Standard

for

AEROSPACE EQUIPMENT

VOLTAGE and FREQUENCY RATINGS

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THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, Inc.

PREFACE

It has been widely recognized that there is a distinct need for preferred voltage and frequency ratings for aerospace electric apparatus, which will be generally acceptable to manufacturers and users, to serve as a basis for voltage and frequency standards for aerospace systems and equipment.

Many difficulties and much confusion will be eliminated by adopting suitable standard voltage and frequency ratings for all aerospace electric equipment. These standard voltages and frequencies should then be made a part of specifications and nameplates marked accordingly. Apparatus should be designed for satisfactory operation over the voltage and frequency ranges given in the tables, but with performance not necessarily the same as guaranteed at rated voltage and frequency. Performance data and acceptance tests should be on the basis of standard voltages and frequencies.

It is recognized that special applications may require operation over other voltage and frequency ranges than those shown as standard.

Standardization of voltage ratings for aerospace electric accessories is especially difficult because of the close margins for application of aerospace equipment. The nominal designations used to identify various systems have in the past been the subject of controversy, but common usage in the aircraft industry and the military aviation services supports the 14- and 28-volt designations for systems using 6- and 12-cell lead-plate storage batteries.

With present large electric systems, the battery has become a relatively small part of the total source capacity. With the widespread use of plug-in power facilities at airline terminals and military bases, operation from battery power seldom occurs.

Although the battery may represent only a small portion of the available system capacity, its limitations determine the direct-current voltages which must be used. Direct-current system voltage must be high enough to maintain the battery in a charged condition, but not high enough to cause excessive battery heating. Twenty-eight volt systems are usually operated at between 27 and 28.5 volts at the point of regulation, and this accounts for the choice of 28 as the nominal direct-current system voltage. Voltage is adjusted by setting the regulators of the generators, or the alternating-current to direct-current conversion equipment, and the particular value chosen is at least partially dependent on operating conditions. Direct-current generators must be capable of 30 volts output over the specified speed range to allow for voltage drops totaling 1½ volts minimum (including the voltage drop in the paralleling resistors, when used) between each generator and its regulated point.

To obtain minimum weight, system wiring is deliberately loaded heavily and allowance must be made for voltage drop between the regulated point and the electric accessories. Best weight economy dictates the use of more heavily loaded cable for intermittent loads than for continuous loads. Rated direct-current voltage has been selected as 27 volts for continuous-duty devices and as 26 volts for intermittent-duty devices.

Accessories such as engine-starter motors must be capable of operation when the battery is the sole source of power. They must also operate after one or more generators have been paralleled with the battery, and in most cases they must be suitable for operation from 30-volt starter trucks. Starters, in particular, require very heavy currents and are designed to operate at voltages of the order of 12 volts at the terminals when drawing power from a 24-volt battery. It does not appear possible to set up standard voltages for starters and items operated during starting, as restrictive values would involve weight penalties which would be unacceptable to the users.

The steady-state voltage extreme limits (all tolerances additive in the same direction simultaneously) of the present state of the art of generation system manufacture is considered excessive. These limits necessitate undesirable design penalties (weight, complexity, cost) in power utilization equipment. Electric genera-

tion equipment manufacturers should make every reasonable effort to improve the state of the art so that the steady-state alternating-current voltage extremes of any phase will be within ±3 percent of nominal at the point of regulation. This includes voltage change due to regulator adjustment error (field level), environment, speed range, no-load to full-load range, load unbalance between any two phases up to 30 percent of average total load, all at power factors from 1 to 0.75 lag.

Designers and detail specification writers need to consider also the following generation system characteristics (reference MIL-STD-704) not defined in IEEE 127:

(a) overvoltage versus time protection limits

(b) undervoltage versus time protection limits

(c) under-frequency-voltage limits

(d) low-frequency and high-frequency voltage transients (primarily due to load and control switching).

The basic purpose of IEEE 127 is to serve as a guide to show preferred (steady-state) frequency and voltage ratings for primary power systems. A careful study, including the pertinent factors noted above, was accomplished by the Flight Vehicle Systems Integration Subcommittee. The attached tabulation gives recommended standard frequencies and voltages for all types of aerospace electric apparatus for which standards appear practical.

