required locomotive speeds unless an inclined ramp and tug is used. A practice test run without impacting the test car may have to be conducted to assure the required speed of impact can be achieved.

d. Position the draft gear knuckles of the stationary and test cars for coupling.

e. Install the timing device to measure the test car speed (±0.05 mph) within six feet of impact with the stationary cars.

f. Push the test car towards the stationary cars and release the test car when the desired test speed of 4 mph (+0.5, -0.0 mph) is reached as observed by using the locomotive's speedometer or other means, thus allowing the test car to freely impact the stationary cars. If an inclined ramp and tug is used, move the test car to the incline position for the desired speed and release the test car allowing it to freely impact the stationary cars.

g. Record the speed of impact.

h. Visually inspect the equipment for liquid leaks, deformation, loosening, breakage or change of fit of any component or part including the method of tiedown, tiedown anchors and fittings, and observations of blocking and lading. Record results of inspection and observations.

NOTE: If adjustment of the lading, reconditioning of the bracing or items of securement is required during the impact tests, testing will stop. A complete, new impact test shall then be required.

i. Repeat 107.1.3.2b through h at a speed of 6 mph (+0.5, -0.0 mph).

j. Repeat 107.1.3.2b through h at a speed of 8 mph (+0.5, -0.0 mph).

k. Repeat 107.1.3.2b through h at any other speeds specified herein.

l. Reverse the test car and repeat 107.1.3.2b through h at 8 mph (+0.5, -0.0 mph). No adjustment of the lading, reconditioning of the bracing or items of securement shall be made.

m. Within four hours after completion of the four impacts and final inspection, perform Method 608.1 Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) at the test site.

107.1.4 Results.

a. Compare the results at the test with the requirements specified herein.

b. Compare the result of the tests specified in 107.1.3.2a and 107.1.3.2m with the requirements specified herein.

TEST METHOD 108.1

SAFETY AND HEALTH TEST

108.1.1 General. The generator set must not pose an unsafe or hazardous condition to personnel.

108.1.2 Apparatus. No specific equipment is required.

108.1.3 Procedure.

108.1.3.1 Preliminary safety and health assessment. A preliminary safety and health assessment will be accomplished upon receipt of the sets. This will establish the safety of the test items so that hazards to test participants can be minimized. As a minimum this preliminary assessment will include the following essentials:

a. A thorough examination will be conducted during the initial inspection and service test to identify all obvious safety problems. Based on a visual examination of the units, the Safety Checklist (table VIII) will be completed by the test director and, if available, a qualified safety engineer. At this point, based on the limited visual inspection, it is realized that only safety problems that are reasonably obvious will be determined since a more thorough evaluation of safety and health will be conducted during the remaining scope of testing. A cursory review of the safety and health warnings and other information will be made of the equipment manuals provided. This is to assure that sufficient information has been provided in these manuals related to safety and health, specifically in the area of data plates, information, warning plates (including noise hazard warnings if required), proper grounding procedures, lifting and tie-down information, electrical shock hazard warnings, and other essential safety and health information that would ordinarily appear in a manual for a generator set. Some limited safety-related tasks will be performed, if necessary, to ensure that the test items are safe for further testing.

b. During the initial inspection, an initial safety review will be made using the safety checklist contained in table VIII. The appropriate questions will be answered insofar as possible without further testing. Detailed comments and answers will be indicated for each applicable question of the safety checklists for electrical and mechanical hazards. Responses will not be limited to only the items appearing on the checklist; any other safety and health hazards found will be recorded and incorporated into this subtest.

