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Aerospace series - Characteristics of aircraft electrical supplies

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Luft- und Raumfahrt - Eigenschaften der elektrischen Stromversorgung von Luftfahrzeugen

Série aérospatiale - Caractéristiques de l'alimentation électrique des aéronefs

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Luft- und Raumfahrt
Eigenschaften der elektrischen Stromversorgung von Luftfahrzeugen

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Central Secretariat or to any CEN member.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat : Rue de Stassart, 35, B—1050 Bruxelles

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Foreword

This European Standard has been prepared by the European Association of Aerospace Manufacturers (AECMA).

After inquiries and votes carried out in accordance with the rules of this Association, this Standard has successively received the approval of the National Associations and the Official Services of the member countries of AECMA, prior to its presentation to CEN.

According to the Common CEN/CENELEC Rules, the following countries are bound to implement this European Standard :

Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

0 Introduction

This standard has taken into consideration national documents together with ISO 1540 and STANAG 3456.

1 Scope and field of application

This standard specifies the characteristics of electrical power supplied to the terminals of equipment installed in the aircraft.

It also defines the supply systems and compatibility requirements for equipment together with the special systems with constant and variable frequency.

This standard applies to a.c. and d.c. on-board or ground systems.

2 References

ISO 1540	Aerospace - Characteristics of aircraft electrical systems
ISO 7137	Aircraft - Environmental conditions and test procedures for airborne equipment
EN 3371	Aerospace series - Bonding [1]
STANAG 3456	Aircraft electrical system characteristics [2]
STANAG 3516	Electromagnetic compatibility for aircraft electrical and electronic equipment [2]
MIL-STD-461	Electromagnetic emission and susceptibility requirements for the control of electromagnetic interference [3].

3 Definitions

3.1 Definition document

Standards or document giving the technical definition of equipment.

3.2 Electrical system (system)

An assembly constitued by the sources of electrical power, utilization equipment, safety devices and all common connections of the installation.

3.3 Power sources

They supply the power from one of the aircraft propulsion engines, a power conversion device, a ground support unit, or batteries.

3.4 Available power of a system

The power which can be used simultaneously under continuous steady-state conditions taking account of the specified conditions of use in the aircraft and the rated power of each power source.

3.5 Utilization equipment

Any equipment or any functional group of units consuming electrical energy.

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1) In preparation at the date of publication of the present standard.

2) This standard is published by : NATO, Military Agency for Standardization (MAS), B-1110 BRUSSELS.

3) This specification is published by : Department of Defense (DOD), the Pentagon, WASHINGTON, D.C. 20301.

3.6 Normal operation

This covers all the conditions of a system in which the utilization equipment shall retain its performance during the missions intended for the aircraft.

A distinction shall be made :

- « normal frequent » operation, i.e. usual systematic operating conditions (steady-state or transient).

Examples : variations in speed of aircraft engines and/or load of system supply from the ground.

Start-up procedures are at the limit of this type of operation.

- « normal rare » operation, which may occur randomly a limited number of times in the equipment life.

Examples : anomalies of load or control, transfer or paralleling of sources, normal clearing of certain faults and switching of load or engine, more significant than « normal frequent ».

3.7 Emergency operation

The condition of the portion of the electrical system remaining in service when the main power sources can no longer respond to requirements.

Emergency sources then used are accumulator batteries, converters or generators of limited power (not considered to be utilization equipment).

3.8 Abnormal operation

The consequence of a failure or disturbance bringing about the loss or deterioration of the system characteristics which may then attain the limits provided by the protective devices.

The extend and duration of this abnormal operation may escape inspection until the end of the flight.

3.9 Steady-state conditions

Operating conditions of the system when only negligible changes in electrical parameters appear which are not due to any variation in load or any fault.

3.10 Voltage values

The value of the a.c. voltage is defined by the r.m.s. value measured between each phase and the neutral, the value of the d.c. voltage is defined by the mean arithmetical value measured between the positive terminal and earth.

