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Performance Specification

For

Military Mobile Power Sources

(0.5kW TO 15kW)

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Performance Specification for Military Mobile Power Sources (0.5kW to 15kW)

1.0 Scope. This specification covers the technical requirements for general purpose military mobile power sources from 0.5kW to 15kW, with 50/60 Hz AC & DC outputs. Configurations include skid or trailer mounted systems; the power sources are fueled with JP-8 or DoD diesel fuels used for ground systems. The intent of this specification is to document the minimum key performance parameters KPPs) and critical non-KPP technical requirements deemed essential for any power source for military use in pan-climatic combat environments. Potential power source technologies include rotating machines with internal or external combustion engines, fuel cells, i.e., PEM, SOFC, DMFC, etc., thermoelectrics, thermophotovoltaics, solar photovoltaics, solar dynamic systems and AMTEC.* Any other energy conversion & energy storage technology may also be deemed applicable by a DoD proponent. The Government also understands that perhaps no technology can simultaneously achieve all technical thresholds and objectives expressed herein. What follows is a general technical summary, not a final all-encompassing procurement specification.

2.0. Technical Requirements Overview. These technical requirements cover general purpose power sources for a wide variety of applications, i.e., for powering communications equipment, computers & associated items**;** charging batteries; operating environmental control units, illumination systems, medical devices, test equipment, etc. This specification does not include power sources for special purpose or niche applications. The 0.5kW to 15kW output range was selected since it represents about 85% of the Army's existing generator fleet. Additionally, many potentially promising technologies with military applications have been demonstrated or are being developed in this output range by private industry & government research & development centers.

2.1. These technical requirements are derived from the Tactical Electric Power (TEP) Operational Requirements Document (ORD) (1) and include statements on power quality & output ranges, weights, fuel consumption & types of fuel; reliability, environmental factors, mobility needs & maintenance (not all-inclusive). The overall intent is to describe the required characteristics of a fueled power source that meets or exceeds approved technical requirements for military general purpose tactical power sources. Cost, as compared to current & emerging power sources is also an important factor based on present and anticipated budgetary constraints. It is recognized that there may not be a single technological approach that meets all of the requirements in all of the power ranges.

2.2. Technical Requirements for Key Performance Parameters (KPP). Meeting or exceeding these KPPs (table 2.1.) is essential. These KPPs are the minimum acceptable operational performance characteristics and capabilities for any future military fueled power source. In the context of a funded DoD program, these parameters are so significant that failure to meet the threshold could result in system re-evaluation and/or program termination.

Technical Requirements KPP Summary - Table 2.1.

* Fuel Cell Technologies: proton exchange membrane (PEM); solid oxide (SO); direct methanol (DM). AMTEC: Alkali Metal Thermal Energy Conversion.

Criteria	Threshold & Objective Requirements*
Power Quality, Output & Modes (KPP)	Power quality: Pass/Fail (threshold = objective) Ref. MIL-STD-1332B, AC Utility Class 2C & DC (utility). Modes: 50/60 Hz & DC. AC Outputs from 0.5kW to 15kW, i.e., 2kW, 3kW, 5kW, 10kW & 15kW. DC Outputs are generally 2kW & under.
Fuel Consumption (KPP)	15% reduction compared to baseline (threshold). 25% reduction compared to baseline (objective).
Weight (AC or DC) (KPP)	10% reduction (threshold). 25% reduction (objective).
Reliability (AC or DC) (KPP)	750 hours between essential function failure (threshold). 1250 hours between essential function failure (objective).
*Threshold & objective requirements are based on the TEP ORD. The values are derived from a comparison with the existing Tactical Quiet Generator (TQG) family of systems. The operating & technical characteristics of the 2kW Military Tactical Generator (MTG) and the TQG (3kW to 200kW) families are the baseline for any comparisons & improvements. See Appendix A for the characteristics of existing military generator sets.	

2.3. Non-KPP Critical Technical Requirements. The military has determined that the following non-KPP requirements are critical to demonstrating the military utility of a fueled power source. These non-KPP requirements cover system performance & operational characteristics expected of military power sources. These requirements are listed in table 2.2. below.

Technical Requirements Non-KPP Critical Summary - Table 2.2.	
Criteria	**Threshold & Objective Requirements***
Electromagnetic Inference (EMI)	**Pass/Fail Technical Requirement. Specifically, EMI & susceptibility characteristics shall comply with requirements in MIL-STD-461E, to include the following EMI test procedures: conducted emissions (CE-102), conducted susceptibility (CS-101, CS-114, CS-115 & CS-116); radiated emissions (RE-102) & radiated susceptibility (RS-103). Any EMI radiated by power sources should not adversely affect other nearby electrical or electronic systems & the power source itself shall not be susceptible to EMI.**
Simplicity, Durability & Ruggedness	**Military power source testing programs include a series of specific tests that verify these qualities, i.e., human factors design, reliability & endurance testing and operating the power source in a realistic tactical environment. These tests are conducted according to applicable Army, DoD & Military Standards (see Appendix C for test examples).**
Configuration & Mobility	Standard ground, skid & trailer mounted (towed by off-road tactical vehicles). Trailer-mounted systems shall be consistent with the mobility of

	its towing vehicle. Towing the system shall not impose any new restrictions on the vehicle.
System Rating & All Weather Operation	All possible relative humidity values, with ambient temperatures ranging from -50°F to 135°F at sea level; and from -50°F to 95°F at 4,000 feet. High temperature requirement remains at 95°F at altitudes above 4,000 feet. Altitudes up to & including 10,000 feet. Rated load may be reduced by 3.5 percent for each 1,000 foot increment above 4,000 feet, e.g., at 10,000 feet rated load may be reduced by 21%. Rated load may be reduced by 3% for each 18^{O} F increment above 125°F. All systems shall operate at rated load in tropical, temperate, arid and cold climates and in the additional environmental elements.
Fuel(s)	JP-8, Diesel-1 (DF-1) & DF-2 fuels, see DoD Directive# 4140.25 and TARDEC "Fuel Users Guide." These are the three logistics fuels commonly available. However, military users may have no choice but to use other available fuels (with/without pre-treatment).
Onboard Fuel	Power source (5kW through 15kW) shall have onboard fuel storage for at least 8-hours of continuous operation at 75% of rated loads (threshold) & 12-hours (objective). For 3kW & under, sufficient onboard fuel for at least 6-hours of continuous operation at 75% of rated loads (threshold) & 12-hours (objective). Design shall also allow safe refueling during operation.
Auxiliary Fuel Capability	Power source design shall allow safe use of standard external fuel tanks approved for military use to extend operating time beyond what the onboard fuel tank can provide. Auxiliary or external fuel tanks include any approved fuel container & a means to convey that fuel to the power source via a suitable hose or fuel line.
Acoustic Signature	2kW or less: 72 and 69 dBA@7 meters (threshold & objective). 3kW to 10kW: 68 and 64 dBA@7 meters (threshold & objective). 15kW: 70 and 67 dBA@7 meters (threshold & objective).
Maintenance Ratio	0.5kW to 3kW: 0.030 (30 hours/1000 operating hours) (threshold). 0.020 (20 hours/1000 operating hours) (objective). 5kW to 15kW: 0.025 (25 hours/1000 operating hours) (threshold). 0.015 (15 hours/1000 operating hours) (objective).
Scheduled Maintenance	500 hours or greater between scheduled maintenance tasks.
System Starting	The power source shall start and accept full-rated load within 5-minutes (threshold) and 3-minutes (objective).
Portability (0.5 kW to 3 kW Systems)	0.5-kW to 3-kW systems shall be soldier-portable by up to four soldiers (threshold) or two soldiers (objective). As a guideline, two soldiers may lift and carry a 164-lb. load for 10-meters (or less). Four soldiers may lift and carry a 246-lb. system for 10-meters (or less). For this requirement,

