OSTIV **P**assive **S**afety **S**tandard

First Issue (Version 2.0)

“to improve the passive safety for sailplane occupants”

Developed and published by the Sailplane Development Panel of OSTIV

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Version control

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1.0	May 2023	First draft version presented to SDP
1.1	July 2024	First consolidated draft version for SDP distribution
2.0	November 2024	First version for publication by OSTIV

Preamble

This OSTIV Passive Safety Standard (OPSS) has been developed within the Sailplane Development Panel (SDP), which is part of the International Scientific and Technical Soaring Organisation (Organisation Scientifique et Technique Internationale du Vol a Voile, in short OSTIV).

The OPSS is not a mandatory airworthiness requirement for sailplanes. Its purpose is to serve as a guideline for improving the safety of the sailplane occupants for organisations and persons who develop sailplanes.

Therefore, the OPSS is published so that everyone can use the information and proposed minimum standards for improved occupant safety against the level of safety as defined in current airworthiness requirement for sailplanes, e.g. CS-22.

OSTIV and the SDP are not certification bodies and will therefore not provide either directly or indirectly a formal and regular certification cross-check on any documents that sailplane developers might draft to show compliance with the OPSS.

The basic idea is that the developer takes the OPSS requirements to improve the sailplane and could then declare as part of the sailplane product advertisement and information that the OPSS has been achieved for this sailplane.

Nevertheless, if such a declaration is made to advertise and sell such a product, the sailplane developer shall also, as a consequence, agree that the OSTIV SDP might approach this developer to analyze the way that compliance has been achieved against the OPSS requirements for the purpose of increasing sailplane safety. Participation of the developer in such an analysis is strongly encouraged given that the SDP is an open panel that promotes research and development for increasing safety in gliding.

If a developer does not want to participate in such an analysis and also does not want to offer documents requested for such analysis by the OSTIV SDP, then OSTIV reserves the right to publish the name of the developer and the particular sailplane on the OSTIV website, advising that adherence to the OPSS was declared but that no assistance for analyzing and demonstrating the compliance was provided.

Content

1. PURPOSE

The motivation for enhancing passive safety in gliding is the continuous high number of accidents with fatalities.

In general, safety is becoming more and more important in all fields of life. In the automotive sector the continued improvement of passive safety successfully resulted in a permanent reduction of fatalities, although the total amount of accidents increased due to significant growth in road traffic. Consequently, most knowledge regarding passive safety has been gained in this field.

With the OSTIV Passive Safety Standard an additional design standard is provided to the manufacturers of sailplanes. The risk of severe injury in the typical accidents occurring during take-off and landing will be minimized.

The OSTIV Passive Safety Standard has been developed with 4 objectives:

- **Fewer casualties in sailplane accidents**,
  by implementing common knowledge regarding passive safety in the sailplane design early on.

- **Make safety sellable**,
  by providing a defined standard to the manufacturers.

- **Voluntariness**,
  by not making the standard mandatory.

- **Cost-effectiveness**,
  by proposing simple means of compliance.

1. PURPOSE, Justification

- *Good reasons are already given in this Chapter.*

- *A technical justification for the OPSS is the increase in wing loading, (and therefore the) stall speed since the first editions of the regulations.*
  Typical wing loadings were increased from below 30 kg/m² to above 50 kg/m².
  The corresponding stall speeds increased almost by 40% from below 65 km/h to 90 km/h.

- *Since the implementation of an energy absorption approach for the landing gear the rule has been revised twice regarding the required rate of descent. It has been increased once from initially 1.5 m/s to 1.77 m/s (+ 18%).*
  Recently it was decreased from 1.77 m/s to 1.75 m/s (- 1%)

- *A comment: The implementation the Standard shall not be delayed by a request for more knowledge. Sufficient knowledge for a common engineering approach is already available.*
- *Regarding the strength of the cockpit, with respect to the survival cell, the growth in stall speed results in almost doubling the velocity-squared factor, the relevant factor for the kinetic energy.*
  The rule has been changed from no requirement, first to a static load of 6 g to currently 9 g. Static conditions are not directly comparable to dynamic conditions. A static requirement is insufficient, because the absorption of the energy involved is not considered. In other fields 26 to 35 g are dynamically demonstrated (Part 23; automotive field).

