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ELECTRICAL SUPPLY OF AIRCRAFT DURING PARKING

Abstract: *The elaboration discusses selected aspects of parking supply of aircraft with electricity generated by mobile, airfield sources. In terms of sublime electrical and electronic systems, as well as avionic systems installed on-board of contemporary aircraft, the quality of electricity supplied by ground sources results in their manufacturers facing with high requirements that are contained in relevant standards and regulations. The quality of electricity generated by ground sources and their compatibility have a direct impact, among others, on the calibration of aircraft avionics systems during the ground flight preparation, which directly contributes to the safety of air operations. Therefore, the possibility of constant real-time monitoring of the supplied electricity (specific parameters) enabling immediate identification, recording, adjusting the deviations, hence, preventing damage or improper preparation of an aircraft for flight, becomes a non-trivial issue.*
Keywords: power supply of aircraft on the ground, mobile power devices, GPU

Streszczenie: *W niniejszym opracowaniu omówiono wybrane aspekty elektrycznego zasilania postojowego statku powietrznego przy użyciu źródeł przenośnych i lotniskowych. Pod względem zaawansowanych systemów elektrycznych i elektronicznych, jak również systemów awionicznych zainstalowanych na pokładzie współczesnego statku powietrznego, jakość elektryczności dostarczanej przez źródła naziemne powoduje, że producenci borykają się z problemem wysokich wymogów zawartych w odpowiednich normach i regulacjach. Jakość elektryczności generowanej przez źródła naziemne oraz ich kompatybilność mają bezpośredni wpływ między innymi na kalibrację systemów awionicznych statku powietrznego podczas przygotowania do lotu, co bezpośrednio przekłada się na bezpieczeństwo operacji powietrznych. Dlatego, możliwość ciągłego monitorowania w czasie rzeczywistym dostarczanej elektryczności (określone parametry) umożliwiającej natychmiastową identyfikację, rejestrację, dostosowywanie odchyleń a co za tym idzie, zapobieganie powstawaniu uszkodzeń oraz nieprawidłowemu przygotowaniu statku powietrznego do lotu, jest kwestią niezwykle istotną.*
Słowa kluczowe: naziemne zasilanie statku powietrznego, mobilne urządzenia zasilające, GPU

1. Introduction

An efficient ground handling system for aircraft, supported with devices meeting the highest requirements stipulated in relevant international regulations and standards must guarantee their reliable operation.

In the era of intensive aviation technology development associated with the appearance of new process possibilities, sublime aircraft designs, avionics equipment and modern propulsion systems, ground flight preparation is a complicated procedure directly impacting the execution of air operations.

Devices for aircraft ground handling (AGH), in the course of providing ground services – in the majority – are directly connected to airframe systems and objects, such as electric and electronic system, hydraulic, air, fuel, oxygen and nitrogen systems. Therefore, they must be characterised by high quality and reliability, not deviating from the quality of integral systems installed on board of the aircraft.

Depending on the purpose, AGH devices are classified into several groups, which include:

- distributors;
- electrical power units;
- compressors;
- battery charging stations (as a separate group);
- hydraulic devices;
- oxygen and nitrogen devices;
- air conditioners, heaters, de-icers and dryers, as a separate group;
- tugs;
- other devices including washing stands, floodlights, jacks, cylinders, etc.

The group of the most noticeable devices in the course of parking procedures for aircraft are electrical power supplies, used to supply the on-board systems with electricity:

- during engine start-up,
- when checking the technical condition of the on-board equipment at any location within the airfield or landing field.

The devices can be operated in hangars, as well as outdoors, in the following weather conditions:

- operating temperature range from - 30°C to + 55°C,
- max. operating relative humidity 96% at a temperature of +35°C.

Domestic examples (WCBKT S.A.) of such devices are:

Fig. 1. Electrical power unit LUZES V/D

Fig. 2. Electrical power unit LUZES V/N

Fig. 3. Electrical power unit LZE-6/M

Fig. 4. Electrical power unit LUZES II/M

Fig. 5. Electrical power unit GPU-7/90 TAURUS

Two basic principles of operation of the power units can be distinguished:

- 400 Hz static power unit, for example, with a capacity of 60, 90, 120, 150, 180 kVA, which is an advanced rectifier-inverter system,
- rotating power unit (machine), for example with a capacity of 40, 60, 90, 120, 150, 180 and 315 kVA, which is a classical motor-generator system.