3.11 Transients

Momentary variations of a characteristic from its steady-state conditions. They result, for example, from the response of the generator regulator to a disturbance.

Brief undervoltages or interruptions due to switching, may be considered as transients.

3.12 Spikes

Brief variations, also called voltage peaks, compared with steady-state conditions or transients which arise in the distribution system, for example, from switching of inductive loads.

They generally produce a voltage peak and/or a wave train, the characteristics of which are dependent on relative impedances of the line, equipment and power source, and on the manner in which the interruption occurs.

3.13 Drift

This is a random and extremely slow variation in a controlled parameter inside the specified limits.

The speed of variation or drift rate of the parameter is expressed in Hz/min or in V/min.

3.14 Modulations

The modulation of the parameter is the cyclic (generally non-sinusoidal) or random variation of its maximum value around a mean value in steady-state conditions.

For a.c. power, the maximum value of modulation (of voltage or current) is the maximum difference between the peak values of the parameter measured on the most unfavourable phase and polarity.

For d.c. power, it is called « ripple », its value is the difference between the mean value (of voltage or current) and the maximum or minimum value attained, measured on either side of the mean value.

In both cases, modulation may be likened to the superimposition of an alternating wave on the base parameter.

A « harmonic analysis » [1] of this wave or of its envelope indicates the frequencies and amplitudes of its components, with a view to limiting them (see figure 8).

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1) Decomposition into « Fourier series ».

3.15 Frequency variations

During transients or modulations of frequency, the instantaneous value of the frequency « f » of a non-periodic wave is deduced from the interval « t » between two consecutive passages of the wave to zero, by the formula :

$$f = \frac{1}{2t}$$

Its speed (or rate) of variation is expressed in Hz/s.

The frequency, or rate of repetition, of the frequency modulation is expressed in the number of occurrences (or periods) per second or minute.

3.16 Total harmonic content (current or voltage)

The percentage of distortion (harmonics, modulation, etc.) compared with the sinusoidal basic wave.

It measures the ratio of the r.m.s. value of the total wave, reduced by the fundamental component, to the r.m.s. value of the fundamental periodic wave.

3.17 Individual harmonic content

The ratio between the r.m.s. value of the fundamental component and the r.m.s. value of the fundamental periodic wave.

The harmonic analysis [1] or spectrum of distortion decomposes a periodic wave giving the amplitude of its components depending upon their frequency.

4 Requirements common to all on-board systems

4.1 General conditions for power generation

The requirements applicable to the systems shall permit them to provide the types of operation in the conditions of use described and within the limits of the envelopes of figures 6 and 7.

Except where specified otherwise (e.g. nominal voltages), all the values of parameters specified in this standard shall be measured at the equipment terminals including during the power supply to the aircraft by a ground support unit, in conformity with this standard.

NOTE : in case of specific applications or necessity it may also be beneficial to increase or reduce the severity of the required characteristics for generators and systems. In this case the limit values of the parameters shall be the subject of an agreement between the interested parties, have the approval of the official Services and be specified in the particular specifications.

1) Decomposition into « Fourier series ».

4.1.1 Supplied power

In continuous steady-state conditions the power consumed on the system shall be between 5 % and 85 % of the available power.

In transient conditions the power to be switched shall be compatible with the generator regulation.

Examples : in « normal frequent » operation, establishment and cut-off from 5 % to 85 % of rated power of the source or sources, in « normal rare » operation this percentage may go from 0 % to 170 % (if applicable to the system overload capacity).

4.1.2 Operating selectivity

The behaviour of the regulation and the selectivity of the protective devices (primary and secondary) shall be such that :

- no single failure on the distribution system shall cause deterioration of the « normal » operation of the generators, nor that of the utilization equipment not involved by this failure ;
- the isolation of a fault having caused « abnormal » operation shall not have any effect on the other systems except a possible transient.