2. SCOPE AND DEVELOPMENT

Compliance with the OSTIV Passive Safety Standard (OPSS) requires as a precondition the compliance with an accepted Certification Standard. The additional demonstration of compliance of a sailplane design with the OPSS entitles the organisation responsible for the type design to market the product as: “Compliant with the OSTIV Passive Safety Standard”.

The demonstration of compliance must be stated by the responsible manager of the organisation.

A first draft was presented on 15th May 2023; the final draft was presented in July 2024. The further development is found in the version control on the title page.

2. SCOPE AND DEVELOPMENT, Justification

- *OSTIV is not an organisation capable of doing certifications.*
  The responsibility for the safety of a product is with the organisation selling the product.

3. PASSIVE SAFETY STANDARD

The OPSS has been developed to amend paragraph 3.75 Emergency Landing Conditions of the OSTIV AIRWORTHINESS STANDARD (OSTIVAS) but is now a stand-alone standard with the following requirements:

OPSS 3.75 Emergency Landing Conditions

OPSS 3.751

The Sailplane, although it may be damaged in emergency landing conditions, must be designed to protect each occupant when proper use is made of the safety harness, of the seat and of other relevant elements in the cabin provided for the design, in these conditions:

OPSS 3.752 (a)

In a **steep touch down attitude** with the relevant impact on the fuselage nose, there must be a high probability of each occupant escaping serious injury in the following conditions:

- Flight path velocity equal to the stall speed in a probable configuration of the sailplane
- With a flight mass of the probable configuration of the sailplane
- Longitudinal impact angle to the ground 45°
- Lateral impact angle 5°

OPSS 3.752 (b)

In a **level touch down attitude** with the relevant impact on the main wheel(s), there must be a high probability of each occupant escaping serious injury in the following conditions:

- Descent velocity 20% of the flight path velocity from (a)
- With a flight mass from (a)
- Wing lift equal to the sailplane weight

OPSS 3.752 (c)

Compliance with this paragraph can be shown by:

- The means of compliance given in Appendix A
- Or, by any other rational method

3. PASSIVE SAFETY STANDARD, Justification

- *The proposed OPSS follows the structure of the OSTIV AIRWORTHINESS STANDARD.*
- *There is a general trend in regulations from “Cooking Book” character to “describe the goals”.*
- *The investigation regarding glider accident scenarios according to M. Sperber [1] shows two level and two steep scenarios. For simplification the proposed OPSS only distinguishes between a steep and a level scenario.*
- *A probable flight path velocity and a probable flight mass is proposed for two reasons:*
  First: passive safety design is done for probable scenarios and not for worst case scenarios.
  Second: The stall speed at MTOM, depending on the class of sailplane, can be in a range where the demonstration of the required energy absorption capability for the steep touch down attitude turns from “challenging” to “almost impossible”.
- *For the level touch down attitude a descent velocity of 20% from the probable flight path velocity is proposed.*
  Example: Assuming a flight path velocity of 22 m/s the corresponding descent velocity is 4.4 m/s. M. Sperber [1] published decent velocities from 2 to 8 m/s and 3 to 11 m/s. Thus, higher values than 4.4 m/s can be discussed.
  We must keep in mind: the landing gear is the only element really protecting the spine in a level emergency landing unless a seat with energy absorbing elements were installed. (Refer to Appendix A, Chapter A.6.)
  The energy absorption capacity required for 4.4 m/s descent velocity can be demonstrated with modest effort. (Refer to Appendix A, Chapter A.6.)

APPENDIX A

Means **of** **C**ompliance (MoC) to OPSS 3.75 Emergency Landing Conditions are provided by this Appendix A.

Justifications for the proposed Means of Compliance (MoC) to OPSS 3.75 Emergency Landing Conditions (Appendix A) are given per Chapters.