In brief, it can be concluded that regardless of the principle of operation of a 400 Hz power unit, we can define two essential power supply systems:

- local: a 400 Hz power unit, started and connected individually, is located by an AC. The power unit is loaded solely by the consumers in a given AC.
- central: a 400 Hz signal is generated by one or more 400 Hz units operating in parallel on a joint output. The number of operating units depends on the current demand. Next, the signal is distributed to all active power take-off points, through a 400 Hz distribution system.

In central systems, in the case of significant distances from the 400 Hz “machine house” to the take-off points (positions near the skybridge, remote positions), the transmission is performed at an elevated voltage of 460V. Right at the take-off point, using a special transformer, the voltage is lowered and adjusted to the rated voltage of 115/200V.

A very important aspect in the functioning of the systems is the quality of electricity generated by ground sources and their compatibility, which have a direct impact, among others, on the calibration of aircraft avionics systems during their ground pre-flight preparation, which directly influences the safety of air operations.

2. Quality-related aspects

The air traffic law introduces the provision of IATA AHM, which defines the quality of energy supplied to aircraft through the international standard ISO 6858:2017 "Aircraft — Ground support electrical supplies — General requirements". The Polish translation of standard PN-ISO 6858:1997 was withdrawn on 3/9/2018. The currently applicable is the international edition in English ISO 6858:2018 (EN), which is the second edition, replacing the edition ISO 6858:1982.

The essential changes are:

1. Clarification of the division of ground power units in view of the device capacity.

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.

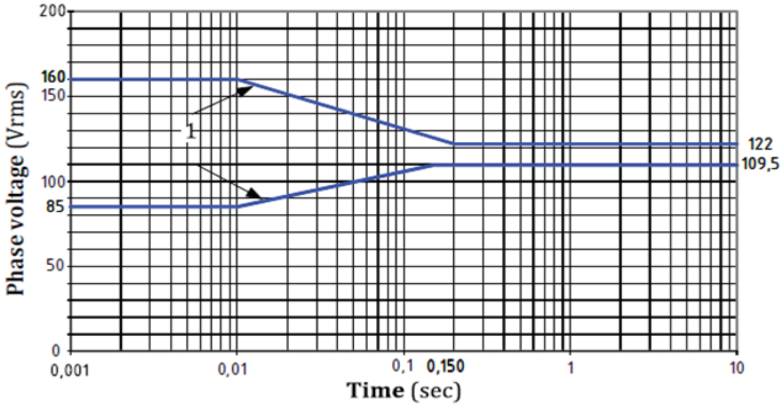
The facilities' peak current capability shall be adjustable, as required to coordinate with different aircrafts. Recommended values for engine start rating, related to the continuous rating, are as follows.

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.

2. Introducing new information on aircraft load characteristics.



Key

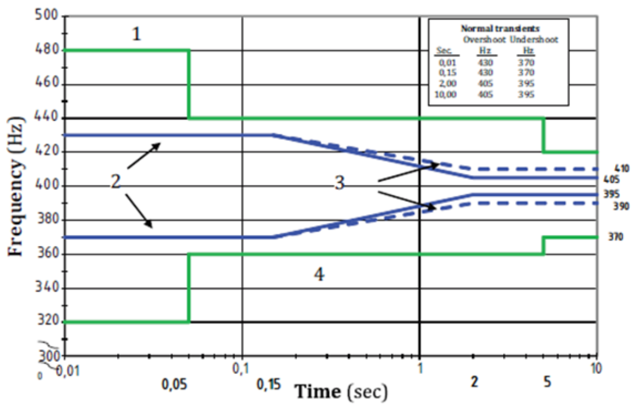
1 normal transients

NOTE 1 Limits are for rms values. Peak values are a function of the values shown and the crest factor limits of Table 3 (Vpk = crest factor × Vrms).

NOTE 2 Limits for 230 V are 230/115 times those shown.

Figure 8 — Envelope for normal AC voltage transients

3. Tightening the requirements regarding the alternating voltage frequency



Key

1 over frequency trip limit
2 normal transients
3 overload transients
4 under frequency trip limit

NOTE Frequency transients of less than the time periods shown are not identified.

Figure 9 — Envelope for AC frequency transients

4. Clear determination of the electricity quality measuring method

A.6 AC facility transient load tests

A.6.1 Step loads test

Apply the following step load and removals and observe that the transient frequency and voltage at the aircraft connector remain within the transient limits specified in Clause 5:

a) 0 % to 25 % at 0,8 PF;

b) 0 % to 25 % at unity;

c) 0 % to 50 % at 0,8 PF;

d) 0 % to 50 % at unity;

e) 0 % to 100 % at 0,8 PF;

f) 0 % to 100 % at unity (Type 1 only);

g) 50 % to 0 % at 0.8 PF;

h) 50 % to 0 % at unity;

i) 100 % to 2 % at 0,8 PF;

j) 100 % to 2 % at unity (Type 1 only).

