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AEROSPACE RECOMMENDED PRACTICE

SAE ARP1148 | REV. B

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Superseded by ARP5015A

Ground Electrical Power Unit, Transportable 115/200 Volt AC (Nominal) 400 Hertz, 3-Phase 4-Wire (Grounded Neutral) Y-Connected System

RATIONALE

This ARP is obsolete and has been fully replaced by ARP5015A Ground Equipment - 400 Hertz Ground Power Performance Requirements. Use of this ARP for Ground Power Unit design may result in unsafe operation for the aircraft and the equipment.

CANCELLATION NOTICE

This document has been declared "CANCELLED" as of October 2013 and has been superseded by ARP5015A. By this action, this document will remain listed in the Numerical Section of the Aerospace Standards Index noting that it is superseded by ARP5015A.

Cancelled specifications are available from SAE.

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TABLE OF CONTENTS

PREPARED BY
SUBCOMMITTEE AGE-2C, VEHICLE, MAINTENANCE AND AIRCRAFT SERVICING, AND
SAE COMMITTEE AGE-2, CIVIL AIRCRAFT GROUND SUPPORT EQUIPMENT

1. SCOPE

This Recommended Practice outlines the electrical performance characteristics for a continuous duty, diesel or gasoline engine driven brushless alternator unit for supplying 400-Hertz electrical power to commercial transport aircraft. It is intended to assist the airlines in standardizing recommendations for various sizes and configurations of equipment and it is a guide for the preparation of detailed specifications. The unit is primarily intended to supply power to the aircraft during passenger loading and unloading, and during servicing operations. The combination of the equipment specified herein and the interconnecting cables(s) between the 400-Hertz alternator and the aircraft shall provide power characteristics at the aircraft receptacle which meet MIL-STD-704 requirements for Category "B" equipment. Other limits which are necessary to meet specific conditions must be specified by the purchaser.

2. APPLICABLE DOCUMENTS

The following documents shall form a part of this Recommended Practice to the extent specified herein. The applicable issue of each shall be that in effect on the date of this Recommended Practice unless otherwise specified in the purchaser's specifications. Supplementary specifications which by reference in any of the following publications are indicated to be part thereof, shall not be considered as effective except as specifically stated in the purchaser's specifications or as may be otherwise mutually agreed upon between the vendor and purchaser. In the event of conflicts between this Recommended Practice and the listed documents, this Recommended Practice shall apply:

DOCUMENT	TITLE
NEMA MG-1	NEMA Standards Publication - Motors and Generators
MIL-G-6099A	Generators and Regulators, Air-Cooled, A-C, Aircraft, General Specification For
MIL-STD-461A	Electromagnetic Interference Characteristics Requirements for Equipment
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of
SAE-J680	Motor Truck Instrument Panel Grouping
SAE ARP 1247A	General Requirements for Aerospace Powered Mobile Ground Support Equipment

3. REQUIREMENTS

3.1 Performance:

3.1.0.1 Recommended unit configuration shall be for a specific maximum output capacity between 37.5 and 200 KVA continuous at 0.8 power factor.

3.1.0.2 The selected rating shall be obtainable at the most stringent operating conditions cited in this specification.

3.1.1 Safety:

3.1.1.1 Personnel Safety: The load contractor(s) shall be interlocked with the aircraft electrical system so that the feeder cable(s) shall not remain energized except when engaged with the aircraft receptacles. As specified by the purchaser, the aircraft system provides a small transformer-rectifier on the airplane fed from the external power lines to provide 28 V DC that can be fed back to the unit. Ground power unit use of this 28 V DC airplane source should be limited to 1/2 ampere per cable.

3.1.1.2 Equipment Safety:

3.1.1.2.1 The overvoltage protective system shall disconnect the electrical system of the aircraft from the ground power alternator when the equivalent step function of the AC line-to-neutral voltage transient exceeds curve 1 of Figure 1 with full rated load removed. (Refer to MIL-STD-704 for calculations of the equivalent step function of a transient surge voltage.)

3.1.1.2.2 The undervoltage protective system shall disconnect the electrical system of the aircraft from the ground power alternator when the average line-to-neutral voltage drops below 102 V for longer than 4 seconds with full rated load applied. See curve 4 of Figure 1. (Refer to MIL-STD-704 for calculations of the equivalent step function undervoltage transient.)