	"portability" means that either four (or two) soldiers can lift & move a load up to 10-meters (33-feet) if each male soldier in the 95th percentile can individually lift 82-lbs. (42-lbs. for female soldiers). See MIL-STD 1472F for further information.
System Employment	Systems shall operate on uneven terrain with omni-directional grades up to 15^{O}.
Inductive Load Capability / Motor Starting	The power source shall withstand short duration overloads (MIL-STD 1332B) that result from applying its output to an inductive load, i.e., as when starting electric motor(s). Motor in-rush currents can equal or exceed 6 times the running current.
Electrical Connections & Sub-System Modularity.	System electrical or electronic sub-systems shall use easily removable plugs and/or quick-disconnect connectors to the maximum extent practicable, if this design practice does not adversely affect system reliability. Sub-system modules, components & assemblies will also be interchangeable with other power sources in the family whenever practical.
System Switching & Paralleling (Under Load)	Power Sources 5-kW and larger shall safely switch between individual power sources while powering electrical equipment and allow automatic paralleling. Power source shall have an automatic paralleling system, whereby two or more power sources of the same mode can operate in parallel. "Automatic" is defined as: (1) a control that senses voltage & frequency phasing; (2) automatically adjusts frequency & voltage to match the other power source(s); (3) closes the contactor when voltage & frequency are in phase with <8 volts difference; and (4) senses & proportionally shares the total load. This system shall also include protective functions of "permissive paralleling" & "reverse power." The paralleling system shall allow the operator to transfer load from one power source to another during parallel operation, without opening the contactor. The intent is to provide uninterrupted power to various loads so failure of a single power source will not jeopardize the operation of critical loads connected to the power source(s) within a power distribution network.
Automatic System Shutdown Override & Circuit Interrupter	Power Sources (5 through 15kW) shall have automatic shutdown protective modes for low fuel, high temperature & high voltage conditions. The operator shall be able to override the automatic protective modes & shutdown the system if certain conditions exist. The manual override shall be readily accessible to the operator. The system shall also have a circuit interrupter that opens in the event of a short circuit, reverse power (if applicable), under-voltage, or all other conditions that can cause equipment damage or uncontrollable hazards to soldiers. Power sources below 2kW output may not have low fuel, reverse power & under-voltage indicators or other protective modes.
*Threshold & objective requirements are based on the TEP ORD. The values are derived from a comparison	

with the existing Tactical Quiet Generator (TQG) family of systems. The operating & technical characteristics of the 2kW Military Tactical Generator (MTG) and the TQG (3kW to 200kW) families are the baseline for any comparisons & improvements.

2.4. Power Source Environmental & Occupational Health Characteristics. Power source design, production, operation, maintenance & disposal shall eliminate or minimize adverse environmental quality impacts to the greatest practical extent. The power source shall not create hazards or toxic by-products that may adversely affect operator or maintainer health & safety. The Government & military end-user wants a safe power source where any known hazards are recognized, and are eliminated or minimized. It is the Government's intent to procure power sources that minimize any adverse environmental effects. Environmental considerations will continue to be a part of source selection criteria in any future power source acquisition programs. These environmental considerations may equal or outweigh other evaluation criteria. Consequently, the Government may not procure a power source that produces hazardous or toxic by-products or which presents a disposal hazard. Additionally, compliance with U.S. Environmental Protection Agency regulations, environmental law or policy is mandatory, regardless of where that power source is used [as in countries with less stringent environmental laws].

2.5. Summary. This specification documents the most important technical requirements for general purpose mobile military power sources; this is not a procurement specification. The Project Manager for Mobile Electric Power (PM MEP) is the DoD executive agent for developing and fielding new power sources. In this capacity, PM MEP deems the performance parameters & technical characteristics specified herein as essential for general purpose military power sources. These power sources could use any number of promising technologies that have the greatest potential of meeting military needs.

Acknowledgement. We want to recognize the CECOM Power Generation Branch at Fort Belvoir for their in-depth technical expertise, professionalism, candid observations and their sincere willingness to help.

Appendices. The appendices listed below are for informational purposes only & serve as a reference to those interested in developing power sources for military use.

Appendix A. Selected Characteristics & Comparison of Existing Military Generator Sets.

Appendix B. Environmental Conditions Summary.

Appendix C. Testing.

Appendix D. Power Ranges from 0.5kW to 15kW Outputs (AC & DC).

Appendix E. Power Quality, Military Standard 1332B.

Appendix F. Power Quality (DC), Military Standard 1332B.

Appendix G. Logistics Requirements.

Appendix A. Selected Characteristics & Comparison of Existing Military Generator Sets. Specification sheets extracted from MIL-Handbook 633F (draft) contains more specific data, i.e., typical output ranges & modes, reliability, configurations, weights, sizes, fuels, lubricants, maintenance intervals, etc.

Selected Characteristics & Comparison of Existing & Proposed Military Generator Sets.

System	Weight (1) (nominal)	Fuel	Noise(2)	Comparison
Existing Fleet – Developed in the late 1960's				
MIL-STD 1.5KW	125 lbs.	0.54 gal/hour	78 dBA	**Reliability:** 250 to 500 Hours MTBMF (mean time between mission failure).
MIL-STD 3KW	526	0.5	90	
MIL-STD 5KW	1040	0.57	79	
MIL-STD 10KW	1406	1.09	77	
MIL-STD 15KW	2892	1.5	80	
Existing Fleet – Developed in the 1980's				
MTG 2kW	158 lbs.	0.32 gal/hour	79 dBA	**TQG vs. MIL-STD** Mean Weight Δ = 17% Lighter. Mean Fuel Δ = 12% Less Fuel. Mean Noise Δ = 11 dBA Quieter. **Reliability:** 500 Hours MTBMF.
TQG 3kW	325	0.33	75	
TQG 5KW	888	0.57	70	
TQG 10KW	1182	0.97	70	
TQG 15KW	2124	1.44	70	
Proposed Fleet – Development in the early 2000's				
STEP 2KW(3)	142 lbs.	0.27 gals/hour	72 dBA (threshold)	**AMMPS Thresholds vs. TQG** Each Weight Δ = 10% Lighter. Each Fuel Δ = 15% Less Fuel. Each Noise Δ = 2 dBA Quieter (5 & 10kW only). **Reliability:** All 750 Hours MTBMF.
STEP 3KW	293	0.28	67 (threshold)	
AMMPS 5KW	765 lbs.	0.48	68 (threshold)	
AMMPS 10KW	1021	0.82	68 (threshold)	
AMMPS 15KW	1854	1.22	70 (threshold)	

(1) Wet weight includes all fluids (DoD approved fuel, coolant & lubricants). (2) Noise levels measured in decibels, "A" scale (dBA) at 7-meters (various orientations). (3) Small-Tactical Electric Power (STEP).

Appendix B. Environmental Conditions Summary. This section covers typical environmental conditions experienced by power sources as they are used by the military. These conditions were extracted from an actual DoD purchase description (see references) and may not be indicative of future requirements. Army Regulation 70-38 documents climatic extremes that military equipment & personnel can experience. In some cases, equipment can be subjected to temperatures from -50°F to 160° F in different parts of the world, during storage or when being operated. Temperature ranges selected for testing power sources vary with the specific procurement and are meant to exemplify likely conditions the equipment will experience during its life cycle. For more detailed data, see tables 2.1. & 2.2. in AR 70-38. The power source must operate when subjected to these conditions when starting, operating & stopping.

Power Source Starting & Operating. The power source shall start & operate within 5 minutes under various operating conditions. The power source shall operate without damage or failure at all loads (continuous & intermittent), up to and including its rated load under any combination of the conditions specified below:

(1) All possible relative humidity values, with ambient temperatures ranging from -50°F to 135°F at sea level; and from -50°F to 95°F at 4,000 feet. High temperature requirement remains at 95°F at altitudes above 4,000 feet.

(2) Altitudes up to & including 10,000 feet. Rated load may be reduced by 3.5 percent for each 1,000 foot increment above 4,000 feet, e.g., at 10,000 feet rated load may be reduced by 21%.

(3) Temperatures up to and including 135°F. Rated load may be reduced by 3% for each 18° F increment above 125°F. All systems shall operate at rated load in tropical, temperate, arid and cold climates and in the additional environmental elements.

(4) With 5 inches of rain per hour impinging on the set at angles from the vertical up to 45°.

(5) With 355 British thermal units (BTUs) per square foot per hour of solar radiation.

(6) With sand and dust particle concentration of up to 1,400 mg/m³. 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.