A.6.2 Motor start load test

Apply the pre-loads and motor start loads, as defined in Table A.4, and observe that the transient frequency and voltage at the aircraft connector remains within the limits specified in Clause 5.

A.7 AC facility protection tests

Provide sufficient stimulus to cause conditions requiring exercise of the following protective functions and verify appropriate responses:

a) overvoltage;

b) undervoltage;

c) frequency;

d) overcurrent and short circuits;

e) phase sequence;

f) DC content (if applicable);

g) open neutral/phase conductor(s);

h) earth/ground fault (if applicable).

A.8 AC facility example test data sheets

Suppliers wishing to show verification of meeting the AC facility test requirements of this document shall prepare documentation of their test results. An acceptable example is shown in Table A.5.

Table A.5 — Acceptable test data sheets for AC facilities

Cover sheet

Manufacturer	
Model	
Facility type (1 or 2)	
Rating (kVA)	
Output voltage (115/200 or 230/400 Vrms)	
GPU-to-aircraft stinger style/length used for test	
Load equipment utilized	
Test date(s)	
Test location	
Test notes (if desired)	

An important parameter characterising the electromagnetic devices for ground power supply of aircraft is their compatibility.

Electromagnetic compatibility EMC) is defined as an ability of a given electrical or electronic device to operate properly in a specified electromagnetic environment and not to emit electromagnetic field interference, which would disturb the correct operation of other devices within this environment.

Due to the sensitivity of electronic and avionics systems of an aircraft to various types of disturbance during their ground inspections and calibrations, the airfield power units, prior to being approved for use, are subject to a series of specialist tests for conformity with specific standards:

- Polish Standard PN-EN 55022:2013 "IT equipment. Characteristics of radio-electric disturbance. Permissible levels and measurement methods";
- Polish Standard PN-EN 61000-4-2:2011 (PB-3-01 "Immunity. Electrostatic discharge", edition II of 25/3/2013);
- Polish Standard PN-EN 61000-6-2:2008 "Electromagnetic compatibility (EMC). Part 6-2: General standards. Immunity for industrial environments";
- Polish Standard PN-EN 61000-6-4:2008 "Electromagnetic compatibility (EMC). Part 6-4: General standards. Emission standard for industrial environments".

Below, you can find sample test parameters of an airfield power unit TAURUS GPU 7/90 by a domestic manufacturer WCBKT S.A.

1. Radiated interference test

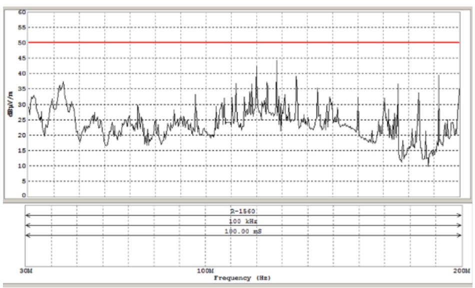


Fig. 6. Radiated interference level over the frequency band of 30MHz÷200MHz; vertical polarization

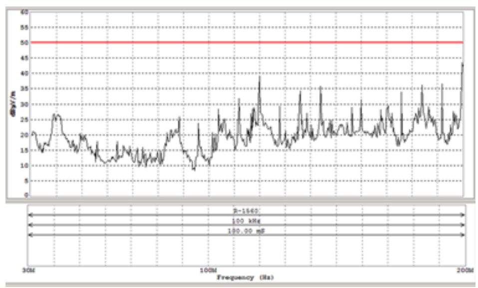


Fig. 7. Radiated interference level over the frequency band of 30MHz÷200MHz; horizontal polarization

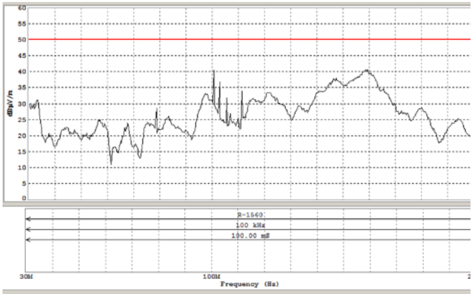


Fig. 8. Radiated interference level under load, and with GPU 7/90 TAURUS deactivated - vertical polarization