A.1. General

This Appendix A gives a guideline for the demonstration of compliance with the OSTIV Passive Safety Standard. Other reasonable methods are acceptable, the responsibility for the compliance demonstration remains with the organisation responsible for the type design of the sailplane. Interpretation shall be done within the sense of the objectives of the OPSS.

A.1. General, Justification

- *The concept of the wording is: The manufacturer of the sailplane is responsible.*

A.2. Energy Absorption

For the two touchdown attitudes described in OPSS 3.752 (a) & (b) the energy of the sailplane must be absorbed by elements suitable to limit the forces acting on the occupant(s) below values regarded as acceptable. (Refer to Chapter A.5 & A.6.) The design of the seat(s), the backrest(s) and the restraint system(s) must provide suitable support for the occupant(s) and must be capable of withstanding the loads occurring.

A.2. Energy Absorption, Justification

- *The energy absorption approach is already common in the landing gear design.*
  For the cockpit/survival cell the current static requirement is amended and replaced by an energy absorption approach. The required static strength for compliance with the proposed OPSS should easily cover the current static 9 g requirement in CS 22.
- *CS 22 covers a wide range of sailplanes, for this reason the probable stall speed of the specific sailplane was proposed as the basis for the energy absorption approach for both emergency landing attitudes.*
- *Limit values for forces acting on the occupant(s) are justified in Chapter A.5 and A.6*

A.3. Probable Flight Mass

The flight mass of the sailplane is one basic parameter for the energy involved during an emergency landing. To avoid too severe conditions a probable flight mass shall be selected not lower than:

- The typical empty mass of the sailplane,
- plus 96 kg Pilot, (this includes a parachute),
- plus 64 kg for the second occupant in two seat sailplanes,
- plus 50% of the fuel storable in the fuselage, (liquids stored in the wings or the tail do not need to be taken into account).

A.3. Probable Flight Mass, Justification

- *To describe a probable scenario, the probable mass was proposed as the sum of:*
  - *The typical empty mass of the sailplane.*
  - *Plus 96 kg, an average pilot with parachute.*
  - *Plus 67% of this mass for the second occupant to cover the probability of the occupation of the second seat and to select a round number making: 160 kg.*
  - *Plus 50% of the fuel storable in the fuselage, to cover the probability of a partially filled tank. The liquids stored in the wings or in the tail will not be considered, because we assume that these masses will separate from the sailplane in a severe crash.*

A.4. Probable Flight Path Velocity

The essential parameter for the energy involved during an emergency landing is the flight path velocity. To avoid too severe conditions a probable flight path velocity shall be used.

The probable flight path velocity shall not be less than the stall speed of the sailplane under the following conditions:

- The sailplane with the probable flight mass
- Camber changing flaps (if applicable): in landing position
- Airbrakes retracted

A.4. Probable Flight Path Velocity, Justification

- *To describe a probable scenario and in order to avoid too severe conditions for the design, the following probable flight path velocity is proposed as a stall speed under the following configuration:*
  - *The sailplane with the probable flight mass.*
  - *Camber changing flaps (if applicable): in landing position.*
  - *The extension of typical airbrakes increases the stall speed by 4 to 6% and consequently, the energy by 8 to 12 %. To avoid too severe conditions, airbrakes retracted is proposed.*

A.5. Steep Touch Down Attitude

For the steep touch down attitude the sum of energy to be absorbed by the structural elements of the sailplane shall not be less than the kinetic energy of the sailplane flying with the probable flight mass and with the probable flight path velocity.

Assumptions regarding the portion of energy absorbed by the different elements of the sailplane shall be made. The sum of the portions must be at least the total kinetic energy of the sailplane under the conditions described above.

A.5. Steep Touch Down Attitude, Justification

A general comment: One must be aware that with the energy absorption approach a completely new concept is followed.

Furthermore, it will not be possible to generate a relevant increase in safety with only small adjustments to the cockpit/survival cell.

In other words: Increasing the survivability significantly will require two to three times more strength in some elements. This will certainly require doubling or tripling the amount of material in these elements.