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

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

(9) In a salt fog or sea spray environment.

(10) When operated on DoD-approved fuels, lubricants & coolants.

Power Source Stopping & Storage. The power source shall be stopped under various operating conditions. "Stopped" is defined as total absence of an electrical output from the power terminals used to convey the power source output to a load; and complete cessation of any and all moving parts that aid

or contribute to its primary function of producing electricity. Exceptions include system essential housekeeping functions that if stopped, could damage the power source, i.e., cooling devices and the like. The power source shall stop within 2-minutes after activating /deactivating the master switch (or functionally equivalent device/process), the emergency stop switch, any protective device or other similar devices intended to stop the power source. Power Source storage will occur under various conditions from benign to severe. The power source (without packaging) shall not be damaged by exposure to storage at -60°F to 160°F, a salt fog environment and all possible relative humidity values.

Appendix C. Testing. These are typical tests that apply to military power sources. Again, this list is not all-inclusive. These tests were extracted from an actual DoD purchase description (see references) and may not be indicative of future testing requirements. Some of these tests only apply to mechanical to electrical conversion power sources & would not apply to other energy conversion systems. However, analogous testing appropriate for a given technology would certainly apply. These tests are performed during different test cycles and include tests designated as pre-production, production qualification, individual and/or sample inspection & first article testing.

Example Tests, Table, C-1.
Note: Test methods (TM) are extracted from MIL-STD-705C.

Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Altitude Operation	TM 720.1. at 4,000 ft, 95°F & 10,000 ft, 95°F.
Audio Noise	TM 100.1 (MIL-HANDBOOK-705C). Typical examples include: 2kW or less: 72 and 69 dBA@7 meters (threshold & objective). 3kW to 10kW: 68 and 64 dBA@7 meters (threshold & objective). 15kW: 70 and 67 dBA@7 meters (threshold & objective). Note: Specific values are normally cited in the purchase description.
Circuit Interrupter (Over Voltage and Under Voltage)	TM 512.3.
Circuit Interrupter (Overload Current)	TM 512.2.
Circuit Interrupter (Short Circuit)	TM 512.1.
Convenience Receptacle Load Test	Total load applied to all convenience receptacles is combined with total load applied to output terminals for activation of protective devices & displays. Must meet UL-1053-1999 & be connected according to National Electric Code. NOTE: Convenience receptacles are generally ground-fault circuit interrupter (GFCI) protected; 20-amp, 120-volt, receptacles located near load cable, but depends on purchase description requirement.
DC Control	TM 655.1. Perform at minimum and maximum settings of the battery charging voltage adjustment control; also test with fully discharged battery.
Data Download	Data download test is conducted by connecting a commercial IBM compatible PC & Maintenance Support Device (MSD), to the power source USB port using a commercial USB cable. Test includes downloading operational log & operational data; fault log & fault data; & maintenance log with applicable prompts/actions. All files will be downloaded and printed, reviewed for format & data storage capacity. Maximum download time is 5 minutes total for downloading data specified above. The Tester will remove power source batteries to verify data retention without battery power.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Drop (Ends)	TM 740.3. The drop test shall be performed on skid mounted configurations at a height of 9 inches.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Electromagnetic Interference (EMI)	MIL-STD-461E. The EMI testing is performed using the following abbreviated procedures fully detailed in MIL-STD-461E: CE-102. Conducted emissions (CE), power leads, 10 kHz to 10 MHz. Conducted emissions exceeding limits of figure CE-102-1 is cause for rejection. CS-101. Conducted susceptibility (CS), power leads, 30 Hz to 150 kHz. This procedure evaluates ability to withstand 30 Hz to 150 kHz input signals coupled to output power leads for source voltages above 28 volts. CS-114. Conducted susceptibility, bulk cable injection, 10 kHz to 200 MHz. This procedure evaluates ability to withstand 10 kHz to 200 MHz RF input signals coupled to output power leads induced by current probe. CS-115. Conducted susceptibility, bulk cable injection, impulse excitation. This procedure evaluates ability to withstand a 30 Hz impulse excitation (5 amps) coupled to output power leads. CS-116. Conducted susceptibility, damped sinusoidal transients, cables & power leads, 10 kHz to 100 MHz. This procedure evaluates ability to withstand a 1 to 2 Hz damped sinusoidal impulse (figure CS-116-1) coupled to output power leads. RE-102. radiated emissions (RE), electric field, 10 kHz to 18 GHz. With cable connected to power source output & energized during no-load test, determine radiated emissions (10 kHz to 18 GHz). Radiated emissions exceeding the limit of figures RE-102-1 through RE-102-4 is cause for rejection. RS-103, radiated susceptibility, electric field, 2 MHz to 40 GHz: **a**. Determine power source frequency susceptibility. At these frequencies, determine threshold of susceptibility. b. Subject power source to electric fields to 50 V/m while operating at no-load, rated load @ 1.0 pf & rated load @ 0.8 power factor & at all voltage & frequency connections. c. Power source output voltage is monitored throughout test to record voltage & frequency variations as a function of field strength or frequency. Upon observing variations, the frequency spectrum is rescanned for analysis. d. Compare test results' short-term stability with voltage & frequency requirement. Output voltage or frequency failure to remain within short-term stability bandwidth is cause for rejection.
External Air Transport	Test conducted according to MIL-STD-913A & certified by the US Army Natick Research, Development & Engineering Center.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Extreme Cold Storage	TM 731.1. The test is conducted according to this TM. However, other extreme cold temperatures (-60°F or colder) may be required by specifications in the purchase description.
Frequency and Voltage Regulation, Stability and Transient Response (Short Term)	TM 608.1 (See Note 2).
Frequency & Voltage Stability (Long Term)	TM 608.2 (See Note 3).
Fuel Consumption	TM 670.1. Test is conducted with #2 diesel fuel & JP-8 turbine fuel. However, mission profiles depend on the purchase description. Typical example is 72 total hours at these load cycles: • 12 hours @ rated load (kW). • 24 hours @ ¾ rated load (kW). • 24 hours @ ½ rated load (kW). • 12 hours @ ¼ rated load (kW). Testers will conduct this test once the power source reaches approx. 500 operating hours (achieved during other tests). During the reliability & availability testing (see R&M test), Testers will also operate power sources for the first 1800 operating hours on #2 diesel fuel; at 1801 hours, power sources will then use JP-8 fuel.
Ground Fault Protective Device	ANSI C101.
High Altitude Electromagnetic Pulse (HAEMP)	Conducted according to power source detailed test plan for first article pre-production test (Classified). Test is conducted on most power source configurations (skid & trailer mounted).
Human Factors Engineering (HFE)	HFE examination is conducted according to Appendix D, TM 103.1.
High Temperature @125°F	TM 710.1 at 125°F. All single & 3-phase connections at maximum & minimum voltage adjustment range as specified in purchase description. Perform TM 619.1 also at rated frequency and 3 phase volt-connections.
High Temperature @135°F	TM 710.1 at 135°F. Operate for 2 hours, followed by performance of TM 608.1 and TM 619.1.
High Temperature Endurance@125°F	TM 710.1 at 52°C (125°F) for 48 hours continuous
High Temperature Protective Device	TM 515.2
Hot Storage Test	TM 732.1. Perform test at 160°F (typical).