108.1.3.2 Comprehensive safety and health assessment. A comprehensive safety and health assessment will be conducted throughout the entire test program. This assessment will include:

a. Systematic observations and analysis of the test items throughout all phases of the entire test to identify and investigate any actual or potential hazards to personnel and equipment that may result from operation and maintenance. A detailed description of all safety hazards identified during operation, maintenance, and all other phases of operation will be documented.

b. To ensure that the checklist of table VIII has been completed and that all hazards have been identified, the units will be continuously monitored for hazards during all phases of testing and maintenance. It is expected that by the end of testing, all items on the safety checklist will have been answered.

c. Limitations or compromises on operating performance and maintenance because of safety considerations.

d. Examination of safety instructions and warning plates for adequacy and appropriate location.

e. Examination of operation and service manuals for adequate safety guidance concerning operation and maintenance.

f. Classification of all safety hazards in accordance with MIL-STD-882 with recommendations for appropriate corrective measures and ways to either reduce or eliminate the hazard severity and hazard probability.

108.1.4 Results.

a. List all mechanical and electrical hazards. Identify all hazards that require warning labels/placards.

b. Each NO answer reported in the checklist of table VIII and any other hazards identified will be reviewed and assessed to determine the degree of noncompliance with the criteria. The hazard classification (including hazard severity and hazard probability) outlined in MIL-STD-882 will be used to classify all identified safety hazards into hazard level categories. The hazards will be categorized as a deficiency, shortcoming, or suggested improvement using table VIII.

c. All problems recorded that have an effect on safety will be thoroughly analyzed to determine the extent of the problems and their impact on the operators, maintainers, and other personnel associated with the sets. Noncompliance with specific elements of the criteria will be evaluated and suggested corrective actions will be proposed. Appropriate recommendations regarding methods to control, downgrade, or eliminate actual or potential hazards will be made so that the necessary changes can be incorporated before field deployment.

TABLE VIII. Safety checklist.

No.	Item	Yes	No	NA	Remarks
1	Are all external parts, surfaces, shields, and all other electrically neutral parts at ground potential at all times during normal operation?				
2	Is the ground connection for all external parts mechanically secured?				
3	Is there a suitable terminal lug or other ground connection located on the chassis or frame to provide a continuous and permanent path to ground?				
4	Are grounding rods furnished?				
5	Are output terminals or other high potentials, in excess of 70 V rms, sufficiently shielded or guarded to prevent accidental contact by personnel?				
6	Are energized components located or enclosed so that suitable protection is provided against contact with uninsulated items?				
7	Are components, conductors, and shielding appropriately located such that overheating, arcing, shorting, and contact with moving parts is avoided?				
8	Are wires and cables adequately supported and terminated to prevent shock and fire hazard?				
9	Are wires and cables properly protected against rubbing at access ports by insulated bushings?				
10	Is the set provided with warning placards or caution plates mounted conspicuously adjacent to any condition presenting a potential hazard to personnel (such as high voltage, rotating parts, sharp corners, etc.)?				
11	Are electrical connectors designed to ensure that only the correct plug can be inserted into its receptacle and not into a wrong receptacle?				
12	Where design considerations require plugs and receptacles of similar configuration, are mating plugs and receptacle suitably coded or marked to indicate the correct mating connection?				
13	Are exposed connector pins energized after being disconnected?				
14	Are controls located away from high voltage areas?				
15	Are emergency controls placed in readily accessible positions?				
16	Is the main circuit breaker in an easily accessible location?				
17	Does a battle short switch (to bypass the safety interlocks) exist on the main control panel?				
18	Is the battle short switch designed with a readily visible indicator light to show that it is on?				
19	Are the following protective devices present with suitable indicators to safeguard against operator injury and/or equipment failure?: Low oil pressure				

