INTERNATIONAL STANDARD

ISO 6858

Second edition
2017-11

Aircraft — Ground support electrical supplies — General requirements

Aéronefs — Alimentations électriques de service au sol des avions — Conditions générales requises

Reference number
ISO 6858:2017(E)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 1, *Aerospace electrical requirements*.

This second edition cancels and replaces the first edition (ISO 6858:1982), which has been technically revised.

The main changes compared to the previous edition are:

— updated normative references, definitions and figures;

— new information regarding aircraft electrical load characteristics, facility capacity requirements and ac power types;

— updated protection and safety requirements; and

— addition of new Annex A and B with acceptable test listings for ac and dc systems respectively.

Introduction

The purpose of this document is to foster compatibility between the providers, distributors and users of aircraft ground support electrical power. This update takes into account several recent trends in aircraft electrical systems, including increase in nonlinear load content on aircraft.

Aircraft — Ground support electrical supplies — General requirements

1 Scope

This document specifies the electrical output characteristics and interface requirements between an aircraft and ground support electrical supplies. This includes all external electric power generation facilities, provided as part of a central source or in point-of-use application. Requirements for safety features are also included. Performance and safety issues under regional control are not addressed in this document. Requirements for ground traffic control purposes, such as towing points, identification and warning lights, etc. are also excluded.

The electrical characteristics relate to nominal 28 V DC and either 115/200 V or 230/400 V three-phase, 400 Hz AC outputs measured at the aircraft attaching connector as indicated in Figure 1.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 461-1, *Aircraft — Connectors for ground electrical supplies — Part 1: Design, performance and test requirements*

ISO 461-2, *Aircraft — Connectors for ground electrical supplies — Part 2: Dimensions*

ISO 1540, *Aerospace — Characteristics of aircraft electrical systems*

ISO 7137, *Aircraft — Environmental conditions and test procedures for airborne equipment*

ISO 12100, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 12384, *Aerospace — Requirements for digital equipment for measurements of aircraft electrical power characteristics*

ISO 13850, *Safety of machinery — Emergency stop function — Principles for design*

IEC 60204-1, *Safety of machinery — Electrical equipment of machines — Part1: General requirements*

IEC 61140, *Protection against electrical shock — Common aspects for installation and equipment*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 1540 and ISO 461 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
alternator speed
nominal speed at which the alternator operates to produce 400 Hz

3.2
altitude
maximum height in feet above sea level at which the *unit* (3.24) needs to operate and maintain characteristics within recommended limits

3.3
ambient temperature
temperature range in degrees Celsius in which the *unit* (3.24) needs to operate and maintain characteristics within recommended limits

3.4
break transfer
mode of transferring the aircraft load from aircraft power source to ground power facility or vice versa whereby power to the aircraft is momentarily interrupted

3.5
connector
supply cable interface with the aircraft

3.6
constant power load
AC utilization equipment which contains active elements that result in an inversely proportional draw of current to that of the applied voltage

3.7
dead front
area of equipment which operators access that has no live voltage potential

3.8
dielectric test
test where high voltages is impressed between a component and the chassis of the *unit* (3.24) to check the insulation characteristics

3.9
emergency stop
E-stop
manually activated switch that is placed in an easily accessible and highly visible position which when depressed causes an immediate stop to the provision of electrical power from the nearby *facility* (3.10) source

3.10
facility
equipment designed to supply electrical power to an aircraft on the ground, including means for power generation, conversion and distribution

Note 1 to entry: Two types of AC facilities are defined by this document. Type 1 is intended for use with more recent aircrafts that have a large electronic load content while Type 2 is intended for use with legacy aircrafts that have a large content of inductive motor loads.

3.11
ground power unit
external power unit
GPU
rotating or static source (or combination thereof) supplied by the ground *facility* (3.10) to source electrical power while the aircraft is on the ground

Note 1 to entry: It may be either a point-of-use or centrally located ground power electrical supply in land-based facilities, or a shipboard power supply in marine applications.

3.12
highest phase voltage limiting
means of limiting the highest phase voltage of the *unit* (3.24) output during any unbalanced load condition

3.13
line drop compensation
system of increasing the *unit* (3.24) output voltage in proportion to the current in the output cable(s) such that the voltage is held constant at the aircraft receptacle

3.14
nominal voltage rating
root-mean-square, line-to-neutral and line-to-line voltage at which the *unit* (3.24) output is rated

Note 1 to entry: The unit is normally set such that output voltage is maintained at this value.

3.15
output terminals
terminals on the ground power unit side of the output-power feeders

3.16
overload rating
time-limited output capacity

Note 1 to entry: It is measured in kVA for an AC unit and in ampere for a DC unit.