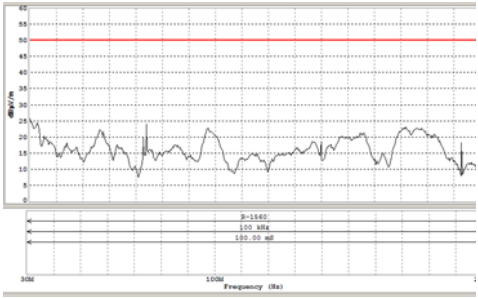


Fig. 9. Radiated interference level under load, and with GPU 7/90 TAURUS deactivated - horizontal polarization

2. Conducted interference test

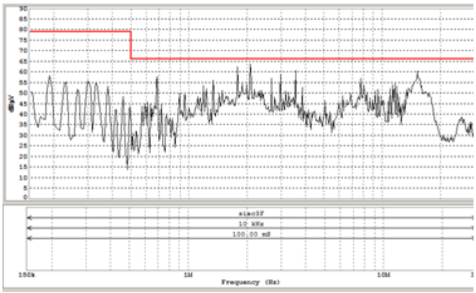


Fig. 10. Conducted interference level over the frequency band of 150kHz÷30MHz; cables plus 28V DC

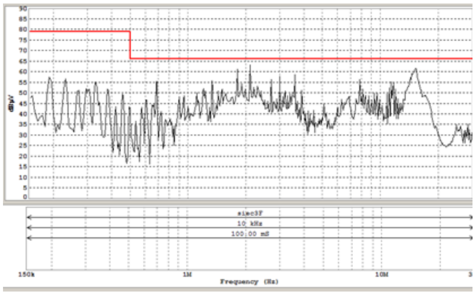


Fig. 11. Conducted interference level over the frequency band of 150kHz÷30MHz; cables minus 28V DC

3. Resistance to radiated exposure

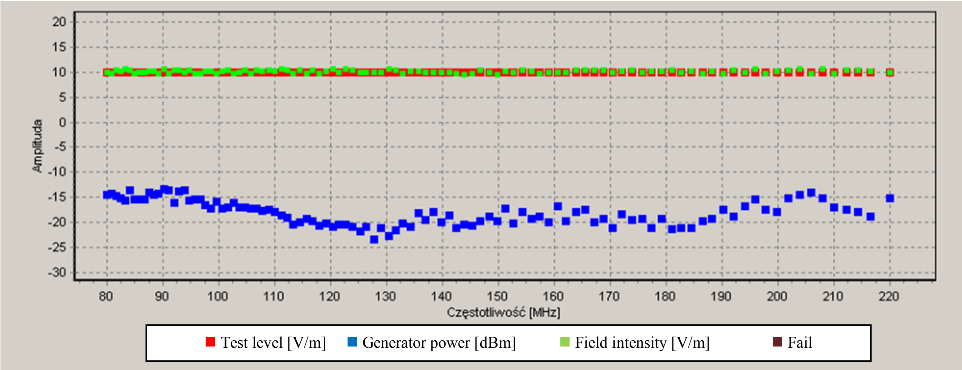


Fig. 12. Displayed test level, actual electromagnetic field intensity and the generator power necessary to generate it; vertical polarization

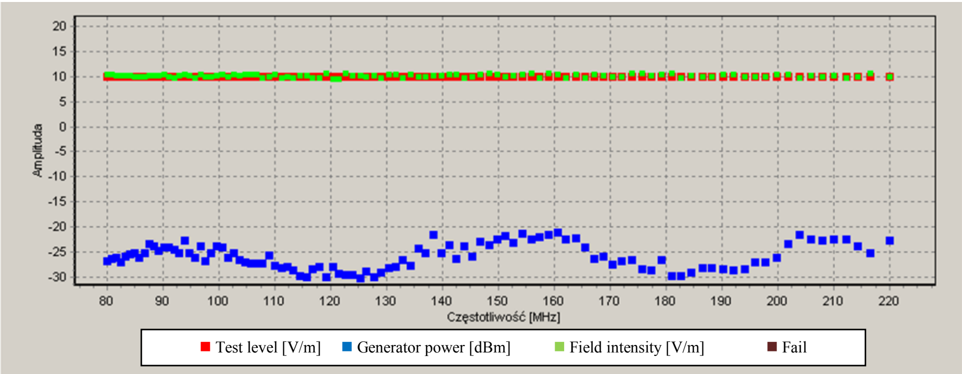


Fig. 13. Displayed test level, actual electromagnetic field intensity and the generator power necessary to generate it; horizontal polarization

3. Real-Time inspection of supplied electricity (certain parameters).

Constant monitoring, controlling and acquiring information regarding the parameters of aircraft ground handling devices, including power equipment, ensures their relatively optimal utilization, as per the planned tasks.