No.	Item	Yes	No	NA	Remarks
	High coolant temperature Overspeed Low fuel Short circuit Overload Under voltage Under frequency Reverse power Overvoltage				
20	Are DC power connections clearly marked for polarity?				
21	Does a DC circuit breaker exist that can cut off all power to the entire system?				
22	Are potential electrical hazards adequately treated in the instruction manual?				
23	Are operator means of detecting hazardous conditions adequate?				
24	Are circuit breakers and all control panel instruments and controls properly labeled?				
25	Does the convenience outlet have provisions for automatic grounding?				
26	Are adjustment screws or other commonly worked-on parts located away from unprotected high voltages?				
27	Are tools to be used near high voltages, such as the load terminal wrench, adequately insulated?				
28	Is the grounding conductor of the equipment electrically insulated from the AC power return (neutral)?				
29	Are internal controls located at safe distances from dangerous voltages?				
30	Is protective guards sufficiently separated from exposed conductors to prevent shorting or arcing?				
31	Are components that sustain high operating temperatures during normal operation (such as exhaust pipes, turbochargers, radiators, etc.) sufficiently protected to prevent accidental contact by personnel?				
32	Are these components adequately identified by warning plates?				
33	Are the materials used in the engine and generator housing including noise attenuating material inherently nonflammable and nonexplosive?				
34	Do exposed gears, cams, levers, fans, belts, or other reciprocating, rotating, or moving mechanical parts have adequate safety covers?				
35	Are doors, hinged covers, panels, and any other exposed sharp projections or overhanging edges presenting a potential safety hazard rounded to prevent injury to personnel?				
36	Are fasteners and methods of securing doors and peripheral ancillary components sufficiently strong to prevent breakaway during normal use?				
37	Is the method of opening doors or covers evident from the				

No.	Item	Yes	No	NA	Remarks
	construction of the cover? If not, is an instruction plate permanently attached to the outside of the cover?				
38	Is it evident when a cover is in place but not secured?				
39	Are tasks of operation and maintenance such that they do not require excessive physical strength?				
40	Can maintenance be accomplished with shielding in place?				
41	Do external or internal surfaces that expand during maintenance have sharp edges?				
42	Is the center of gravity and weight of the set distinctly marked?				
43	Are weight capacities indicated on tie-downs, lifting points, etc.?				
44	Is the set provided with sufficient caution plates to warn maintenance personnel of potential safety hazards?				
45	Is the control panel adequately illuminated for safe and efficient operation?				
46	Have fire-extinguishing methods been included in the technical publications?				
47	Are potential mechanical hazards adequately treated in the draft instruction manual?				
48	Do floor surfaces provide adequate nonslip characteristics?				
49	Are lifting rings or slings provided?				
50	Are climbing rings, handholds, rails, etc., provided where needed?				
51	Do doors and hinged covers have positive-action hold-open devices?				
52	Are handles recessed rather than extended where they might be hazardous?				
53	Are doors and other openings free of hazards from improperly designed catches, hinges, supports, fasteners, and stops?				
54	Are the tasks of operation and maintenance such that they do not require excessive physical strength?				
55	When glass is used is it glare proof and shatter proof?				
56	Does the ventilating system provide for operator safety by ducting excess heat liberated by the radiator cooling air or other hot air outlets to the exterior of the set?				
57	Are adequate precautions made to prevent exposure of operators and maintainers to exhaust gases or other toxic fumes?				
58	Is the air intake isolated or at a sufficient distance from the exhaust?				
59	Does the instruction and maintenance manual specify type of cleaning fluid and precautions to be taken when cleaning the equipment?				

TABLE IX. Hazard probability versus hazard severity.

	HAZARD PROBABILITY				
	FREQUENT	PROBABLE	OCCASIONAL	REMOTE	IMPROBABLE
SPECIFIC INDIVIDUAL ITEM	Likely to occur frequently	Will occur several times in life of item	Likely to occur sometime in the life of item	Unlikely but possible to occur in the life of an item	So unlikely it can be assumed the occurrence may not be experienced
FLEET OR INVENTORY	Continuously experienced	Will occur frequently	Will occur several times	Unlikely but can reasonably be expected to occur	Unlikely to occur but possible
HAZARD SEVERITY	A	B	C	D	E
I - CATASTROPHIC May cause death or system loss	Deficiency	Deficiency	Deficiency	Deficiency	Shortcoming
II - CRITICAL May cause severe injury occupational illness, or major system damage	Deficiency	Deficiency	Deficiency	Shortcoming	Suggested improvement
III - MARGINAL May cause minor injury, minor occupational illness or minor system damage	Deficiency	Shortcoming	Shortcoming	Suggested improvement	Suggested improvement or Acceptable
IV - NEGLIGIBLE May cause less than minor injury occupational illness or system damage	Shortcoming	Suggested improvement	Acceptable	Acceptable	Acceptable

TEST METHOD 109.1

HUMAN FACTORS ENGINEERING TEST

109.1.1 General. The generator set must satisfy general human engineering design criteria and practices.

109.1.2 Apparatus. The following equipment shall be required: photographic and video equipment, tape measure, ruler, illumination meter (lighted displays).