The proposed approach uses a cascade of energy absorbing factors and elements:

Wings

It can be assumed that the first contact with the ground is typically with one wing. A portion of the total kinetic energy of the sailplane will be absorbed by the wings. In the absence of a more rational analysis, 50% of the kinetic energy of the wings may be regarded as absorbed by the wings themselves.

Wings, Justification

Occupants survive crashes even in sailplanes without a strong survival cell "by a miracle!" "Miracles" do not exist for engineers; it is always about physics! It can be observed that the first contact with the ground typically is with one wing. Consequently, a portion of the total kinetic energy of the sailplane will be absorbed by the wings. The proposed 50% of the energy stored in the wing mass is an arbitrary figure. However, it covers the fact that for sailplanes with high span and aspect ratio, and consequently heavier wings, a relatively greater and also an absolutely greater part of the total energy will be absorbed by the wings themselves. Typical wing masses are about 20 to 30 % of the typical flight mass. This means 10 to 15 % of the total energy is assumed to be absorbed by the wings themselves.

Terrain

Typically, the relevant impact with the nose of the sailplane is on moderately soft ground. A portion of energy will become absorbed by the terrain. This requires a certain strength of the nose, up to a designed maximum force prior to crumpling.

In the absence of a more rational analysis, it can be assumed that the energy absorbed by the ground is equivalent to the energy absorbed by a force linearly increasing from zero to the designed maximum force over 0.6 m. The nose must be able to withstand the selected maximum force under the impact angles to the ground according to OPSS 3.752 (a). (i.e. 45° longitudinal and 5° lateral.)

Sufficient strength of the nose prior to crumpling can be demonstrated by test, by analysis, by comparison with an existing design where the strength has been demonstrated or a combination of these methods.

Terrain, Justification

It is shown by several tests that the terrain has a significant influence on the destruction of a sailplane during a crash.

To assure that the sailplane nose can penetrate the terrain, a certain strength of the nose is required. Observed impact traces on the ground are between some centimetres and some meters. The proposed method covers the observations to a certain extent and takes the strength of the nose into account. Depending on the strength of the nose, the terrain will absorb about 15% of the total energy of the sailplane.

Crumple Zone

The forward part of the sailplane must have a designated crumple zone. The crumple zone typically will have the most relevant contribution to the total energy absorption. The crumple zone should not extend beyond the most rearward position of the rudder pedals. The energy absorbing capability and the corresponding maximum force can be derived by test, by analysis, by comparison with an existing design where the energy absorbing capability has been evaluated or a combination of these methods.

Crumple Zone, Justification

As mentioned, the crumple zone will have the most relevant contribution to the total energy absorption. Beside the strength and the crumple characteristics, its length is the important parameter to keep the accelerations below critical values. In CS 22, a crumple zone is not specified and the cockpit/survival cell begins at the most forward rudder pedal position. To allow a longer crumple zone, the most rearward pedal position is proposed. Example: To absorb 40% of the energy of a sailplane flying with 22 m/s, 0.5 m travel and an almost constant compression level of about 26 g is required. With 0.6 m travel it is still 21.7 g

The design and the tests published by TU Hannover and TU Munich give an indication regarding a suitable design of a crumple zone. Formula Student is using "off the shelf" Impact Attenuators. (www.formula-seven.com)[2], upscaling might be possible. In any case, this topic will require additional testing.

Survival Cell

The part of the fuselage in front of the wings aft of the crumple zone must be able to withstand at least 120 % of the corresponding designed maximum force of the crumple zone acting at a longitudinal impact angle to the ground of 45° and a lateral impact angle of 5°. The highest force for which sufficient strength of the survival cell has been demonstrated may be used for the evaluation of its energy absorbing capacity. In the absence of a more rational analysis the proportion of energy absorbed by the survival cell is 0.5 x the highest force multiplied with the deformation under the highest force.