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Humidity	TM 711.1. Test consists of 5 consecutive 48-hour humidity cycles as specified in this TM.
Ice Glaze and Wind	MIL-STD-810F (3), TM 521.2, Procedure I. Power source is subjected to combined action of wind & ice as follows: a. Perform TM 608.1 of MIL-STD-705C. b. With the ambient temperature between -10°F & 32°F, with a steady wind speed of 73 ft/s, deliver a uniform rain spray on non-operating power source until 0.5" of ice glaze has accumulated on top of power source. c. After accumulating 0.5"of ice as above, power source is started & 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-705C is performed.
Inclined Operation	TM 660.1. Perform at maximum fuel levels. Perform at full and add positions on the oil dipstick).
Indicating Instrument (Electrical)	TM 513.1 (At all rated voltage connections.)
JP-5/JP-8 Fuels	TM 710.1. Test is performed using JP-5 fuel as follows: a. Perform high temperature test at 125°F, according to the TM. Note: a purchase description may call for modifying this TM, e.g., perform only paragraphs "a" & "g" of 710.1.3.2. b. Perform a moderate cold test at 0°F except performing TM 608.1 in lieu of 701.2.3.2k (example). c. Operate power source for a total of 300 hours according to TM 690.1. Acceptance criteria; no relevant or critical failures. JP-5 fuel shall conform to MIL-DTL-5624T.
Lifting and Tie-down	TM 740.4, MIL-STD-209J (1). Power sources are statically tested to ensure lifting, tie-down provisions & connecting structure meet the requirements this military standard.
Low Fuel Protective Device	TM 515.5 (See Note 4)
Low Oil Pressure Protective Device	TM 515.1

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Maintainability Demonstration	Demonstration consists of performing all scheduled maintenance actions. Maintainers & operators wear arctic mittens & personally-worn chemical protective equipment. Any service task the operator or maintainer cannot perform with this personal protective equipment constitutes a failure. Test also verifies maintenance ratio (operating hours/maintenance hours); mean time to repair & the maximum time to repair.
Malfunction Indicator Exam	Indicator operation shall be noted throughout all testing.
Maximum Power	TM 640.1.
Maximum Power	TM 640.4.
Median Time to Repair (MTTR)	Test determines MTTR for all field level repair actions. The field level repair actions are detailed in the applicable power source technical publication and maintenance allocation chart (MAC). Each MAC field level repair is demonstrated within these constraints: a. Use of allowable tools only (typically detailed in purchase description). b. Follow repair procedures in applicable Operator/Field Level Repair technical publication. c. Each repair starts from a completely assembled power source. d. Each repair includes removing and replacing the part, component and/or assembly. e. Each repair concludes with returning the power source to a fully assembled condition. f. Time to Repair (TTR) for each action is recorded (in minutes) & verified by a Government representative. g. The arithmetic median is obtained by adding the total time(s) for all field level repairs & determining the median time that shall not exceed 90 minutes (typical example cited in the purchase description).

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Motor Starting	Test is performed with a motor rated @1 HP/kW of power source kW rating. Motor starting current rating shall comply with NEMA Code F (MG-1). Motor is loaded with flywheel or equivalent having inertia equal to that of motor rotor. Satisfactory starting is when motor accelerates to rated speed without tripping any power source protective devices.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
NBC (nuclear, biological & chemical)	Test is normally conducted according to the purchase description requirement. A typical & realistic example follows: a. Within 4-hrs of test and at test site, perform TM 608.1. Take color photographs of power source exterior & interior components. b. Cycle 1 through 5. Decontaminate power source exterior using hot soapy water followed by water rinse using M17 Lightweight Decontamination System. Within 1-hour of test at test site, perform TM 608.1. Each succeeding cycle is the same as cycle 1, but is performed on a different day. g. Wait 48-hours (minimum) to determine corrosion effects. Conduct TM 608.1. Take color photographs of power source exterior & interior components before proceeding to the next decontaminant. NOTE: Ensure M17 Lightweight Decontamination System (LDS) maximum water pressure is 100 psi. Ensure maximum water temperature is 248^{o}F. Power source exterior side (top, back, left, right, & control panel) is washed for approx. 30-secs. Power source is washed from the top down. LDS nozzle is approximately 36-inches from power source surfaces. The hot soapy water is then rinsed within 30 minutes after application. Soap shall conform to NSN 7930-00-282-9699. Above results are normally compared with the requirements in the purchase description. Typical requirements include: a. Equipment quantities for testing. b. Failure definitions for damage. c. Frequency. Maximum allowable short term stability bandwidth or deviation [% of rated frequency]. Maximum allowable recovery time & maximum allowable overshoot & undershoot. Frequency(s) at time when TM is performed & maximum allowable regulation. d. Voltage. Maximum allowable short term stability bandwidth or deviation [% of rated frequency]. Maximum allowable recovery time & maximum allowable overshoot & undershoot. Voltage connection(s) at time when TM is performed & maximum allowable regulation.
Over-speed (if applicable)	TM 505.1. Performed @125% rated speed for 15 minutes.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Over-speed Protective Device	TM 505.2
Parallel Operation	TM 630.1 (See Note 3). Testing done with two power sources of each output mode shall be tested IAW TM 630.1. Testing is also done with three power sources in parallel. Certain other conditions or restrictions may apply, i.e., power sources from the same or different production lots. Testing normally follows TM 630.1, but changes are typical, e.g., using control panel instrumentation vs. external test instrumentation; load connections include no-load, half-load, & rated load; 15 minute instead of 1-hour runtimes, etc. Testing also includes switch boxes & these are typically parallel tested using TM 630.1 with potentially other changes to the TM, but similar to changes cited above. The Tester will verify that two or more power sources [same mode] will not parallel until voltage difference of the same phase is less than 8 volts. The Tester will also verify that the permissive paralleling device is not damaged or falsely operate when either of its AC terminals is raised to 300 volts above ground; and when voltage across AC input terminals is at any value from 0 to 300 volts.
Phase Balance (Voltage)	TM 508.1. To be measured at load terminals. Measure voltages also for each winding using separate excitation. On individual production sets measure line-to-line & line-to-neutral at load terminals only.
Phase Sequence (Rotation)	TM 507.1.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Railroad Impact	MIL-STD-810F (3), TM 516.5, Procedure VII, applies. The power sources are subjected to rail impact testing that simulates rail shipment impacts. Tests are typically performed with these conditions: a. Two power sources of each size and configuration are used. b. Power sources are mounted opposite each other. Power sources large enough for trailer-mounting, are mounted with the trailer's longitudinal axis parallel to the length of flatcar but in opposite directions. c. The power sources are secured to the railcar according to tie-down procedures. d. The power sources will not require any type of packaging for the test. e. Power source fuel tanks are half full during test. f. Trailer tests are conducted with trailer brakes "off" (not set). Within 4-hours before testing & within 4-hours after test completion & final inspection, the Tester performs TM 608.1 on all power sources & then compares the results of two TM 608.1 tests for each power source.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Rain	MIL-STD-810F(3), TM 506.4. (procedure I), applies with these conditions: a. Simulated rainfall, 5-inches per hour, impinging on power source at angles from 90° to 45°; done at 40 mph wind speeds. b. Perform TM 608.1 (MIL-STD 705C) within 4-hours before rain test start. c. With control panel doors open (if applicable), spray water on power source for 3 consecutive hours. Expose each side of power source to simulated blowing rain for 30 minutes; start at control panel end. At onset of last test hour (with blowing rain on control panel end), perform TM 608.1 (MIL-STD-705C). Continue operating power source until completing this TM or until completing 3 total test hours; whichever period is longer. d. Immediately after exposure to rain (as above), examine power source for water penetration & damage. After the examination, start power source and perform TM 608.1 (MIL-STD-705C).