3.1.1.2.3 The overfrequency protective system shall disconnect the electrical system of the aircraft from the ground power alternator when the alternator frequency exceeds 420 ± 5 Hertz.

3.1.1.2.4 The underfrequency protective system (manual reset) shall disconnect the electrical system of the aircraft from the ground power alternator when the alternator frequency drops below 380 ± 5 Hertz.

3.1.1.2.5 The overload protective system shall disconnect the electrical system of the aircraft from the ground power alternator when the output exceeds 125% rated current for five minutes. Overload protection must have an inverse time characteristic and should operate instantaneously if a short circuit occurs within the ground power unit. See paragraph 3.2.0.8 for additional requirements.

3.1.1.2.6 All components shall be fail-safe, in that no failure will cause another failure.

3.1.1.2.7 An optional phase sequence protective system if specified by the purchaser shall disconnect the electrical system of the aircraft from the ground power alternator if the phase rotation of the alternator output is reversed.

3.1.1.2.8 The protective system shall include fault lights for underfrequency, overfrequency, undervoltage, overvoltage and overload. There shall be some means of testing the lights other than the operation of one of the protective relays.

3.1.1.2.9 Optional devices to automatically shut down the prime mover when a hazardous or self-destructive condition exists during use may be specified by the purchaser.

3.1.1.2.10 An optional protective device that will disconnect the electrical system of the aircraft from the ground power alternator in the event of the neutral line going to open circuit may be specified by the purchaser.

3.1.1.2.11 An optional ground fault relay may be specified by the purchaser.

3.2 Equipment Definitions:

3.2.0.1 Prime Mover: The prime mover for driving the alternator shall be a diesel or gasoline engine of sufficient horsepower to produce the rated KVA at 0.8 power factor and normal overload at the altitude and temperature range in which the equipment will be operated.

3.2.0.2 Alternator Speed: Shall be based on the acceptable continuous operating speed of the engine.

3.2.0.3 Temperature Rise: Components of the alternator shall have insulating properties meeting NEMA MG1 Standards.

3.2.0.4 Dielectric Tests: The components of the alternator shall meet the requirements of paragraph 4.5.6 of MIL-G-6099A.

3.2.0.5 Alternator Rating: The recommended alternator ratings shall range from 37.5 to 200 KVA continuous at 0.8 power factor.

3.2.0.6 Overload Rating: The normal overload rating of all alternators shall be 125% of rated KVA at 0.8 power factor for 5 minutes. (See paragraph 3.2.0.37 for additional overload capabilities.)

3.2.0.7 Maximum Overload: The maximum overload required from the alternator shall be 125% of rated KVA at 0.8 power factor for 5 minutes. Other maximum overload ratings may be stipulated by the purchaser if aircraft loadings demand a different value.

3.2.0.8 Three/Unit Short Circuit Current: Three/unit short circuit current (not to exceed four per unit) shall be provided if a short occurs at the end of the output cable or within the aircraft. Time period shall be a minimum of 4 seconds and a maximum of 8 seconds.

3.2.0.9 Nominal Voltage Rating: The AC system shall be a 3-phase, 4-wire "Y" system with grounded neutral having a nominal voltage of 115/200 V. The grounded neutral shall be tied solid to the alternator frame with sufficient capacity in the tie to handle maximum ground fault current for a period of 10 seconds.

3.2.0.10 Regulated Voltage Range: The regulated voltage range shall be ± 15% of the nominal voltage rating line-to-line in unloaded condition. This range shall be adjusted by the regulator rheostat. Range specified will permit checking overvoltage and undervoltage protective devices.

3.2.0.11 Type of Regulator: The regulator furnished with the alternator shall be a magnetic amplifier or solid state design.

3.2.0.12 Regulator Sensing: Regulator sensing shall be three-phase averaging.

3.2.0.13 Highest Phase Voltage Limiting: A highest phase voltage limiting system shall be incorporated in the voltage regulator to limit the highest phase voltage of the alternator to 130 V during unbalanced load conditions.

3.2.0.14 Line Drop Compensation: A system of automatic line drop compensation shall be incorporated in the voltage regulator to provide constant voltage at the aircraft receptacle(s) irrespective of current and power factor. Minimum compensation capability shall be 5%.