The strength and the deformation of the survival cell can be derived by test, by analysis, by comparison with an existing design where the strength and the deformation has been evaluated or a combination of these methods. If the strength is demonstrated by a static test, a dynamic strength and deformation of 110% of the statically demonstrated strength and deformation can be assumed. The highest force used for the energy absorption shall not exceed a load factor of 26 x Probable Flight Mass [kg] x 9.81 [m/s²]. If the load factor of 26 is exceeded, suitable belt load limiting elements must be implemented into the restraint system. (See: 8. Restraint System)

Survival Cell, Justification

It is obvious that the survival cell must be stronger than the crumple zone, 20% reserve in strength is proposed.

The tests published by TU Hannover and TU Munich show that the elastic deformation of the survival cell is relevant for its contribution to the total absorbed energy.

Currently the cockpits are designed for 6 or 9 g deceleration of the MTOM of the sailplane.

Considering that the proposed probable flight mass can be in a range of about 55 to 90 % of the MTOM, the strength required by the proposed OPSS will typically be more than twice of the 9 g. This is in contrast to the existing designs, where only the strength was required. Flexibility is required for the energy absorption approach as well.

From tests with composite structures that we know, these structures withstand higher short interval loads than static loads. Typical crash scenarios are in 0.1 s time magnitude. To cover this fact, it is proposed to assume for the dynamic strength 110 % of the static strength. Considering the 20 % reserve when applying the highest loads from the crumple zone, as proposed above, sufficient reserve will remain in any case.

Tests performed for the certification of CS 23 Airplanes show that a forward deceleration of 26 g typically can be demonstrated without exceeding the critical values on an anthropomorphic dummy. Higher values require shoulder belt load limiting devices.

Example: Assuming an elastic deformation of the survival cell of 0.4 m, with a maximum strength of 30 g the contribution of the elastic deformation of the survival cell from the total energy absorption will be about 25 %.

A.6. Level Touch Down Attitude

For the level touch down attitude the sum of energy to be absorbed by the structural elements of the sailplane shall not be less than the kinetic energy of the sailplane flying with the probable flight mass and descending with a velocity of 20% of the probable flight path velocity.

Assumptions regarding the proportion of energy absorbed by the different structural elements of the sailplane shall be made. The sum of the proportions must be at least the total kinetic energy of the sailplane in a downward direction.

A.6. Level Touch Down Attitude, Justification

A general comment:

The capability of a landing gear up to limit load is of low relevance to the safety. (Pilots certainly will appreciate that they can fly on the next day after a hard landing without a repair. That's nice to have!)

For the protection of the spine alone the total energy absorption capability including plastic deformation prior to collapsing of the landing gear is relevant.

Sufficient energy absorbing elements under the seat would have an even wider effect on the protection of the spine than sufficient reserve energy capacity in the landing gear.

But the space under the seat would require larger cockpits and new fuselage designs with higher drag. Acceptance for this cannot be expected!

The proposed approach for the Level Touch Down Attitude uses a cascade of energy absorbing factors and elements:

Wings

Due to the flexibility of the wings, it can be assumed that a portion of the kinetic energy of the sailplane will be absorbed by the wings. In the absence of a more rational analysis, 50% of the kinetic energy in the downward direction of the wings may be regarded as absorbed by the wings themselves.

Wings, Justification

A portion of the total kinetic energy of the sailplane during touch down will be absorbed by the flexibility of wings themselves. The proposed 50% of the energy stored in the wing mass is an arbitrary figure and it does not take into account a specific distribution of stiffness and mass, but it covers the fact that on sailplanes with a high span and aspect ratio, and consequently heavier wings, a relatively greater and as well an absolutely larger part of the total energy will be absorbed by the wings themselves. Typical wing masses are about 20 to 30 % of the typical flight mass.

This means 10 to 15 % of the energy is assumed to be absorbed by the wings themselves.

Suspension system

The energy absorbing capability of the suspension system up to the mechanical travel limit of the suspension elements can be derived by test, by analysis, by comparison with an existing design where the energy absorbing capability has been evaluated or a combination of these methods. Conditions, such as tyre pressure, must be defined. Where the energy absorption characteristics are not essentially affected by the rate of compression, a static test is sufficient.

