SLOVENSKI STANDARD
oSIST prEN 4888:2022

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Aeronavtika - Potniški sedeži v komercialnih letalih - Preskušanje zanesljivosti

Aerospace Series - Commercial aircraft passenger seats - Reliability testing

Luft- und Raumfahrt - Fluggastsitze für die zivile Luftfahrt - Zuverlässigkeitstests

Série aérospatiale - Sièges passagers d’avions commerciaux - Essais de fiabilité

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Aerospace Series - Commercial aircraft passenger seats - Reliability testing

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This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee ASD-STAN.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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European foreword

This document (prEN 4888:2022) has been prepared by the Aerospace and Defence Industries Association of Europe — Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this document has received the approval of the National Associations and the Official Services of the member countries of ASD-STAN, prior to its presentation to CEN.

This document is currently submitted to the CEN Enquiry.

Introduction

A well-organized reliability management process is very important for manufacturers in order to achieve the reliability requirements set by the customers and to continuously maintain market position. The prediction of the failure behaviour of a product in the field should be accomplished as early as possible. An optimized reliability management process contains qualitative and quantitative reliability methods based on fatigue damage calculations, test data, condition monitoring, field failure data and warranty cost analysis, which have to be fused to a closed loop failure analysis system in order to consider all lessons learned in the analysis tools used in product development.

Customers expect a reasonably priced product for reasons of time and costs, which has a high level of quality and reliability at the same time.

The determination of the reliability of products is an essential component in the development and manufacture of products. The reliability of these technical products describes the property of not failing within a specified time period and to keep the failure rate on an acceptable rate until the end of life in given functional and ambient conditions.

The reliability and its characteristics are described via the confidence level and confidence range. An important contribution concerns the analysis of service life information resulting from corresponding tests or reported from the service by customers.

Reliability testing involves the definition, implementation and analysis of tests that are to represent the use of seats in aircraft.

Furthermore, the second largest task of reliability testing involves analysing field data provided as feedback from airlines. In this way, the data are validated based on previously conducted tests and prognoses for future seat models are compiled.

1 Scope

This document specifies minimum reliability test requirements for sub-components of commercial aircraft passenger seats. Test procedures including in-service load cases regarding passenger behaviour for sub-seat components are defined. Abuse loads are excluded. This document is applicable to the sub-seat components such as but not limited to backrest, headrest, armrest, table, literature pocket and control elements.

This document does not apply to belts, Inflight-Entertainment, seat dress cover and cushions.

Additional environmental influences like temperature, radiation, gases and liquids may also alter the reliability of the aircraft passenger seats and their sub-components over their lifetime but are not taken into consideration of this document.

Tests on abrasion and surface durability are defined in EN 4860, EN 4864 and EN 4876.

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.

EN 1728:2012, *Furniture - Seating - Test methods for the determination of strength and durability*

SAE J826, Devices for Use in Defining and Measuring Vehicle Seating Accommodation[1]

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
reliability
probability, that a product will not fail during specified time period under given functional and environmental conditions

[1] Available at www.sae.org

4 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

A/C	aircraft
ATD	anthropomorphic testing device
CTR	centre
DWD	downward
FOLD-EXT	fold extant
FC	flight cycle
FH	flight hour
FWD	forward
LAP	load attack point
LH	left hand
LR	long range flight
MTBF	mean time between failure
MTBUR	mean time between unexpected/unscheduled repair/removal
MTTF	mean time to failure
RH	right hand
RWD	rearward
SR	short range flight
SWD	sideward
TTL	taxi – take off – landing
UWD	upward

5 Reliability testing of aircraft sub-seat components

5.1 Failure behaviour

The failure behaviour of a product is recorded by the reliability and is, additionally to the functional properties, an essential criterion for the product assessment.

Decorative is to be interpreted as a cosmetic addition to the substrate materials functionality.