In order to obtain such information, it is necessary to construct a remote diagnostics system intended to collect diagnostic data, which not only cover the monitoring of current operating parameters and identify the occurring malfunctions (deviations), but also determine the actual device dislocation position.

Trying to meet the aforementioned issues halfway, the only domestic manufacturer of Aircraft Ground Handling equipment – Wojskowe Centralne Biuro Konstrukcyjne S.A. developed and launched a test version of a Remote Diagnostics System for the devices it manufactures. The system was tested based on the "TAURUS" power unit.

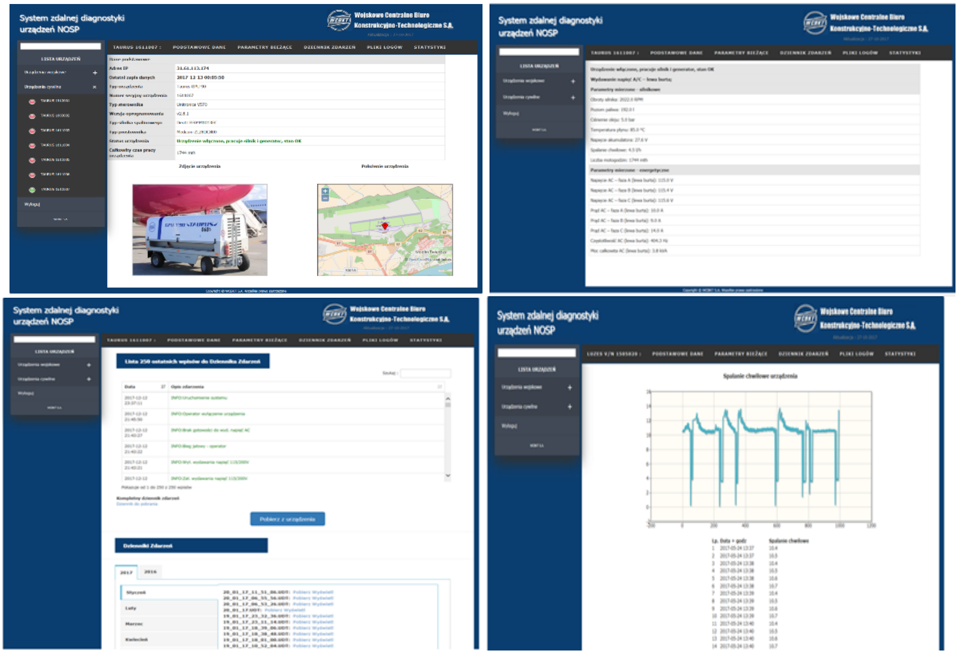


Fig. 14. Examples of reading acquired from the system

The system is designed to collect diagnostic data from AGH devices. The data is used for current functional analysis of monitored devices and - which is the main purpose of the system - for analysing the operation of the devices (parameter quality). The collected data is also used to generate statistical analyses showing, e.g. the number of operated hours, fuel consumption, device technical condition, etc. according to standard statistical and probabilistic relationships. Whereas, determining the technical condition of an object (device) requires adopting the following inference principle:

$$\forall i \in (1,2,\ldots,n) \;\; WS = \left[x_i, \frac{dx_i}{dt} \right] \in WT \Rightarrow \text{Obiekt sprawny}$$

where: n – number of analysed parameters,

WS – device technical condition vector,
x_i – n diagnostic parameter of device operation,
WT – technical conditions specified by the Manufacturer.

The data collected by a Remote Diagnostics System of AGH devices is directly associated with device characteristics. For this purpose, the following was prepared and installed on the devices: a set of measuring systems together with a dedicated communications protocol; software for the entire system was developed. In consequence, it is possible, depending on the purpose of the device, to send their selected operating parameters.

4. Conclusions

The applicable standards and regulations regarding the quality parameters of aircraft ground handling devices set stringent requirements for their manufacturers. This aspect also applies to organisations using the devices for direct servicing and pre-flight ground preparation of aircraft. This elaboration presents selected issues in the field of meeting the quality-related requirements and the qualification tests for power units used within the ground handling process.

It also emphasised the significance of applying relevant standards and regulations within such devices, and the possibility of continuous, remote monitoring of the operating parameters, which directly contributes to flight safety.

5. References

1. System Diagnostyki Urządzeń NOSP *[Diagnostics System for AGH devices]*. WSBKT S.A. sygn.1.36.3-1 Warszawa 2015.
2. Standard ISO 6858:2017
3. Test report GPU 7/90 TAURUS WIŁ 2013.