3.2.0.15 Voltage Regulation: The voltage at the generator output terminals and/or connectors shall stay within ±1% of the rated line-to-neutral voltage for all balanced loads up to and including 125% rated KVA at 0.8 power factor except during switching.

3.2.0.16 Voltage Regulation Steady State: The voltage at the generator output terminals and/or connectors shall stay within ±1% of the steady state voltage for all balanced loads up to and including 125% rated KVA at 0.8 power factor.

3.2.0.17 Voltage Transients: The equivalent step function of the AC voltage shall not exceed curves 2 and 3 of Figure 1 during full load application or removal. (Refer to MIL-STD-704 for calculations of the equivalent step function of the voltage transient.)

3.2.0.18 Voltage Transient Recovery: Output voltage transients shall recover to and stay within ±1% of the steady state voltage in 200 milliseconds with full rated load applied or removed from the ground power unit.

3.2.0.19 Voltage Modulation: The output voltage modulation shall not exceed 0.5% at any steady state condition within the rating of the machine.

3.2.0.20 Frequency of Voltage Modulation: The frequency components of the voltage modulation envelope wave form shall not exceed 100 Hertz.

3.2.0.21 Phase Voltage Balance with Balanced Load: The maximum deviation of any of the three-phase voltages from the average of the three-phase voltages shall not exceed 1% with a balanced three-phase load. The voltages shall be measured at the alternator output terminals. If measurement of phase voltage balance with balanced load is to be taken at other than the alternator output terminals, maximum deviation, output cable size and output cable length must be specified by the purchaser.

3.2.0.22 Phase Voltage Displacement with Balanced Load: The phase voltage displacement with a balanced load shall be within the limits of 120 degrees ± 1.5 degrees.

3.2.0.23 Phase Voltage Balance with Unbalanced Load: The maximum deviation of any of the phase voltages from the average of the three-phase voltages shall not exceed 4% with 1/3 rated current at 0.8 power factor lagging on any one phase and no load on the other two phases when measured at the alternator output terminals. If measurement of phase voltage balance with unbalanced load is to be taken at other than the alternator output terminals, maximum deviation, output cable size and output cable length must be specified by the purchaser.

3.2.0.24 Phase Voltage Displacement with Unbalanced Load: The phase voltage displacement with a 1/3 rated current unbalanced load shall be within the limits of 120 degrees ± 4 degrees.

3.2.0.25 Individual Harmonic: The RMS value of any individual harmonic shall not exceed 2% of the fundamental (RMS) when measured from line-to-line and line-to-neutral at no load and rated KVA at 0.8 power factor with a harmonic analyzer.

3.2.0.26 Total Harmonic Content: The total harmonic content of the output voltage shall not exceed 3% of the fundamental (RMS) when measured from line-to-line and line-to-neutral at no load and rated KVA at 0.8 power factor with a distortion meter of calculated from the individual harmonics as measured with a harmonic analyzer. The total harmonic content of the output voltage shall not exceed 4% of the fundamental (RMS) when measured from line-to-line and line-to-neutral for a 1/3 rated current unbalanced load.

3.2.0.27 Crest Factor: The crest factor of the alternator shall not exceed 1.414 ± 0.07.

3.2.0.28 Frequency Regulation: The output frequency shall stay within 400 Hertz ± 5 Hertz at all steady state loads up through full rated load.

3.2.0.29 Frequency Regulation Steady State: The output frequency shall stay within ± 1 Hertz of the steady state frequency for all loads up to and including full rated load.

3.2.0.30 Frequency Transients: The instantaneous frequency shall not be greater than 417.5 Hertz or less than 382.5 Hertz during full load application or removal.

3.2.0.31 Frequency Transient Recovery: Output frequency shall recover to and stay within 400 Hertz ± 5 Hertz in 2 seconds.

3.2.0.32 Frequency Modulation: The output frequency modulation shall not exceed .25% of the steady state frequency for all loads up to and including full rated load.

3.2.0.33 Frequency Modulation Rate: The rate of frequency change due to frequency modulation shall not exceed 13 Hertz per second.

3.2.0.34 Frequency Drift: Variation within steady state frequency limits due to drift shall not exceed ± 1 Hertz.

3.2.0.35 Frequency Drift Rate: Frequency variation due to drift shall not occur at a rate greater than 0.15 Hertz per minute.