The original draft of this revision to AIEE 700 was prepared by the following panel members under an assignment given by AIEE Flight Vehicle Electric System Subcommittee Chairman, T. B. Owen:

B. F. Varney, *Chairman*

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The IEEE Standards Committee takes this occasion to draw attention to the value of suggestions based upon experience gained in the application of the Standards to general practice. Any suggestions looking toward improvement in the Standards will be welcomed for the guidance of the committee in preparation of future editions, and should be communicated to the Secretary of the IEEE Standards Committee, Box A, Lenox Hill Station, New York 21, New York.

AEROSPACE EQUIPMENT
STEADY-STATE VOLTAGE RATINGS
(Direct Current)

Nominal System Designation (volts)	14	28	120
Generators			
Rated Voltages	15	30	125
Voltage Adjustment Range (Based on generator rated voltage)	+0 to —15%	+0 to —15%	+0 to —15%
*Continuous Duty Devices			
Rated Voltages	13	27	115
Voltage Range	±10%	±10%	±10%
*Intermittent Duty Devices			
Rated Voltages	12.5	26	115**
Voltage Range	±10%	±10%	±10%
***Battery-Operated Devices (Devices which must operate with or without the generator supplying power).			
Rated Voltages	11.5	23	—
Voltage Range	±25%	±25%	—
****Dielectric Tests (RMS Volts for 1 minute at 60 cycles or 120 percent of value shown for 5 seconds)			
Factory Test Volts	1500	1500	1500
****Field Test or Retest before and after use (CLEAN and DRY only)			
(75% of Factory Test Volts)	1125	1125	1125

Apparatus is to function satisfactorily over the voltage ranges given, but with performance not necessarily in accordance with guarantees at rated voltage.

*For operation from a voltage-regulated system. If operation is required from battery alone, use values for "battery-operated devices".

**It is assumed that most 115-volt wiring will be applied on the basis of thermal rating, and provisions for wider tolerances for voltage regulation on intermittent loads has not been made.

***Devices such as starters, et cetera, and items operated during starting, must operate under conditions of much wider voltage ranges. These devices are not covered by these Standards.

****In accordance with recommendations of AIEE No. 803 (now IEEE No. 135) Proposed Test Code for Aircraft Equipment Electrical Insulation, dated July 1957.

AEROSPACE EQUIPMENT
STEADY-STATE FREQUENCY RATINGS
(Alternating Current)

Nominal System Frequency (cycles per second)	400	2000	3200
Type I —Standard	±5%	±5%	±5%
Type II —Optimum	±1%	±1%	±1%
Type III—Precision	±0.01%	±0.01%	±0.01%
Type IV—Broad	±25%	±25%	±25%

Type I Standard Frequency is in accordance with MIL-STD-704, Military Standard, Electric Power, Aircraft, Characteristics and Utilization of, dated 6 October 1959.

Type II Optimum Frequency represents current state of the art capability.

Type III Precision Frequency represents close tolerance power for systems with high accuracy requirements which cannot be met using power with wider frequency tolerances.

Type IV Broad Frequency represents an alternating-current generating system with broad frequency tolerances such as results from direct, or simple, coupling of an alternating-current generator to a prime mover which is not regulated for frequency control.

Unless otherwise stipulated, Type I Standard Frequency is assumed to be applicable.

AEROSPACE EQUIPMENT
STEADY-STATE VOLTAGE RATINGS
(Alternating Current)

Nominal System Designation (volts)	115	115/200	230/400
Generators			
Rated Voltages	120	120/208	240/416
Adjustment Range	115 ± 5%	115/200 ± 5%	230/400 ± 5%
Continuous Duty Devices			
Rated Voltages	115	115/200	230/400
Voltage Range	±5%	±5%	±5%
Intermittent Duty Devices			
Rated Voltages	115	115/200	230/400
Voltage Range	+5 to —10%	+5 to —10%	+5 to —10%
Emergency Duty Devices			
Rated Voltages	115	115/200	230/400
Voltage Range	+5 to —15%	+5 to —15%	+5 to —15%
*Dielectric Tests (RMS Volts for 1 minute at 60 cycles or 120 percent of value shown for 5 seconds)			
Factory Test Volts	1500	1500	1800
*Field Test or Retest before and after use (CLEAN and DRY only)			
(75% of Factory Test Volts)	1125	1125	1260

Apparatus is to function satisfactorily over the voltage and frequency ranges given (simultaneously), but with performance not necessarily in accordance with guarantees at rated voltage.

*In accordance with recommendations of AIEE No. 803 (now IEEE No. 135) Proposed Test Code for Aircraft Equipment Electrical Insulation, dated July 1957.