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Reliability & Maintainability (R&M)	TM 695.1. R&M testing includes a series of tests that determines if the power source will properly function when subjected to many different conditions; climatic & otherwise. This testing also identifies failure rates & modes; repair times & other characteristics. Mean Time Between Essential Function Failure (MTBEFF). Minimum (threshold) MTBEFF for power sources is 750 hours or 1250 hours (objective) with an 80% lower confidence limit. Fuel Consumption & Inclined Operation. Inclined operation & fuel consumption is also evaluated during this test series (see fuel consumption test). Maximum time to repair (MAXTTR). When any failure occurs (naturally occurring or induced), MAXTTR is demonstrated during this testing. Typical values; MAXTTR threshold of 2 hours (or less) for 90% of all essential failures or an objective value of 1 hour. An "essential failure" is normally any failure that prevents the power source from providing power to mission-critical equipment. Power Source Operating Hours. Power sources in a given category (output & mode) are expected to operate for 14,400 hours minimum; at least 3,600 hours on each power source in that category. Power Source Failures. It is expected that a power source will accrue 15 or fewer relevant failures. The power source is rejected if it accrues 16 or more relevant failures. However, if one critical failure or catastrophic safety hazard occurs, the power source is rejected. Failure & Hazards Definitions. Each procurement specification will typically define relevant failures, critical/catastrophic failures & hazards. However, as a general guideline, the power source shall safely provide power to mission-critical equipment under all ambient conditions, i.e., combat operations, severe weather, etc. Maintainability Ratio (MR). The MR is a ratio derived from 1000 operating hours divided by the maintenance hours. A typical power source MR is 0.025; 25 maintenance hours per 1,000 operating hours. The power source is rejected if it exceeds this value. The MR normally does not include preventive and scheduled maintenance tasks.
Reliability Maturation Test	TM 690.1. This test is conducted according to this TM. When exceptions are not expressed, the Testers will follow TM 690.1 without deviations. However, the procurement specification may list exceptions or additions to this TM. For example, exceptions may include writing test incident reports (TIR) for each incident; what items to inspect or not to inspect; loads, instrumentation, operating hours, etc.
Remote Operation	This test involves remotely operating & monitoring power source operating status, battle-short override, emergency stop or fault conditions via a remotely located commercial computer (PC). Testers use a suitable cable (manufacturer-fabricated) connected to the power source's remote operation port.
Reverse Battery Polarity	TM 516.5.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Reverse Power Protective Device	TM 516.2.
Road	These road tests are normally conducted in cycles that include mileage, speed & road surface. Testers conduct TM 608.1 after each test cycle & after all test cycles are completed. This testing may involve five or more cycles. The testing verifies power source durability when transported (towed or as cargo) by military-tactical vehicles over various surfaces, i.e., highway, cross-country, etc. Specific road conditions are typically cited in the procurement purchase description. For example, power sources are expected to withstand shock & vibration from traveling cross-country (off-road), without sustaining structural or functional damage. Typical speeds range from 20 to 50 mph. Distances range from 15 to 250 miles on various road or off-road surfaces; total accrued test mileage can reach or exceed 640 miles.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Safety & Health	Examination. The Government conducts an initial safety examination of all power sources upon receipt; these systems must not pose an unsafe or hazardous condition to personnel. Preliminary Assessment. The Govt. then performs a more in-depth safety and health assessment. This assessment documents any safety concerns or actions needed to minimize potential hazards to personnel. Typically, a preliminary assessment includes: a. Complete visual examination to identify all obvious safety problems. A qualified safety inspector or safety engineer records observations using a Safety Checklist. This examination only identifies obvious safety problems. b. Qualified safety inspectors or safety engineers will also review safety and health warnings and other information documented in the power source technical manuals. This review ensures that sufficient safety and health information is included in these manuals, i.e., data plate information, warning plates, noise hazard warnings (if required), grounding procedures, lifting and tie-down information, electrical shock hazard warnings, etc. (not all-inclusive). Safety inspectors will also perform limited safety-related tasks to ensure the power sources are safe for further testing. c. Qualified safety inspectors or safety engineers will perform a comprehensive safety and health assessment throughout the entire test program. This assessment normally includes the following elements (not all-inclusive): • Systematically observing power sources during testing; includes investigating actual or potential hazards to personnel/equipment that may result from operating & maintaining the power source. • Documenting all safety hazards identified during operation, maintenance & all other phases of operation. • Ensuring the Safety Checklist is completed & all hazards are identified. Testers or safety inspectors continuously monitor hazards during all testing and maintenance activities. • Classify all safety hazards according to MIL-STD-882 with recommendations for corrective measures and ways to reduce or eliminate hazard severity & hazard probability.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Salt Fog	MIL-STD-810F(3), TM 509.4. Power sources are normally subjected to salt fog during two 48-hour exposure cycles; (1) 24 hours, salt fog exposure; and (2) 24 hours, standard ambient (drying). The salt concentration typically used is a NaCl 5% (±1%) aqueous solution. Testers operate the power sources in their normal operating mode. Testers perform TM 608.1 within 4 hours of starting salt fog cycle. They also isolate & measure the exciter field (if used) coil insulation resistance according to TM 301.1 (before starting salt fog cycle). After completing salt fog cycles & before performing the post-cycle TM 608.1, Testers measure insulation resistance of all circuits per TM 301.1., except the power source is not operated before this test. Measured resistance values are not corrected for temperature. When post-cycle TM 301.1 is completed, technicians reconnect all circuits; perform TM 608.1 within 4 hours after removing the power source from the test chamber. Power sources are then examined for corrosion or other physical damage.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Sand and Dust	MIL-STD-810F(3), TM 510.4 (Procedure II). Sand & dust testing is conducted using the procedures & under the conditions outlined below: • Power source is operated on a bed of sand & dust of the same composition. • Perform TM 608.1 (MIL-STD-705C). • Testing is performed at ambient temperature & relative humidity. • Air velocity is maintained at 20 mph (minimum). • Sand concentration is 1.4 g/m³. • Testing consists of four 90-minute periods. Power sources are oriented so each side is exposed to blowing sand for one 90-minute period. Power source is operated at no load for 10 minutes (minimum) during last half of each 90-minute period. • After completing four 90-minute periods, Testers perform TM 608.1.
Secure Lighting	MIL-L-85762A, table V. Testing is conducted to ensure power source lighting (indicator, status or illuminating) complies with cited military standard. Manufacturers also normally submit compliance certificates for incandescent and/or light emitting diodes (LEDs) to show compliance with DoD secure lighting requirements.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Short Circuit (Mechanical Strength)	TM 625.1. Testing determines if the power source mechanical design can adequately withstand stresses caused by abnormal operating conditions, i.e., sustained short circuits. Procedures include: • Starting & operating power source, allowing it to stabilize at rated load, voltage & frequency (speed). • After stabilization occurs, apply single-phase short circuits at each line-to-line & each line-to-neutral connection (for 5 secs). • Testers also apply symmetrical 3-phase short circuits at output terminals (for 10 secs). Power input to voltage regulator [to sustain required short circuits] may be obtained from a separate source. • Testers record all instrument readings & steady-state short-circuit current for each short circuit condition. • Testers inspect power source and exciter windings (if so equipped), voltage regulator & all control devices (as applicable) for damage. • List any damage that occurred to any components.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Size and Weight	This testing or examination verifies power source compliance with purchase description size & weight specifications. Power source size is measured with all doors, flaps & panels closed. Power source weights are measured as: a. "Wet weight" or operating weight, i.e., all fluids (fuel, coolant, oil, etc.) filled to capacity. b. "Dry weight", i.e., all fluids filled to capacity except for fuel (fuel tank(s) completely drained).

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Solar Radiation	MIL-STD-810F(3), TM 505.4 (procedure I). Solar radiation testing verifies that power sources can withstand the effects of solar loading (in storage or when operating). The following conditions are typical: a. Test chamber air temperature is ±2°C of test temperature (measured with temperature probe shielded from radiated heat). b. Perform TM 608.1, MIL-STD-705C. c. Fill power source fuel tank & all other liquids to capacity. d. Install thermocouples in engine compartment & controls, fuel tank; top, front, rear & side housing surface (see TM 202.1.4, MIL-HANDBOOK-705C). e. Each power source side is exposed to four 24-hour, hot-dry test cycles. Power source is positioned so a vertical side & top receive the greatest amount of radiation during first 24-hour cycle. Equal irradiation of entire power source is achieved by test completion. f. After completing four cycles, Testers examine power source for physical damage; they then remove power source from chamber and perform TM 608.1.
Start and Stop	TM 503.1.
Starting and Operating (extreme cold battery start)	TM 701.1 at -50°F.
Starting and Operating (Moderate Cold Battery Start)	TM 701.2 at -25°F.
Torsiographing	Perform search for dangerous flexural vibration and dangerous torsional critical speeds between low idle speed and 115% of rated speed.
Voltage and Frequency Drift	This test verifies voltage & frequency drift. Testers will normally follow TM 608.2, but the purchase description may include exceptions or additional procedures. For example, procedures may state that Testers initially stabilize the power source at a temperature that differs by 60F° from final stabilization temperature; and/or the test will occur over an 8 hour period (etc.).
Voltage Dip and Rise for Rated Load	TM 619.2.
Voltage Dip for Low Power Factor Load	TM 619.1 (See Note 2).
Voltage Unbalance with Unbalanced Load	TM 620.2.