3.2.0.36 Phase Rotation: Phase rotation shall be A-B-C.

3.2.0.37 Inrush Current Provisions: Units rated at 140 KVA or larger shall be capable of starting a 28 HP motor with an inrush current of 400 amps superimposed on a 50% rated KVA at 0.9 power factor lagging, steady state load. The 400-amp surge decays to a steady state value of 70 amps in 2 seconds, and is followed by a 160-amp inrush current in 4 seconds. The 160-amp surge decays to 30 amps in 2 seconds.

3.2.0.38 Output feeder cable length and size shall be specified by the purchaser.

3.2.1 Interface Requirements: Each output feeder cable and plug assembly shall be compatible with an AN-3114 receptacle.

3.3 Design and Construction:

3.3.1 Control Panel:

3.3.1.9.1 The control panel shall have easy accessibility of controls and instruments and shall contain all equipment necessary for the operation and control of engine and alternator. The panel controls and instruments shall be suitably identified and distinctly divided between prime mover and alternator controls and instruments.

3.3.1.2 Instruments shall be of a type easily read and of a well known manufacture so that replacements are readily obtainable. Instruments shall be of 2% accuracy. All instruments and control panels shall be lighted so that they can be read at night.

3.3.1.3 The control panel for the alternator shall contain the following minimum equipment:

3.3.1.3.1 One ammeter of adequate range, and a switch to permit reading the current in each phase.

3.3.1.3.2 One voltmeter with 0-300 V scale and a switch to permit reading of line-to-line and line-to-neutral voltage on each phase.

3.3.1.3.3 A frequency meter with a range from 380 to 420 with a minimum of 9 reeds if applicable.

3.3.1.3.4 A load "on" green indication light.

3.3.1.3.5 An "On-Off" switch or pushbuttons for the alternator with a contactor closed indicating lights.

3.3.1.4 The control panel for the engine shall contain the following:

3.3.1.4.1 Starter pushbutton, automatic or manual throttle, oil pressure gauge, ammeter, engine hourmeter, and water or cylinder head temperature gauge.

3.3.1.5 The wiring shall be brought to terminal blocks and/or suitable connectors and each conductor identified in accordance with a wiring diagram by means of numbers or color coding. The wiring shall be formed and restrained to give a neat appearance.

3.3.1.6 All meter panels and any components containing printed circuit boards or solid state electronics shall be shock mounted.

3.3.2 Electromagnetic Interference: The unit shall meet radio suppression specification MIL-STD-461A. This shall be applicable throughout the entire aircraft radio frequency range. Provisions shall be designed into the power unit to protect it from voltage fluctations which might result from the operation of aircraft radio frequency equipment.

4. DEFINITIONS AND ABBREVIATIONS

This glossary of terms is included as a part of this specification for use in its interpretation.

Type of mounting is the means of mounting the alternator with its prime mover and controls.

Prime mover is the source of power for driving the alternator.

Unit refers to the complete power package such as the prime mover, alternator and all associated equipment and systems.

Alternator speed is the nominal speed at which the alternator operates to produce 400 Hertz.

Altitude is the maximum height in feet above sea level at which the unit must operate and maintain characteristics within recommended limits.

Ambient temperature is the temperature range in degrees Fahrenheit in which the unit must operate and maintain characteristics within recommended limits.

Temperature rise is the rise in degrees Centigrade above ambient for components of the 400 Hertz alternator.

Dielectric tests are the high voltages impressed between a component and the frame of the alternator. This test is used to check insulation characteristics.

Alternator rating is the full load value expressed in KVA at 0.8 power factor.

Overload rating is the normal overload value expressed in KVA at 0.8 power factor for a specified time.

Maximum overload is the maximum load expressed in KVA at 0.8 power factor that the alternator must produce for a specified time.

Three/unit short circuit current provides that the alternator under short circuit conditions must provide at least three times rated current. This feature will trip any overcurrent devices in the aircraft so that a fault may be isolated.

Nominal voltage rating is the root-mean-square line-to-neutral and line-to-line voltage at which the alternator is rated. The alternator is normally set such that output voltage is maintained at this value.

Regulated voltage range is the range in adjustment of the line-to-line voltage as controlled by the regulator rheostat.

Type of regulator refers to the system for controlling the output voltage of the alternator.