109.1.3 Procedure.

109.1.3.1 Control, display, labeling. Observations will be made of all controls, displays, and labeling with respect to HFE design practices (based on paragraphs 5.1, 5.2, 5.4, and 5.5 of MIL-STD-1472). Control separation and control dimensional measurements will be taken to determine if any design problems exist. The ability of the operator to successfully operate the sets while wearing regular, arctic, and NBC gloves will be observed as well as the operator's ability to operate the set at night.

109.1.3.2 Workspace and maintenance access. Maintenance access openings and workspaces will be observed with respect to the ability of the crew to perform maintenance and to determine compatibility with anthropometric dimensions for the 5th through 95th percentile personnel while outfitted in battle dress uniform (BDU), arctic, and NBC protective ensembles.

109.1.3.3 Subjective assessment.

a. Questionnaires/interviews. Human factors questionnaires will be administered to personnel assigned to the testing program. Questionnaires will primarily pertain to operating and maintaining the equipment. A section of each questionnaire will be devoted to task performance while wearing NBC and arctic gear. Questionnaires, (table X), will be administered near the end of the test cycle to assure that all personnel are thoroughly experienced with system operations before completing the forms. Interviews will be conducted to determine the test participants opinions on the overall operation, maintenance, and performance of the generator.

b. Checklists. Checklists (table X) will be prepared by an HFE engineer on the following elements of system design:

1. HFE design - controls, displays, and markings.

2. Maintainability.

c. General HFE observations. Observations will be made throughout all testing to gain additional information on any HFE-related problems. Comments and informal interviews, in addition to HFE observations, will be documented throughout to provide subjective input to assess the TQG sets. These interviews, comments, and observations will be used to augment data from other HFE subtests supplements and will be integrated into the analysis of the TQG sets.

109.1.3.4 Anthropometric and demographic data.

a. Anthropometric data. Anthropometric measurements (standard distribution presented in table X) will be taken of test personnel who participate in daily operation, maintenance, and performance exercises.

b. Demographic data. Demographic data will be compiled of the same test participants and will include the following:

(1) Sex.

(2) Job position (for this test).

(3) Length of experience (in job position).

(4) Age.

109.1.3.5 Operator/maintainer performance tasks. The ability of the test participants to perform critical maintenance tasks while outfitted in MOPP IV and nuclear, biological, chemical (NBC) protective ensembles (arctic mittens, and NBC gloves with liners), will be determined by comparing performance times required to complete the following tasks:

a. Checking, filling, and draining engine oil.

b. Replacing engine oil filter(s).

c. Replacing air filter element.

d. Connecting load cable.

e. Replacing fuel filter(s).

f. Checking, filling, and draining hydraulic fluid (if equipped).

g. Replacing hydraulic fluid filter(s) (if equipped).

h. Other common field maintenance actions such as filling fuel tank, radiator, battery, and adjusting belts, etc.

Excessive maintenance times or inability to perform any critical maintenance tasks will be recorded.

109.1.3.6 Manual readability. The reading grade level (RGL) of the operation and maintenance manual will be determined by conducting a readability test as referenced in TOP 1-2-609, Instructional Material Adequacy Guide and Evaluation Standard (Images), January 1981. An adequate number of text samples will be used to determine the overall grade level (OGL).