Example Tests, Table, C-1. Note: Test methods (TM) are extracted from MIL-STD-705C.	
Tests (typical):	Test Method (TM) (per MIL-STD-705C) &/or Test Paragraph (See Note 1)
Voltage Waveform	TM 601.1 and 601.4. (see Note 5 below). Test verifies power source voltage waveform as it applies to AC power sources. Some equipment that uses AC power may not function properly if voltage waveform deviates too much from a true sine wave. This test is performed at all rated voltage connections & under these loading conditions: a. No-load. b. Rated kW at 0.8 power factor lagging. c. Rated kW at 1.0 power factor.
Wet Stacking	TM 695.1. This test determines if "wet stacking" occurs when the power source is operated at less than a certain percentage of its rated load. Wet stacking is a characteristic of internal combustion engines and this test may not apply to other technologies. If power source uses an internal combustion engine as its prime mover, typical testing may include operating the power source for 300 hours [0 to 10% load]. Successful test completion is judged by then performing TM's 608.1 & TM 640.1, before & after the test.

NOTES:

1. Tests are conducted with the 240/416-volt connections for power sources 15 kW & above & with 120/240-volt connections for power sources 10 kW & below, unless otherwise specified. For Mode I sets, tests are conducted at 60 Hz [only] unless otherwise indicated. These values are typical, but not necessarily representative of all power sources. The Government reserves the right to reject the power source for not meeting any purchase description requirement even when not performing a test directly related to the specific requirement. NOTE: MIL-STD 705C test methods (TM) apply unless otherwise indicated.

2. For Mode I sets (50/60 Hz), tests are normally conducted at 50 and 60 Hz at all voltage connections. For Mode II sets (400 Hz), tests are normally conducted at all voltage connections.

3. For Mode I and Mode II sets, tests are conducted with 2 & 3 [or more] power sources, but this depends on the actual program requirements.

4. For the low fuel protective device test, the requirements of the fuel system shall be verified as applicable.

5. View waveform with an oscilloscope having a bandwidth of DC to 1.5 MHz & a usable viewing screen of 8 by 10 cm. Oscilloscope gain is adjusted so one voltage cycle covers approximately the entire viewing screen.

Appendix D. Power Ranges from 0.5kW to 15kW Outputs (AC & DC).

Note: Power range below 0.5kW is notional & not documented elsewhere in DoD publications. Additional notes are included on the means to provide the given outputs (notional & actual). Other potential power source technologies that can apply to the power ranges below include rotating machines with internal or external combustion engines, fuel cells, thermoelectrics/thermionics, thermophotovoltaics, solar photovoltaics & solar dynamic systems. Any other energy conversion & energy storage technology may also be deemed applicable by a DoD proponent.

D.1. 50W to 250W. Lower Output Chemical Battery-based Energy Sources. Usually communications-electronics type batteries (primary & secondary, various chemistries). Primary applications are portable communications & electronic equipment.

D.2. 250W to 500W. Higher Output Chemical Battery-based Energy Sources. Possibly hybrid systems with a power source & energy storage features. For example, limited use of automotive secondary batteries for energy storage, as when powering communications equipment without running the vehicle engine, i.e., "silent watch mode."

D.3. 500W to 2kW Lightweight Power Sources (DoD "small" category). Usually internal combustion engine driven, but possibly alternative energy conversion technologies/hybrid systems with batteries or other energy storage technologies in the future. Primary applications are communications, electronic equipment, power tools, battery charging, small appliances, etc.

D.4. 2kW to 3kW Lightweight Power Sources (DoD "small" category). Internal combustion engine driven, but possibly alternative energy conversion technologies/hybrid systems. Primary applications are communications, electronic equipment, power tools, battery charging, small appliances, computers, lighting, etc.

D.5. 5kW to 15kW Power Sources (part of DoD "medium" category). Internal combustion engine driven, but possibly alternative energy conversion technologies/hybrid systems in the future. Current output breakdown is 5, 10, 15, 30 & 60kW (medium category). Applications include any electrical or electronic item needing power in this range and also include aggregating individual smaller power consuming electrical items as in a local power grid or utility network.

Appendix E. Power Quality & Electrical Characteristics (AC only)

This is a summary of power quality characteristics from Military Standard-1332B. MIL-STD 1332B details the operating characteristics for DoD standard power sources & is a guide for preparing power source specifications. MIL-STD 1332B defines criteria used to classify DoD power sources as 'tactical & prime' & includes sub-classifications of 'precise & utility'. For this example specification only, 0.5kW to 15kW output range falls under Utility Class 2C (0.5kW to 15kW). For informational purposes only, the MIL-STD 1332B table & definitions is also included below (see Table E-2).

Operating Characteristics - Electrical.

Power Source Ratings & Voltage Adjustment Ranges. These ratings are examples of past, present & future (under contract) military power source ratings. The power source should be re-connectable for the following voltage ratings as indicated in the table below. This is representative data and does not include 50 or 400 Hz ratings & it may not be indicative of future procurements.

Power Source Ratings from 0.5kW to 15kW (60 Hz & DC)
Table E-1.

Power Output:	**Connections:	**Voltage Adjustment Range:	Phase:	Conductors:
0.5kW	120V	114 – 126V	1	2 wire
1.5kW	120V	114 – 126V	1	2 wire
	240V	228 – 252V	1	2 wire
*1.5kW (DC)	28V	26.6 – 29.4V	N/A	2 wire
2kW	120V	114 – 126V	1	2 wire
*2kW (DC)	28V	26.6 – 32V	N/A	2 wire
3kW	120V	114 – 126V	1	2 wire
	120 / 240V,	228 – 252V	1	3 wire
	240V	228 – 252V	1	2 wire
5kW	120V	114 to 126V	1	2 wire
	120/240V	228 to 252V	1	3 wire
	120/208V	205 to 240V	3	4 wire
10kW	120V	114 to 126V	1	2 wire
	120/240V	228 to 252V	1	3 wire
	120/208V	205 to 240V	3	4 wire
15kW	120/208V	197 to 240V	3	4 wire
	240/416V	395 to 480V	3	4 wire

***Note (1)** See Electrical Performance Characteristics Parameters (DC, Utility), Table F-2. ****Note (2)** These voltage connections & ranges shall apply to all loads between no-load & rated load, at rated

power factor & frequency, under all environmental conditions. A means to adjust voltage to a value that activates the over-voltage protective device is not desirable.

Frequency Regulation. Frequency control system will maintain frequency within 3% of rated frequency for all loads, from no-load up to and including rated-load.

Frequency Short-Term Stability (30 seconds). Power source will maintain frequency within a bandwidth equal to 4% of rated frequency at every constant load from no-load to rated load. Power source shall not permit repetitive frequency oscillations above & below the mean value [hunting], even though within the allowable 4% band.

Frequency long-term stability (4 hours). Power source will maintain frequency within a bandwidth equal to 4% of rated frequency in a 4-hour operating period, at constant ambient temperature, barometric pressure, voltage & any constant load from no-load to rated load.

Frequency Drift. When power source is operating at constant load & voltage, with its frequency regulation adjusted to not more than 3%, frequency will not change by more than 3% when subjected to changes in ambient temperatures up to 60F° in an 8-hour period [when temperature stabilization is done at initial & final ambient temperatures].

Frequency Transient Performance. (1) The governing system shall re-establish stable operation within 4 seconds after any sudden increase in load [including no-load to rated load]. Maximum transient frequency change below new steady-state frequency (undershoot) will not exceed 4% of rated frequency. (2) The governing system shall re-establish stable operation within 4 seconds after any sudden decrease in load [including rated load to no-load]. Maximum transient frequency change above the new steady-state frequency (overshoot) shall be not more than 5% of rated frequency.[1]

Voltage Waveform. No evident waveform discontinuities, spikes, or notches are permitted when viewed on an oscilloscope [with DC to 1.5MHz bandwidth & an 8X10cm usable viewing screen]. Oscilloscope gain & period is adjusted so one voltage wave cycle approximately covers the viewing screen. The deviation factor & any single voltage harmonic for line-to-line & line-to-neutral voltage for each voltage connection & load connection will not exceed values in the following paragraphs.

Deviation factor. The deviation factor will not exceed 6% in the single phase connections or 5% in the 3-phase, 120/208-volt connection.