4.1.3 Interruptions

The duration of power interruptions which may occur in flight and on the ground in the case of transfer of sources shall not exceed 50 ms, except where specified otherwise, in this case they shall not exceed 150 ms.

The specification for each system or aircraft shall state the duration of these interruptions (wave form, etc.).

4.1.4 Spikes

All on-board systems shall be such that at the equipment terminals the characteristics of the voltage spikes generated by other equipment shall not exceed the values of table 1.

Depending upon the location and nature of the associated equipment and actuating device, the voltage spikes may occur in the form of a wave or wave train, of frequency 30 kHz to 2,5 MHz.

Phenomena of atmospheric origin are not within the scope of this standard.

The repetitive or permanent interference voltages transmitted or radiated by the system lines are the subject of standards STANAG 3516 (MIL-STD-461) or ISO 7137.

Table 1 - Spikes

Characteristics	Single wave	Per wave train
Maximum amplitude	+ 300 V peak − 400 V peak	± 400 V peak
Rise time	2 μs to 20 μs	0,5 μs to 10 μs
Duration of 1 wave	10 μm to 100 μm	2 μs to 20 μs
Max. duration of disturbance	-	500 μs

4.2 General requirements applicable to utilization equipment

4.2.1 Power supplies

Equipment shall only use one type of power supply.

This supply is that of the primary three-phase a.c. power system, in principle 115/200 V, frequency 400 Hz.

28 V d.c. supply shall be minimized except if it constitutes the primary generation of the aircraft.

Although not advised, power supplies of different types for the same equipment may be the subject of an agreement between the purchaser and the manufacturer, provided the systems described in this standard are used.

In this case, equipment shall withstand without damage the authorized variations of the two sources and/or the interruption of one or more of the power supply lines.

In certain specific cases, equipment forming part of sub-assemblies may receive power of another type (frequency and/or voltage), on condition that the power conversion remains internal to these sub-assemblies and does not disturb the other systems.

Such arrangements shall be the subject of agreements between the purchaser and the manufacturer.

In the case where equipment would require previous energizing to ensure its operation (pre-heating or storing), its consumption in the *waiting period* shall be maintained at the minimum value.

The wiring of return currents shall be carried out as follows : no point of equipment internal wiring shall be bonded to its casing.

All connections to neutral or negative (d.c.) shall be separately brought out from the equipment before being connected to the structure or the referenced earth.

The casing shall be bonded to the aircraft structure by an independent connection.

The details of application shall appear in standards dealing with interference elimination and bonding (see EN 3371).

4.2.2 Types of operation

Any equipment shall be capable of withstanding the voltages, frequencies, interruptions of supply, transients and spikes described in this standard under the following conditions :

In « normal » operation (frequent and rare), it shall deliver all its performances and operate with perfect safety.

The slight possibility of changing from « normal frequent » operation to « normal rare » shall be considered during the equipment design and the reliability study (it is in principle less than once per 100 flight hours).

In « emergency » operation, only the required equipment shall have the corresponding performance specified in the relevant standard or definition document.

The same applies to the equipment behaviour during « start-up » of aircraft engines.

In « abnormal » operation, equipment is not expected to retain full performance.

After return to normal conditions it shall recover automatically - unless otherwise stated - its performance without operational safety being affected.

The definition document of equipment shall :

- indicate the conditions capable of bringing about damage or malfunction ;
- specify any exceptions or deviations.

4.2.3 Power supply interruptions

During operation, equipment shall withstand all cut-offs of one or more supply cables however repetitive. These interruptions shall not have any other consequences than those of « abnormal » operation.

In the case of power supply interruptions, the voltage loss may be progressive : the recovery voltage may be followed by a so-called transient of « normal » operation.

Micro-interruptions or under voltages of variable duration may be seen as interruptions of supply by certain components.

In this case, equipment comprising digital and/or memory or sequential circuits shall be the subject of a behaviour check.