During the tests, occurrence of defects will be separated in four different categories:

a) minor: defects or cosmetic findings, which have no or only a minor effect on the functionality of the seat or a component and may be repaired or exchanged easily if necessary; depending on the occurrence, these defects may be considered for the MTBF evaluation; test will be continued;

b) major: defects which have a direct effect on the functionality of the seat or a component; these defects will be considered for the MTBF evaluation; test has to be stopped;

c) safety: defects which have a direct effect on the safety of an occupant, these defects will be considered for the MTBF evaluation. The test shall be stopped and a safety evaluation shall be done.

5.2 Reliability characteristics and their conversion

The following reliability characteristics are usually taken as a basis from the customer viewpoint:

a) in case of non-maintainable units: mean time to failure (MTTF);

b) in case of maintainable units: mean time between failure (MTBF);

c) mean time between unexpected/unscheduled repair/removal (MTBUR).

These values are usually given in flight hours (FH) and shall be converted for the tests in the load spectrum. Assuming that a load spectrum corresponds to the use of the component during a flight cycle (FC), it is necessary to determine how many flight cycles an aircraft undergoes during the given MTBF time in flight hours.

This results from multiplication of the requirement in flight hours by the ratio of flight cycles per flight hour:

$$MTBF_{Load\ collective} = MTBF_{FH} \cdot \frac{FC_{day}}{FH_{day}} \quad (1)$$

where

$MTBF_{Load\ collective}$	is the mean time to failure load collective;
$MTBF_{FH}$	is the mean time to failure in flight hour (h);
FC_{day}	is the flight cycle per day;
FH_{day}	is the flight hour per day (h).

The MTBF values determined from tests are converted into flight hours by transposing the equation according to $MTBF_{FH}$:

$$MTBF_{FH} = MTBF_{Load\ collective} \cdot \frac{FH_{day}}{FC_{day}} \quad (2)$$

where

$MTBF_{FH}$	is the mean time to failure per flight hour (h);
$MTBF_{Load\ collective}$	is the mean time to failure load collective;
FC_{day}	is the flight cycle per day;
FH_{day}	is the flight hour per day (h).

Failure and degradation parameters are defined in each individual testing criteria.

5.3 Aspect test cycle time versus flight time and range

To define scenarios, representing the daily usage of aircraft sub-seat components, different types of commercial aircraft shall be considered. Single aisle aircraft mainly used for short and medium-range flights and twin aisle aircraft used for mid-, long- and ultra-long range flights. As the flight hours per flight cycle ratio differs between these two categories of commercial aircraft, different load scenarios, occurring during one flight (e.g. repetition of a specified load case per flight), shall be considered.

As a minimum utilization of the aircraft, the data from Table 1 shall be used for the transformation of MTBF values from load collectives into flight hours and vice versa according to 5.2. Deviation from these values shall be justified by statistical data.

Table 1 — Data for short range and long range

	Value
Short range	
Average flight duration	1,5 h
Average daily utilization	8,5 h
Average flight cycles per day	5,8
Long range	
Average flight duration	8,0 h
Average daily utilization	13,0 h
Average flight cycles per day	1,6

5.4 Determination of reliability characteristics

The systematic failure behaviour rate, i.e. failure rate shall be calculated according to Formula (3).

$$\lambda(t) = \frac{\beta}{T} \cdot \left(\frac{t}{T}\right)^{\beta-1} \tag{3}$$

where

$\lambda(t)$ is the failure rate (per load collative);

T is the characteristic lifetime (number of load collectives);

t is the running time (number of load collectives);

β is the Weibull shape parameter.

The MTTF can be calculated according to Formula (4).

$$MTTF = T \cdot \Gamma\left(\frac{1}{\beta} + 1\right) \tag{4}$$

where

$MTTF$ is the mean time to failure (number of load collectives);

T is the characteristic lifetime (number of load collectives);

t is the running time (number of load collectives);

β is the Weibull shape parameter;

Γ is the Gamma function.

If the characteristic lifetime T is unknown, it can be calculated according to Formula (5).

$$T = \left(\sum_{i=1}^{n} \frac{t_i^{\beta}}{x} \right)^{\frac{1}{\beta}} \qquad (5)$$

where

T	is the characteristic lifetime (number of load collectives);
t_i	is the running time of each test (number of load collectives);
β	is the Weibull shape parameter;
x	is the number of failure found;
n	is the number of samples.