109.1.3.7 Data required. The following data will be obtained.

a. Control separation and dimensional measurements.

b. Ability of operators to operate the sets while wearing regular, arctic, and NBC gear.

c. Anthropometric and demographic data of test participants.

d. Results of interview and questionnaires administered to test personnel.

e. Results of completed checklists.

f. An assessment of controls and displays.

g. The adequacy of NET.

h. RGL of the operation and maintenance manuals.

i. Photographs and videotapes of HFE problems associated with the setup, operation, or maintenance of the generator sets.

j. Performance times of critical maintenance tasks while maintainers are outfitted in arctic and NBC ensembles.

109.1.4 Results.

a. Qualitative results of observations, checklists and questionnaires will be summarized and presented in narrative and tabular form.

b. The degree to which the generators conform or do not conform to HFE standards and requirements will be presented. Instances of nonconformance will be supported by measurements and photographic illustrations. The causes and consequences of nonconformance will be assessed with regard to the effect on mission performance. Any degradation of the systems man-item relationship with regard to safety will be assessed and corrective action recommended. Human performance reliability will be assessed in terms of frequency and consequence of human error committed during preparation, operation, and maintenance of the generators. Subjective data analysis will include a structured interview follow-up of all unfavorable/negative comments to arrive at a description of the cause and possible corrective action.

c. The following will constitute failure of this test:

(1) Controls, displays, or labeling that do not conform to MIL-STD-1472, paragraphs 5.2, 5.4, and 5.5 in relation to appearance, spacing, size, or location.

(2) Inability to successfully operate or maintain the sets when personnel are wearing regular, NBC, or MOPP IV gear.

(3) Workspace and maintenance access openings that do not allow personnel, with anthropometric dimensions between the 5th through the 95th percentile, to perform maintenance.

TABLE X. HFE questionnaires and checklists.

How would you rate the adequacy of the following?

Rating Scale

6 Excellent
5 Very Good
4 Adequate
3 Not Quite Adequate
2 Poor
1 Extremely Poor

Human Factors Engineering - Adequacy	6	5	4	3	2	1
1. Before, during, and after operation checklist.						
2. Display panels.						
3. Space provided to service generator.						
4. Accessibility of hand controls.						
5. Illumination of instruments during night operation.						
6. Protection of operator from moving parts by guards and warning panels.						
7. Lifting provisions.						
8. Access for using test equipment.						
9. Standard tools and test equipment.						
10. Technical manuals for operations and maintenance.						
11. Based upon the previous questions, rate the OVERALL ADEQUACY of the generator.						

TABLE X. HFE questionnaires and checklists.

How would you rate the adequacy of the following?

Rating Scale

6 Excellent
5 Very Good
4 Adequate
3 Not Quite Adequate
2 Poor
1 Extremely Poor

Human Factors Engineering - Tasks	6	5	4	3	2	1
1. Readings warnings or instruction labels.						
2. Connecting and disconnecting power cables.						
3. Operation and maintenance while wearing arctic clothing.						
4. Operation and maintenance while wearing NBC clothing.						
5. Reading and understanding the material presented in the technical manuals.						
6. Set up for operation.						
7. Operation during hours of darkness.						
8. Based upon the previous questions, rate the OVERALL EASE OF OPERATION.						

TABLE X. HFE questionnaires and checklists. - Continued.

Please rate how often the following occur?

Rating Scale

6 Almost Never
5 Very Seldom
4 Seldom
3 Often
2 Very Often
1 Almost Always

Human Factors Engineering - Intensity	1	2	3	4	5	6
1. The vibration level during operation. 2. The noise level during operation. 3. Exhaust fumes during operation.						
Human Factors Engineering - Frequency	**1**	**2**	**3**	**4**	**5**	**6**
1. Requirement for special tools and test equipment. 2. Glare on operating instruments and gauges.						

TABLE XI. HFE checklists.