Suspension system, Justification

In typical suspension systems the tyre still provides the relevant contribution to the required energy absorption. Often additional spring elements are used to improve comfort and to reduce the deceleration during landing. The limit g-factor has been discussed several times, sometimes distinguishing between training and other sailplanes.

It was always between 3 and 4 g.

Example: Assuming for a "state of the art" landing gear a travel of 0.1 m with linear spring rate designed for a maximum acceleration of 3.5 g, it will be capable of absorbing about 15% of the total energy as required by the OPSS. (The assumed descent velocity is: 4.4 m/s.)

Energy Absorbing Elements

Additional energy absorbing elements might be necessary to absorb the total required energy. Typically, the energy is absorbed by a sustained deformation of these elements.

The energy absorbing capability and the corresponding maximum force can be derived by test, by analysis, by comparison with an existing design where the energy absorbing capability has been evaluated or a combination of these methods.

The maximum force shall not exceed a load factor of 9 x Probable Flight Mass [kg] x 9.81 [m/s^2].

Energy Absorbing Elements, Justification

A typical acceleration limit for the spine is 15 g. (e.g.: Eiband 1958 [3]). It is depending on several factors: duration, fitness, age, fit of the seat and others. To consider these factors in a conservative manner 9 g is proposed. (A design would still be feasible with a 6g limit, see the example below.)

Example: Additional energy absorbing elements with a relatively constant compression characteristic at a load of 5.2 g and with a travel of 0.12 m will be capable to absorb about 70% of the total energy as proposed by the OPSS. (The assumed descent velocity is: 4.4 m/s)

A.7. Landing Gear Locking Mechanism

The locking mechanism for a retractable main landing gear in the extended position must assure that the main landing gear remains extended under the decelerations and the deformations expected during an emergency landing. The deformation of the forward fuselage must be considered. Typical electrically operated retraction mechanisms may not require an additional down lock mechanism.

A.7. Landing Gear Locking Mechanism, Justification

After accidents caused by emergency landings in steep attitude, it can be observed in most cases that the landing gears collapse although they are not damaged. The reason is the deformation and/or the destruction of the forward fuselage where the landing gear handle is locked.

The test performed by TU Hannover and by TU Munich and the reported spinal loads show the relevance of the landing gear for the energy absorption during the second impact following the rebound.

A.8. Restraint System

Each single belt and each attachment point to the sailplane structure of a restraint system with a 4-point harness must be able to withstand at least 7000 N in the main load direction. Sufficient strength of the attachment points can be demonstrated by test, by analysis, by comparison with an existing design where the strength has been demonstrated or a combination of these methods.

If the highest force occurring during the emergency landing in the steep touch down attitude exceeds a load factor of 26 (see 5. Steep Touch Down Attitude) suitable belt load limiting elements must be implemented into the shoulder harness.

The load in each shoulder belt should be limited to 4500 N ± 450 N.

The travel of the load limiting element should be at least 15 mm multiplied by the difference between the actual load factor and 26.

The suitability of the load limiting elements should be demonstrated by test or by comparison with an existing design where the function has been demonstrated. For typical metal bending and hole bearing elements, where the characteristics are not essentially affected by the rate of deformation, a static test is sufficient.

A.8. Restraint System, justification

Currently 15 g ultimate forward load is required for an occupant with 110 kg mass.
This is far below the limit of a human body!
To ensure that the restraint system never becomes the weakest element during an emergency scenario 26 g plus 15% reserve is a reasonable figure.

Considering an average occupant with 96 kg mass (incl. parachute) the total acting force incl. reserves is 28 kN.
For simplification it is assumed that the force will be equally distributed to the 4 attachment points.

CS 23.562 requires a load limit for dual shoulder straps of 2000 lb (= 8898 N). [4]
Similar values for the max. loads on the upper torso are given by other authors.
For simplification a load limitation of 4500 N ± 10% is proposed.

Simple assumptions show that about 11 mm is required per additional g. 15 mm per additional g is proposed, because there is no good reason to design a load limiter to the absolute minimum.