The MTTF can then be calculated according to Formula (6).

$$MTTF = \left(\sum_{i=1}^{n} \frac{t_i^{\beta}}{x} \right)^{\frac{1}{\beta}} \cdot \Gamma\left(\frac{1}{\beta} + 1 \right) \qquad (6)$$

where

$MTTF$	is the mean time to failure (number of load collectives);
t_i	is the running time for sample i (number of load collectives);
β	is the Weibull shape parameter;
x	is the number of failure found;
n	is the number of samples;
Γ	is the Gamma function.

Typical Weibull shape parameters for different materials are shown in Table 2 and shall be used.

Table 2 — Typical Weibull shape parameters

Material	Weibull shape parameter β
Aluminium alloys (2024/3.1355), (7075/3.4365)	4,0
Titanium alloys (Ti6Al4V/3.7164)	3,0
Steel ($R_m \leq$ 1 655 MPa)	3,0
Steel ($R_m >$ 1 655 MPa)	2,2

For other materials an estimation of the shape parameters should be compared to fixed values and if no other proven data are available a conservative choice should be selected by using a Weibull shape parameter of $\beta \geq 2{,}2$.

The method in 5.4 is representing non-random failure behaviour and is therefore more accurate as the simplified method shown in Annex A.

EXAMPLE 1 Five aluminium armrests ($\beta = 4$) of a long range seat were tested according to loads given in Clause 8 until occurrence of a failure. The results of these 5 tests are shown in Table 3.

Table 3 — Example test results

Repetition	Running time (load collectives)	Findings
1	5 961	Armrest structure cracked
2	2 761	
3	3 301	
4	4 536	
5	3 305	

$$MTTF = \left(\frac{5961^4 + 2761^4 + 3301^4 + 4536^4 + 3305^4}{5} \right)^{\frac{1}{4}} \times \Gamma\left(\frac{1}{4} + 1 \right) = 4462 \times 0,9064 = 4044 \text{ load collectives}$$

According to 5.2, 4 044 load collectives at a long range seat are representing a *MTTF* of 32 350 flight hours.

It may happen, that after a reasonable time, no failure will be found and the test is stopped. In this case the method above cannot be used for the evaluation.

If no failure is found, only statistical minimum values can be determined with the formulas below:

$$MTTF_{min} = T_{min} \cdot \Gamma\left(\frac{1}{\beta} + 1 \right) \quad (7)$$

where

$MTTF_{min}$ is the minimum mean time to failure (number of load collectives);

T is the characteristic lifetime (number of load collectives);

β is the Weibull shape parameter;

Γ is the Gamma function.

with

$$T_{min} = \left(\frac{2 * \sum_{i=1}^{n} t_i^{\beta}}{X^2_{2(x+1);1-\frac{\alpha}{2}}} \right)^{\frac{1}{\beta}} \quad (8)$$

where

T_{min} is the minimum characteristic lifetime (number of load collectives);

t_i is the running time of each test (number of load collectives);

β is the Weibull shape parameter;

x is the number of failure found;

X^2 is the Chi-Square distribution;

α is the statistical level of significance (1 % to 99 %).

EXAMPLE 2 The armrest from the example above was improved and tested again. Each test was stopped after 6 000 load collectives equals 48 000 flight hours equals 10 years without any failure.

$$MTTF_{min} = \left(\frac{2 \times (6000^4 + 6000^4 + 6000^4 + 6000^4 + 6000^4)}{X^2_{2(0+1);1-\frac{0,5}{2}}} \right)^{\frac{1}{4}} \times \Gamma\left(\frac{1}{4}+1\right) = 8913 \text{ load collectives}$$

According to 5.2, 8 913 load collectives at a long range seat are representing a $MTTF_{min}$ of 71 300 flight hours.

5.5 Degradation

This document only covers mechanical wear and tear on new parts. Degradation due to environmental influences e.g. chemical ageing of plastic parts are not part of the scope of this document and neither shall it be applied on anything then new parts.