Yes - Adequate No - Inadequate NA - Not Applicable

NO.	ITEMS	YES	NO	REMARKS
	HFE DESIGN - CONTROLS, DISPLAYS, AND MARKING			
1	Controls			
a	Are all adjustments located on single panel?			
b	Are controls placed on the panel in the order they will normally be used?			
c	When controls are used in a fixed procedure, are they numbered to indicate?			
d	Are controls labeled with functional statements?			
e	Are control-position markings descriptive rather than coded or numbered?			
f	Are control scales fine enough to permit accurate setting?			
g	Except for detents or selector switches, do the controls have smooth, even resistance to movements?			
h	Are concentric knobs adequately coded to avoid confusion?			

TABLE XI. HFE checklists. - Continued.

Yes - Adequate No - Inadequate NA - Not Applicable

NO.	ITEMS	YES	NO	REMARKS
i	Are adjustment controls easy to set and lock?			
j	Do all physical adjustment procedures provide visual, auditory, or tactical feedback?			
k	Are controls free of excessive backlash that could require needless readjustment?			
l	Are primary and emergency controls easily identifiable both visually and non-visually?			
m	Can controls be operated by personnel wearing arctic and NBC clothing?			
n	The method used to prevent accidental activation of the control, if any does not increase the time required to operate the control to such an extent that it is unacceptable.			
2	Displays			
a	When this equipment is placed in ways that it will typically be used, can the display be easily read?			
b	The information presented is necessary for the decisions or actions required of the operator.			
c	The information is presented in the most immediately meaningful form, i.e., no interpretation or decoding is required.			
d	The information is displayed to the accuracy required by the decisions or actions of the operator.			
e	Are display scales limited to only that information needed to make decisions or to take some action?			
f	Information is current, that is, lag is minimized.			
g	Failure is clearly shown or the operator is otherwise warned.			
h	The contrast ratio and illumination of controls and/or displays are sufficient under all expected light conditions.			
i	A warning device is provided to indicate significant deviations from normal operating conditions.			
3	Miscellaneous			
a	Vibration and noise are kept below levels that might impair the efficiency of personnel.			
b	Visibility provides the maximum field of view possible in consonance with station, task requirement, and body conformation.			
c	Illumination of controls and displays is sufficient for the operators to carry out necessary tasks.			
d	Vibrations do not affect operator performance in reading dials and manipulating controls.			

TABLE XI. HFE checklists. - Continued.

Yes - Adequate No - Inadequate NA - Not Applicable

NO.	ITEMS	YES	NO	REMARKS
e	No material within the operator's vision is capable of reflecting glare sufficiently to impair vision during day or night operation.			
	MAINTAINABILITY			
1	Handles			
a	When possible, handles are provided on covers, drawers, and components to facilitate handling.			
b	When handles cannot be provided hoist and lift points are clearly marked.			
2	Covers			
a	Method of opening a cover is evident from the construction of the cover itself. If not, an instruction plate is permanently attached to the outside of the cover.			
b	Hinges are used where possible to reduce the number of fasteners required.			
c	When a hinged cover is used, a space equal to the swept volume of the cover is provided (e.g., opening of the cover is not obstructed by bulkheads brackets, etc.).			
d	Structural members, other components, etc., do not interfere with removal of a cover.			
e	It is evident when the cover is in place but not secured?			
f	If instructions applying to a covered unit are lettered on , hinged door, the lettering is properly oriented for reading when the door is open.			
g	A minimum number and type of fasteners are used, commensurate with requirements for stress, bonding, etc.			
h	When possible, the same size and type of fasteners are used for all covers, cases, and access doors.			
i	Captive nuts and bolts are used where feasible.			
3	Location of Replaceable Components			
a	Large components which are difficult to remove are mounted so that they do not prevent access to other components.			
b	Components are placed to allow sufficient space for use of test equipment and other required tools without difficulty or hazard.			
c	All throwaway components are accessible without removal of other components.			
d	Structural members of the frame do not prevent access to components.			
e	Delicate components are so located or guarded that they will not be damaged while the unit is being handled or worked on.			
f	Sensitive adjustments are so located or guarded that they cannot be accidentally disturbed.			
g	Internal controls are located at a safe distance from dangerous voltages or access to dangerous voltages is prevented by suitable			

TABLE XI. HFE checklists. - Continued.