A.9. "Personal Fit Seat"

All space in the cabin and in the seat-shell, below the occupant not occupied by the individual occupant and a parachute, must be used for energy absorption in the seat. In addition, the occupant's spine & head need to be adequately supported.

Compliance can be shown by offering removable customized seat inlays where all space not used for the individual occupant is filled with firm energy absorbing foam(1) or similar suitable material. The minimum thickness of the hard foam below the occupant should not be less than 20 mm and the thickness of soft layers for comfort and ventilation between the occupant and the hard foam should not exceed 10 mm in total.

The shape and the size of a specific parachute must be considered.

Adequate support of the spine can be shown by offering spine shells in different sizes to be used between the occupant and the parachute.

Adequate support of the head can be provided by a headrest for each occupant with a minimum width of 0.3 m covered with energy absorbing foam[*] of at least 30 mm thickness. The shape of the headrest shall ensure that the headrest is not missed under asymmetric rebound conditions.

A.9. "Personal Fit Seat", Justification

As discussed, (refer to chapter A.6) energy absorbing elements under the seat would have a wide effect on the protection of the spine. But the space under the seat would require larger cockpits and new fuselage designs with higher drag. Acceptance for this cannot be expected!

In compensation, it is proposed to require at least a minimum of 20 mm of energy absorbing foam under each occupant and to take the advantage of all space not used by the individual occupant.

Tests show that perfect seating and support of the spine provide additional protection in crash scenarios.

The rebound of the head after a forward impact can be considerably pronounced and involve high g. Requiring a certain energy absorbing capability for the headrest is proposed.

It was observed that occupants have missed the headrest in a rebound. It is proposed to require a minimum width. On tandem seat sailplanes the headrest in the front reduces the view for the occupant in the rear. 0.3 m width is regarded as a reasonable compromise. Concave shapes or wings on the headrest avoid missing the headrest under asymmetric rebound conditions but the downside is that they will limit the view to the sides.

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[*] Note: Different products of suitable energy absorbing foams are on the market: e.g.: Confor, Dynafoam, etc.

A.10. Maximum Occupants' Height

The maximum dimensions for occupant(s) on the seat(s) must be specified. Limiting factors are the canopy, the space for 20 mm energy absorbing foam under the occupant, the adequate support of the spine, the parachute, and the space for the legs in the most forward position of the rudder pedals. The information should be published to the pilot with a notice that bigger occupants may have less passive safety.

A.10. Maximum Occupants Height, Justification

Passive safety is related to the "survival space". It was discussed to require a minimum space for each occupant. This would require a minimum size of the fuselage. As a compromise it is proposed to specify the maximum height of an occupant for the specific sailplane and to publish the value in the Airplane Flight Manual.

A.11. Cabin Items

The cabin shall be free from sharp items endangering the occupant(s) during an emergency landing. Elements likely to be struck by the occupant(s) in an emergency landing need to be designed to be soft and/or flexible. This can be demonstrated by a design review.

Heavy items, e.g., batteries, oxygens bottles, luggage etc. must be fixed and secure under the maximum deceleration likely to occur during an emergency landing. This can be demonstrated by analysis or test.

A.11. Cabin Items, Justification

Surviving the impact and dying due to blood loss is just as deadly as being killed immediately and so the secondary effects endangering the occupant(s) must be considered.

A.12. References

[1] M. Sperber, Untersuchungen des Insassenschutzes bei Unfällen mit Segelflugzeugen und Motorseglern, BMV-Forschungsbericht FE-Nr. L-2/93- 50112/92, TÜV Rheinland, 1998

[2] F. Imanullah, A. S. Prasojo, A. A. Wirawan, Experiment evaluation of impact attenuator for a racing car under static load, AIP Conference 2018

[3] M. Eiband, Human Tolerance to Rapidly Applied Accelerations, A Summary of the Literature NASA Memorandum 5-19-59E, Washington D.C., June 1959

[4] CS-23 Amendment 4, § CS 23.562, 2015