Harmonics. Single frequency harmonics will not exceed 3% in the single phase connections or 2% in the 3-phase, 120/208-volt connection.

Voltage Unbalance. Maximum difference between line-to-line voltages will not exceed 5% of rated voltage for single phase 120/208-volt connections with a line-to-line unity power factor load at 25% of rated current [no other load connected to power source].

Phase Balance Voltage. When operating at rated voltage & frequency (no-load), the maximum difference in the three line-to-neutral voltages will not exceed 1% of the rated line-to-neutral voltage

[1] **Undershoot & Overshoot:** The amount that voltage or frequency is below or above nominal value after a sudden load change.

when connected for 120/208-volt, 3-phase (4-wire). Maximum voltage difference between any 120-volt windings of any phase will not exceed 1 volt.

Voltage regulation. Voltage regulation from no-load to rated load & from rated load to no-load shall not deviate more than 4% from the rated voltage for all voltage connections throughout the voltage ranges specified above.

Voltage Short-Term Stability (30 seconds). The voltage at output terminals will remain within a bandwidth equal to 2% of rated voltage at every constant load from no-load to rated load.

Voltage Long-Term Stability (4 hours). The voltage will remain within a bandwidth of 4% of rated voltage in a 4-hour operating period at constant ambient temperature, barometric pressure, frequency & any constant load from no-load to rated load.

Voltage Drift. When power source is operating at constant load & frequency, a change in ambient temperature up to 60F^{o} in an 8-hour period will not change the voltage by more than 4 %, [when temperature stabilization is done at initial & final ambient temperatures].

Voltage Transient Performance. Power source performance under transient conditions will comply with the following guidelines. Note: this is done with the voltage regulator reactive droop compensation disabled):

Low Power Factor Load. When power source is initially operating at no-load, rated voltage & frequency, terminal voltage will not drop below 60% of no-load voltage when a balanced 3-phase, 0.4 pf (or less) lagging, static load [0.5 per unit impedance] 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 5 seconds (utility class 2B only) and shall stabilize at or above this voltage. The specified voltage dip shall not exceed this value when a fully-loaded induction motor [with impedance above] is used instead of a static load & no reactions shall occur that prevents full motor acceleration with rated torque applied to its shaft.

Rated Load. When power source is initially operating at rated frequency & voltage and after any sudden change in load from no-load to rated load, instantaneous voltage shall not drop below 80% of rated voltage & will stabilize within 3 seconds. Final voltage overshoot or undershoot will not exceed the initial voltage transient amplitude. These requirements also apply when the load is suddenly changed from rated load to no-load, except the initial voltage transient shall not exceed 130% of rated voltage.

Motor Starting. Power source will be capable of across-the-line starting of a motor rated at 1 horsepower per kW of power source output rating. Starting current rating of the motor shall comply with NEMA Code F. The motor shall have a flywheel load with inertia equal to that of the motor rotor.

MIL-STD 1332B Generator Set Classifications & Definitions.

Type 1, Tactical. Generators designed for high mobility in direct support of military forces where output of the generator is normally used at generated voltage without further transformation or distribution.

Type 2, Prime. Generators designed for long-term use in semi-fixed locations for extended periods, with size, weight and mobility considered secondary to long life and reliability. Output is generally at high voltage and requires transformation and power distribution systems.

Class 1, Precise. Generators designed to provide close control of voltage and frequency performance for critical applications.

Class 2, Utility. Generators designed to provide power for general purpose applications. This class is further subdivided into; Utility A, B and C, ranging from commercial power distribution systems quality (Class 2A) to that required for utilitarian purposes where requirements for voltage and frequency control are minimal.

Mode I, Generators capable of operating at either 50 or 60 Hz.

Mode II, Generators operating at 400 Hz.

Mode III, Generators operating ONLY at 60 Hz.

Mode IV, Generators providing direct current (DC) output.

MIL-STD-1332B Electrical Performance Characteristics Parameters (AC), Table E-2:				
CHARACTERISTIC PARAMETER	**Precise Class I**	**Utility Class 2A**	**Utility Class 2B**	**Utility Class 2C**
a. Voltage characteristics				
1. Regulation (%)	**1%**	**2%**	3%	**4%**
2. Steady-state stability (var./bandwidth %)				
(a.) Short term (30 seconds)	**1**	**1**	**2**	**2**
(b.) Long term (4 hours)	**2**	**2**	**4**	**4**
3. Transient performance				
(a.) Application of rated load				
(1) Dip (%)	**15**	**20**	**20**	**30**
(2) Recovery (seconds)	**0.5**	**3**	**3**	**3**
(b.) Rejection of rated load				
(1) Rise (%)	**15%**	**30%**	**30%**	**30%**
(2) Recovery (seconds)	**0.5**	**3**	**3**	**3**
(c.) Application of simulated motor load (2X rated)				
(1) Dip (%)	**30%**	**NA**	**40%**	**NA**
(2) Recovery to 95% rated voltage (sec) (Note1)	**0.7**	**NA**	**5**	**NA**
4. Waveform (Note 2)				
(a.) Maximum deviation factor (%)	**5%**	**5%**	**5%**	**6%**
(b.) Maximum individual harmonics (%)	**2%**	**2%**	**2%**	**3%**

5. Voltage unbalance with unbalanced load (%) (Note 3)	**5%**	**5%**	**5%**	5%
6. Phase balance voltage (%)	**1**	**1**	**1**	1
7. Voltage adjustment range (%) (min) (Note 4)	**-5 +17%**	**+/-10%**	**-5 +17% (Note 5)**	**-5 +5%**
b. Frequency characteristics				
1. Regulation (%)	**0-3% Adjustable**	**0-5% Adjustable**	**3%**	**3%**
2. Steady state stability (variation) (bandwidth %)				
CHARACTERISTIC PARAMETER	**PRECISE Class I**	**UTILITY Class 2A**	**UTILITY Class 2B**	**UTILITY Class 2C**
(a.) Short term (30 seconds)	**0.5%**	**0.5%**	**2%**	**4%**
(b.) Long term (4 hours)	**1**	**1**	**3**	**4**
3. Transient performance				
(a.) Application of rated load				
(1) Undershoot (%)	**4%**	**4%**	**4%**	**4%**
(2) Recovery (seconds)	**2**	**4**	**4**	**4**
(b.) Rejection of rated load				
(1) Overshoot (%)	**4%**	**4%**	**4%**	**5%**
(2) Recovery (seconds)	**2**	**4**	**4**	**6**
4. Frequency adjustment range (%) (min) (where required)	**+/- 3%**	**+/- 4%**	**+/- 3%**	**+/-3%**

Note 1. Voltage shall stabilize at or above this voltage (not applicable to all power sources rated 5kW or below, or 500kW or larger.

Note 2. Specified values are for three-phase output; for single phase add additional 1%.

Note 3. With generator connected for three-phase output and supplying a single line-to-line, unity power factor, load of 25% of rated current, with no other load (not applicable for single-phase connections).

Note 4. For Mode II sets, upper voltage adjustment is +10% of rated voltage. For Mode I power sources operating at 50 Hz, upper voltage adjustment may be limited to the nominal voltages shown in Table IV of MIL-STD 1332B (not included here.)

Note 5. Values shown in this entry are for sets rated at 15kW and above.

Appendix F. Power Quality (DC, Utility).

Military Standard 1332B also covers the operating characteristics for direct current (DC) output power sources (Mode IV category in this standard). Characteristic parameters are summarized in Table F-1.