Yes - Adequate No - Inadequate NA - Not Applicable

NO.	ITEMS	YES	NO	REMARKS
	barriers.			
4	Conductors and Cables			
a	Conductors are bound into cables and held by means of lacing twine or other acceptable means.			
b	Long conductors or cables, internal to equipment, are secured to the chassis by cable clamp.			
c	Cables are long enough so that each functioning component can be checked in a convenient place or, if this is not feasible, extension cables/devices are provided.			
d	Cables are long enough to permit jockeying or movement of components when it is difficult to connect or disconnect other cables.			
e	Electrical cables are not to routed below fluid lines.			
f	Cables are routed so they cannot be walked on or used for handholds.			
g	Cables are easily accessible for inspection and repair.			
h	Cables are so routed that they need not be bent or twisted sharply or repeatedly.			
i	Input and output cables, with the exception of test cables, do not terminate on a control-display panel.			
j	If test cables terminate on control-display panels test receptacles are located so that their associated cables do not interfere with controls and displays.			
5	Connectors			
a	One-turn or other quick- disconnect plugs are used.			
b	When dirt and moisture are a problem, plugs have an attached cover.			
c	Connectors are located far enough apart so that they can be grasped firmly for connection and disconnection.			
d	Plugs are designed so that it is impossible to insert the wrong plug in a receptacle.			
e	Socket rather than plug contacts are "hot".			
f	Test points to determine that a unit is malfunctioning are provided.			
g	Appropriate test provided when a component is not completely self-checking.			
6	Fuses and Circuit Breakers			
a	Fuses and circuit breakers are so located that they can be easily seen and quickly replaced or reactivated by personnel wearing clothing appropriate to environment of interest.			
b	No special tools are required for fuse replacement.			
7	Tools			
a	Variety of tools is held to a minimum.			
b	As few special tools as possible are required.			
c	Tools to be used near high voltage are adequately insulated.			

TABLE XI. HFE checklists. - Continued.

Yes - Adequate No - Inadequate NA - Not Applicable

NO.	ITEMS	YES	NO	REMARKS
d	Metal handles are avoided on tools likely to be used in extreme cold or heat.			
8	Lubrication			
a	Equipment containing mechanical components either has provision for lubrication without disassembly or does not require lubrication.			
b	When lubrication is required, the type of lubricant to be used and the frequency of lubrication is specified by a label at or near the lubrication point.			

TABLE XI. HFE checklists. - Continued.

Yes - Adequate No - Inadequate NA - Not Applicable

TABLE XII. Distribution of anthropometric measurement data by uniform type.

MEASUREMENT	5th Percentile				95th Percentile			
	Regular		Arctic		Regular		Arctic	
	cm	in.	cm	in.	cm	in.	cm	in.
Stature (nude)	163.8	64.5			186.0	73.2		
Functional reach	72.6	28.6	77.7	30.6	90.9	35.8	95.5	37.6
Sitting height, erect	85.1	33.5	87.9	34.6	97.0	38.2	101.5	40.0
Eye height, sitting	72.6	28.6	74.7	29.4	84.6	33.3	85.9	33.8
Knee height	49.8	19.6	56.4	22.2	58.7	23.1	64.0	25.2
Buttock-knee length	54.9	21.6	60.0	23.6	64.3	25.3	67.3	26.5
Shoulder breadth, sitting	41.4	16.3	47.5	18.7	49.8	19.6	55.9	22.0
Hip breadth, standing	30.7	12.1	41.1	16.2	38.4	15.1	48.8	19.2
Buttock-popliteal length	46.0	18.1	43.7	17.2	54.6	21.5	52.0	20.5
Hand length	17.5	66.9	20.8	8.2	20.6	8.1	23.9	9.4
Hand breadth	8.0	3.1	12.7	5.0	9.7	3.8	12.2	4.8
Palm length	9.5	3.7	10.4	4.1	11.7	4.6	12.4	4.9
Weight (kg)	57.3	---	---	---	91.6	---	---	---