3.17
prime mover
source of power for driving the alternator

Note 1 to entry: This generally refers to either a diesel engine (engine generator set) or a utility power-driven motor (motor generator set) with respect to ground support equipment.

3.18
rated load
maximum continuous output in kVA for AC and maximum continuous current in ampere for DC

3.19
remote sensing
means of providing constant voltage at the aircraft receptacle(s) by sensing the voltage at the receptacle with separate leads in the output cable

3.20
temperature rise
rise in degrees above ambient for components of the *unit* (3.24)

3.21
total life
hours of use from time of delivery of the equipment to the using activity until its identity is destroyed by classifying it as salvage and/or subject to cannibalization

3.22
trip
actuation of electrical switchgear to inhibit or stop the flow of current through the device

3.23
type of mounting
means of mounting the *unit* (3.24) and controls

3.24
unit
complete power package

EXAMPLE *Prime mover* (3.17), alternator and all associated equipment and systems.

3.25
voltage transient recovery
time required for the output voltage to recover to and remain within the prescribed limits after load application or removal

4 Technical basis

Limits defined in this document are based upon historical as well as near-term projected equipment characteristics. They have been derived, following an analysis of ground power facilities, ground power distribution systems, aircraft distribution systems and aircraft user equipment characteristics in an effort to provide compatibility between ground power and the aircraft. These limits provide allowance for typical power quality degradations as power moves downstream from the aircraft's ground power connector (where this document applies) and arrives at the input terminals of user equipment (where ISO 1540 applies).

5 Electrical characteristics

5.1 General

5.1.1 Overview

As illustrated in Figure 1, the combination of the facility, the interconnecting cable and the on-board electrical network shall combine to provide electrical power at the aircraft user-equipment input as defined in ISO 1540. The characteristics viewed at the aircraft interfacing connector, when the facility is supplying power to the aircraft, are those specifically defined in this document. These are generally similar to those of ISO 1540 but account for items such as voltage drop in the aircraft network. Voltage at the facility source terminals are not defined.

Because of the complex nature of the aircraft network, and often the power quality degrading effects of aircraft user equipment, the characteristics defined by this document are likely to be inferior to those which the facility source might provide when connected to a simple load simulation (e.g. a linear load bank). Test conditions found in this document are therefore aimed at providing manufacturers with reasonable ability to verify their equipment's performance prior to connection to an aircraft.

The AC voltage characteristics stated below apply to line-to-neutral quantities. Line-to-line characteristics should be as a result of the specified line-to-neutral values. All AC voltages and currents are rms values unless otherwise stated.

All DC values are mean values unless otherwise stated.

The stated capacity of the facility equipment shall be provided at the end of the aircraft interfacing connector.

The facility equipment should be designed so that normal service maintenance will ensure the retention of these specified characteristics throughout the full range of operational and environmental conditions likely to be encountered in the location in which they are installed over its service life.

5.1.2 Alternating current (AC) power sources

5.1.2.1 General

The AC power system shall be three-phase, with a four-wire, wye-connected output, a nominal voltage of either 115/200 V or 230/400 V, a nominal frequency of 400 Hz and a phase sequence of A-B-C. The neutral point shall be connected in accordance with the circuits shown in Figure 2. If tied to the chassis ground, the tie shall be capable of withstanding maximum ground fault current for a minimum of 5 s.

The output voltage shall be sufficiently adjustable to allow the checking of overvoltage and undervoltage protective devices in an unloaded condition.

NOTE AC facility performance can be measurably affected by the formation of the three-phase cable bundle between the facility source and the aircraft. In addition to basic ampacity considerations, cabling is preferred which maintains equal distances between any two phases and between each phase and neutral conductors.

5.1.2.2 AC source rating

Two distinct AC source types, Type 1 and Type 2, are defined in this document. Type 1 AC sources are defined to support all aircraft types and load suites. Type 2 AC sources are defined to support classical aircraft with load conditions that are predominantly motor loads.

Each ground facility source shall indicate its continuous power capacity in kilo-volt-amperes (kVA). Its short-term overload capacity shall be a function of its continuous capacity according to Table 1. Continuous power capacity and source type (Type 1 or Type 2) shall be clearly marked for operator inspection.

Power factor and overload capability as a function of the type classification shall be as follows.

Table 1 — Minimum capacity requirements for AC facility sources

AC facility capacities		Continuous	Overload (% of rated kVA)			
Type	Power factor range	(% of rated kVA)	10 min	5 min	10 s	2 s
1	0,8 lagging to unity	100 %	110 %	125 %	140 %	—
	0,7 to 0,8 lagging	—	—	—	140 %	200 %
2	0,8 lagging to unity	80 %	—	100 %	—	—
	0,7 to 0,8 lagging	100 %	—	—	120 %	150 %

NOTE 1 Power factor range is the average three-phase power factor. Individual phase power factors can be different.