Electrical Performance Characteristics Parameters (DC, Utility) **Table F-1:**	
Characteristic Parameters	**Value**
1. Voltage Characteristics	
a. Voltage Regulation (%). Voltage regulation from no-load to rated load & from rated load to no-load shall not deviate more than 4% from the rated voltage for all voltage connections throughout the voltage range(s) for the power source.	**4%**
b. Steady State Stability (variation %). Voltage at output terminals will remain within 2% of rated voltage at every constant load from no-load to rated load at constant ambient temperature & barometric pressure.	**2%**
c. Voltage Drift. When power source is operating at constant load & voltage, with its voltage regulation adjusted to not more than 3%, voltage will not change by more than 3% when subjected to changes in ambient temperatures up to 60F^{o} in an 8-hour period [when temperature stabilization is done at initial & final ambient temperatures].	**3%**
d. Voltage Short-Term Stability (30 seconds). Voltage at output terminals will remain within 2% of rated voltage at every constant load from no-load to rated load.	**2%**
e. Voltage Long-Term Stability (4 hours). Voltage will remain within a bandwidth of 4% of rated voltage in a 4-hour operating period at constant ambient temperature & barometric pressure & any constant load from no-load to rated load.	**4%**
2. Transient performance & Application of Rated Load.	

a. Dip (%). When the power source is initially operating at rated voltage and after any sudden changes from no-load to rated load, instantaneous voltage dip shall not exceed 30% of rated voltage. Final voltage undershoot will not exceed the initial voltage transient amplitude.	**30%**
b. Recovery (seconds). When the power source is initially operating at rated voltage and after any sudden change from no-load to rated load, terminal output voltage shall stabilize within 2 seconds. Final voltage overshoot or undershoot will not exceed the initial voltage transient amplitude.	**2 sec**
3. Transient performance & Rejection of Rated Load.	
a. Rise (%). When the power source is initially operating at rated voltage and after any sudden change from load to no-load, terminal output voltage rise shall not exceed 40% of rated voltage.	**40%**
b. Recovery (seconds). When the power source is initially operating at rated voltage and after any sudden change from rated load to no-load, terminal output voltage shall stabilize within 2 seconds. Final voltage overshoot will not exceed the initial voltage transient amplitude.	**2 sec**
4. Ripple voltage (%). Output terminal voltage intrinsic ripple (no-load) will not exceed +/- 5.5% of the rated voltage at constant ambient temperature & barometric pressure.	**5.5%**
5. Voltage Adjusting Range. Voltage adjustment range is 23 to 35 volts at normal ambient temperatures and +/-5 % of nominal (28 V) at extreme temperatures.	**+/-5 %**

Appendix G. Logistics Requirements. This is a summary of the key logistics requirements as they apply to DoD fueled power sources, for information purposes only. This is not an all-inclusive list. Any prospective fueled power source must meet these requirements for acceptance as a military standard fueled power source.

Maintenance & Support Equipment. The military will perform system maintenance according to its maintenance and supply systems. Maintenance procedures will use military standard tools and test equipment. Introducing any new, unique or special tools that are specific to the power source is undesirable. The power source should have a modular design that will aid fault isolation, removal & replacement of components and/or sub-assemblies. The inherent design should reduce the time needed to inspect, isolate, remove, replace and repair components. Power source design will emphasize the use of existing test and other support equipment.

Human Factors Engineering. Power source design shall address human factors engineering, manpower, personnel, training, health hazards, system safety & personnel survivability to ensure systems can accommodate the human performance characteristics of end-users who will operate, maintain and support the system. Introducing any new power source will not increase the military's end strength. Existing military organizations will operate or support the power sources without any increase in total end-strength. The power sources will not require new technical specialties for their operation, maintenance or repair. Power source design should minimize any operational complexity or maintenance. System design shall be conducive to effective operation, maintenance and support by all applicable military personnel. The target audience is the 5th to 95th percentile anthropometric individual when wearing all mission appropriate uniforms, in all environmental conditions**.**

Training. Any new power source will require a multi-media training package for training military personnel. The training program consists of: institutional training, new equipment training and unit training. New institutional training (within the military's education system) is incorporated into existing courses for soldiers, airmen, sailors & marines who have the power generation repair military occupational specialty. Developing or updating any interactive multimedia instruction, technical manual or computer-based training is also required. The training program will allow training via CD-ROM (threshold) and the Internet (objective). This training material is updated throughout the system's life cycle. The training programs & materials ensure that military personnel are trained to properly operate & maintain the power sources. A training support package is created & used for this training. This package includes electronic and/or paper technical publications, interactive multimedia materials, web-based training, etc. Military organizations will use this material to conduct power source operator training according to their internal operating procedures.

Logistics, Facilities, Supportability & Provisioning. These areas include a life cycle cost analysis for estimating operations and support costs and identifying whether new power sources will require any new or unique facilities or supporting infrastructures for their operation, maintenance, or support. The DoD developer (working with the manufacturer) shall also ensure the repair parts compatibility and special tools lists, provisioning data, support equipment, maintenance allocation charts and operator and maintenance manuals are approved and provided before the power source is approved for military use. Provisioning includes identification of all spare and repair parts (to component, piece-part level) by national stock number before the power source is approved for military use.

Transportation and Basing. The military will store the systems at installations, depots and on pre-positioned ships. Military organizations will get the power sources from storage for deployment to a theater of operations. Power source transportation, storage and packaging shall meet military and commercial requirements for international shipping by ground, rail, air and sea regardless of its

operating configuration. This requirement also includes preservation and packing of equipment during transportation and/or long term storage. These power sources shall not require any special packaging, handling or transportation.

Power Source Environmental & Occupational Health Characteristics. Power source design, production, operation, maintenance & disposal shall eliminate, or minimize adverse environmental quality impacts to the greatest practical extent. The power source shall not create hazards or toxic by-products that may adversely affect operators or maintainer health & safety. The Government & military end-user wants a safe power source where any known hazards are recognized, eliminated or minimized. It is Governments' intent to procure power sources that minimize any adverse environmental affects. In any future power source acquisition programs, environmental considerations will continue to be a part of source selection criteria. These environmental considerations may outweigh or at least equal other evaluation criteria. Consequently, the Government may not procure a power source that produces hazardous or toxic by-products or is a disposal hazard. Additionally, compliance with U.S. Environmental Protection Agency regulations, environmental law or policy is mandatory, regardless of where that power source is used [as in countries with less stringent environmental laws].

APPLICABLE DOCUMENTS

General. Documents listed below are needed to meet the requirements specified herein. This is not an all-inclusive list. Document users are cautioned that a power source must meet all applicable technical & policy requirements specified in (1) through (8) cited below.

(1) Tactical Electric Power Operational Requirements Document (ORD), CARDS# 16125, 18 August 2004.

(2) MIL-STD-1332B, Definitions of Tactical, Prime, Precise and Utility Terminology for Classification of the DoD Mobile Electric Generators, 13 March 1973 (reactivated 29 June 1998).

(3) DoD Directive# 4120-11, Standardization of Mobile Electric Power Generating Sources, 9 July 1993.

(4) MIL-STD 1472F, DoD Design Criteria Standard Human Engineering, 23 August 1999.

(5) MIL-STD 461-E, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, 20 August 1999.

(6) MIL-STD-705C, Generator Sets, Engine-Driven, Methods of Tests & Instructions, 24 April 1989.

(7) MIL-STD-1474D, Noise Limits for Army Material, 12 February 1997.

(8) DoD Directive# 4140.25, DoD Management Policy for Energy Commodities & Related Services, 20 April 1999 (single fuel policy).

(9) Purchase Description (PD#6115-0125), Generator Sets, 5kW-60kW, Skid Mounted, Trailer Mounted, Advanced Medium Mobile Power Sources, 13 February 2004.

(10) Statement of Work, Generator Sets, 5kW-60kW, Skid Mounted, Trailer Mounted, Advanced Medium Mobile Power Sources, 24 September 2004.

(11)Purchase Description, (PD#6115-0111), 2kW (DC & 60Hz) Generator Sets, Diesel Fueled, Skid Mounted, Lightweight, Military Tactical, 1 February 1999.

(12)Purchase Description, 3kW Generator Sets, Diesel Fueled, Skid Mounted, Lightweight, Tactical Quiet, 31 May 2002.

(13)US Army Tank-Automotive Command (TARDEC) Fuel Users Guide, 2000 (extracted from AR 70-12, Fuels & Lubricants Standardization Policy for Equipment Design, Operation & Logistics Support, 1 May 1997.

(14)Army Regulation 700-101, Joint Operating Procedures Management and Standardization of Mobile Electric Power Generating Sources, 29 November 1999.

(15)DoD Military Handbook-633F (Draft), Standard Family of Mobile Electric Power Generating Sources: General Description Information & Characteristics Data Sheets, May 2001.