6 General test conditions

6.1 General

All sub seat components should be tested with the pertinent seat. Any sub seat components not pertinent to the relevant load paths do not need to be installed.

If the seat is used for the test, the seat shall be fixed via seat tracks or equivalent fixation to the test bench.

Unless otherwise specified, the seat shall be stored in indoor ambient conditions for at least 24 h immediately prior testing.

The test shall be carried out at indoor ambient conditions with a temperature of 23 °C ± 10 °C and should be carried out with a relative humidity of 50 % ± 20 %.

Applied loading shall be maintained for at least 0,5 s.

After initial calibration of test equipment the equipment shall be kept in good working order to maintain pertinent test results.

The following tolerances shall be used for the tests:

a) forces: ± 1 % of the nominal force for 100 N and above; ± 5 % of the nominal force below 100 N;

b) velocities: 0 % to 5 % of the nominal velocity;

c) masses: ± 1 % of the nominal mass;

d) dimensions: ± 3 mm of the nominal dimensions;

e) angles: ± 2° of the nominal angle.

The speed for cycle testing shall not be higher than 3 600 cycles per hour.

6.2 ATD

An ATD according to SAE J826 shall be used for the following test in this document.

The ATD device shall be representing the human body. Therefore, the dimensions and weights of the different body parts shall be representative.

Table 4 shows the weight distribution for a standard Hybrid III crash test dummy and the 90 kg ATD device which shall be used for testing. The values for the 90 kg test device are interpolated between the 77,7 kg (50 %il) and the 101,2 kg (95 %il) values.

Table 4 — Weight distribution for a standard Hybrid III crash test dummy and the 90 kg ATD device

	50 %il **kg**	90 kg ATD **kg**	95 %il **kg**
Head	4,54	4,75	4,94
Neck	1,54	1,61	1,68
Upper torso	17,19	19,85	22,27
Lower torso	23,04	26,84	30,3
Upper arm, left or right	2	2,42	2,81
Hands, left or right	0,57	0,57	0,57
Lower arms, left or right	1,7	1,89	2,06
Upper leg, left or right	5,99	7,15	8,21
Lower legs left or right	4,29	5,05	5,75
Feet, left or right	1,16	1,39	1,59
Sum	77,7	90,00	101,2

If some of the body parts are not existing (e.g. arms, hand, feet) or not separated (e.g. upper and lower torso) the weights shall to be added to the parts where the missing parts are normally attached or two parts have to be combined into one body part.

EXAMPLE The ATD according to SAE J826 has only an upper body parts a lower body part, lower and upper legs and feet. So first the weight of the upper and lower torso has to be combined in the upper part and also the weight of the head, neck, arms and hands have to be added to the weight of the combined upper and lower torso weight.

The weight shall be evenly distributed over the whole body parts.

For dimensions of the body parts refer to Figure 1.

Dimensions in mm

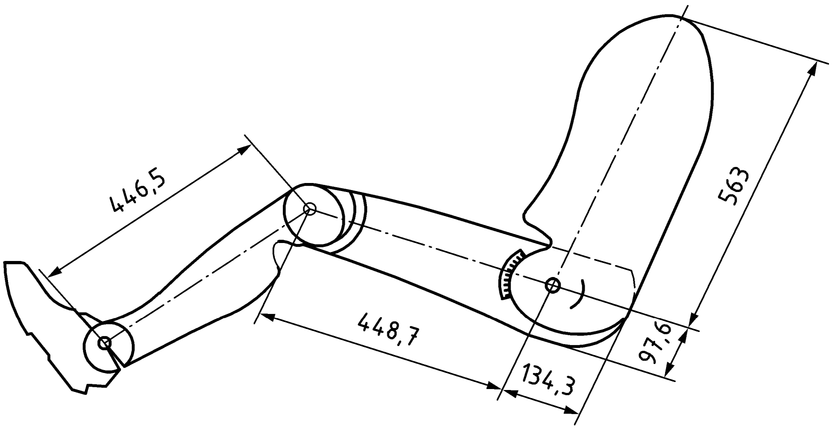

Figure 1 — Dimensions of ATD body parts