NOTE 2 Type 1 or Type 2 facility requirement is per aircraft manufacturer direction.

NOTE 3 Aircraft with multiple facility connections can assume that all are independent 90 kVA sources.

5.1.3 Direct current (DC) power sources

5.1.3.1 General

The DC power system shall be a two wire system having a nominal voltage (at the aircraft plug) of 28 V, the output of which shall be connected in accordance with the circuits shown in Figure 3.

5.1.3.2 DC source rating

The continuous and engine start rating of the DC ground power facility, in amperes shall be clearly marked for operator inspection.

Engine start rating, which is also used for wash and purge cycles, is required for a minimum of 30 s to accommodate both a short-term, peak current inrush and an overload value during engine motoring.

The facilities' peak current capability shall be adjustable, as required to coordinate with different aircrafts. Recommended values for engine start rating, related to the continuous rating, are as follows.

Continuous rating	Recommended engine start rating
a) 300 A	between 600 A and 1 200 A
b) 350 A	between 700 A and 1 400 A
c) 400 A	between 800 A and 1 600 A
d) 600 A	between 1 200 A and 2 000 A
e) 800 A	between 1 200 A and 2 500 A

Declaration of any additional overload current capability, and the associated time period the facility may provide, shall also be clearly marked for operator inspection.

NOTE Current levels listed above exceed those defined by ISO 461-1.

5.2 Interface connector

The interconnecting cable shall be terminated with a ground supply connector complying with the requirements of ISO 461-1 and ISO 461-2 for all continuous ratings supported.

NOTE 230 V AC equipment is not defined by ISO 461-1 and ISO 461-2. Suitable styles for 230/400 V ground connection plugs and sockets would need to be defined in the International Standards to support the usage of higher voltage systems.

5.3 Electromagnetic interference

5.3.1 Utility interface

If the facility requires a utility power input, it shall be tested in accordance with the requirements of the relevant national standard.

5.3.2 Aircraft interface

The facility shall be tested for conducted emissions in accordance with the requirements of ISO 7137, Category B limits.

5.4 AC steady-state output characteristics

5.4.1 General

AC voltage characteristics are to be guaranteed at the mating interface between the ground facility plug and the aircraft connector, as indicated in Figure 1, throughout the extremes of electrical loading and environmental conditions stated in this document.

5.4.2 Steady-state AC load characteristics

Table 2 lists the range of AC steady-state aircraft load characteristics expected to be provided through the aircraft connector(s) during normal (no failure) conditions.

Table 2 — Aircraft steady-state loading characteristics

Parameter	Minimum	Maximum	Units	Comment
Current draw	0	100 %	Rated amperes	Continuous, as per Table 1
Power factor	0,7 lagging	Unity	—	Each phase PF is independent of the other two phases.
Current imbalance	0	1/3	—	Facilities of up to 40 kVA
	0	1/6	—	Facilities of more than 40 kVA
Single-phase rectifier load content	0	1/9	Phase kVA rating	Rectifier load may be on any or all phases.
Three-phase (6-pulse) rectifier load content	0	1/6	Output kVA rating	—
Three-phase transformer rectifier (12-pulse)	0	1/3	Output kVA rating	—
Three-phase transformer rectifier (12-pulse) with constant power load characteristic	0	1/3	Output kVA rating	Type 1 facilities of more than 60 kVA
NOTE 1 In all cases, additional load may be resistive.				
NOTE 2 Conditions shown may appear simultaneously within the facilities capacity limitations.				

5.4.3 Steady-state AC voltage performance

5.4.3.1 General

AC ground power facility steady-state electrical characteristics at the aircraft connector shall be within the limits of Table 3 for all load conditions identified in Table 2. In cases where there is more than one aircraft connection with the ground power facility, all outputs shall be maintained within these limits.

Phase relationship between the three phases is as shown in Figure 4.

5.4.3.2 Highest phase voltage limiting feature

Means shall be provided in any Type 1 ground power facility to limit the highest phase voltage to 124 V (248 V for 230/400 V systems) at all aircraft connectors during unbalanced load conditions.

5.4.3.3 Line drop compensation feature

Means shall be provided in the ground power facility to compensate for the reduction in AC voltage between the ground power facility and the aircraft connector (due to voltage drop in the interfacing cable) such that the characteristics of Table 3 are maintained during all steady-state loading conditions.

Sources with multiple outputs shall coordinate these regulation features to accomplish the performance required in Table 3 during conditions of unequal loading of the individual outputs.

5.4.3.4 Voltage regulation in presence of highly distorting loads

Means of voltage sensing for the regulation function shall maintain regulation during conditions of up to 10 % voltage total distortion.