PMA Standard

Connecting Elements for Paragliding

Requirements and test methods for continuous vibration and structural strength of metallic and textile fasteners

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Content

1 Preface

This standard was developed by the experts of the Paragliding Manufacturers Association (PMA) in cooperation with independent experts; it is not a norm.

Paraglider Manufacturers Association
Uttigenstrasse 87
CH 3600 Thun
Switzerland
info@p-m-a.info
www.p-m-a.info

Section 8 of this standard contains safety specifications.

The English version of this document shall be used as reference in case of differences between translations.

This standard can evolve over time. Please refer to the latest version of this document.

1.1 Introduction

The aim of this standard is to increase safety in paragliding and to remove from service those connecting elements between paraglider and harness, or between rescue system and harness, which show an unacceptable function or insufficient strength in the tests recognized by this standard.

1.2 Scope of application

Requirements and test methods for the structural strength of metallic and textile connecting elements.

This standard applies to

1. Textile fasteners with manual closure
2. Metal fasteners with locking device
    - Manual locking device
    - Automatic locking device

Special carabiners like "quickout" are treated as "metal fasteners with manual locking system".

1.2.1 Application subdivision

a) Connecting elements of the paraglider connection to the harness
b) Connecting elements of the rescue reserve connection to the main harness attachment
c) Connecting elements for tandem connections (tandem spreader)

1.2.2 Special remark

Metal fasteners without locking device and tandem spreader bars are not considered in the standard.

1.3 Start of application

The date of application of this standard is September 2023.

1.4 Document history

The document versioning scheme is as follows: V Year.Month.Editorial

- Year.Month: Major changes, e.g., regarding inspection criteria and/or procedures
- Editorial: Only editorial change between versions

Date	Version	Change(s)
20/09/2023	V 2023.09.1	

2 Normative references

The following documents, which are cited in part or in their entirety in this document, are required for the application of this document. For dated references, only the referenced edition applies. For undated references, the latest edition of the referenced document (including all amendments) applies.

DIN EN 926-1: Paragliding equipment - Paragliders - Part 1: Requirements and test methods for structural strength; German version EN 926-1:2015

DIN EN 926-2: Paragliding equipment - Paragliders - Part 2: Requirements and test methods for classifying flight safety characteristics; German version EN 926-2:2013

DIN EN 12491: Paragliding equipment - Emergency parachutes - Safety requirements and test methods

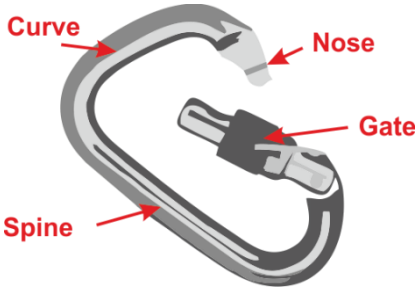
DIN EN 1651: Paragliding equipment - Harnesses - Safety requirements and strength tests

NfL 2-565-20: Notice of Airworthiness Requirements for Hang Gliders and Paragliders (LTF 565-20)

DIN EN 12275: Mountaineering equipment - Connectors - Safety requirements and test methods

3 Terms

For the application of this document, the terms according to DIN EN 926-1, DIN EN 12491, DIN EN 1651, DIN EN 12275, and the following terms apply:



Gate - The part of the carabiner that can be opened and closed again.
Spine - The longest side of the carabiner faces the Gate.
Nose - The part the gate drops into to close the carabiner.
Curve - The carrying strap runs over this and lies above the opening.

3.1 Metal fasteners without locking device

Screw links have to be closed manually and need to be closed with a proper torque or with an additionally secured clip to guard against unintentional opening.

Illustration - opened and closed screw cap

3.2 Textile fasteners with manual closure

A softlink is also used as a textile alternative to metallic connecting elements. This is a multi-spliced or stitched line that is looped or knotted and closed manually by means of a loop. A softlink cannot be opened under load.

The mounting of the softlink is problematic because there are several possibilities to do so incorrectly. Incorrectly mounted softlinks can be significantly reduced in the maximum tensile strength.

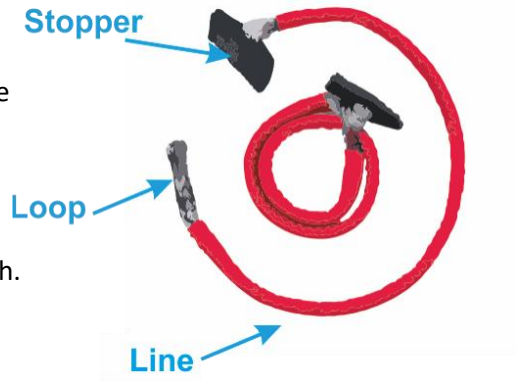
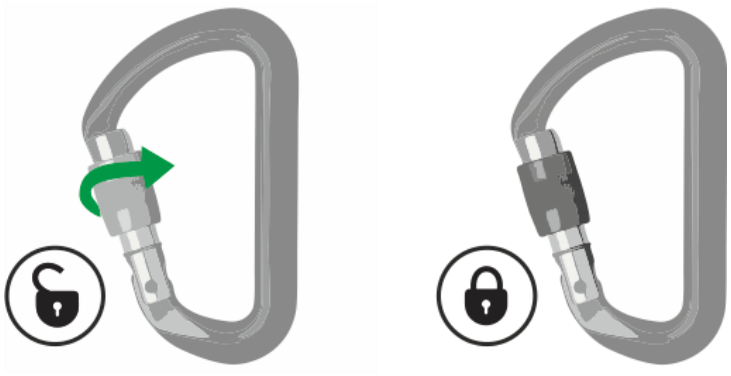


Illustration - opened and closed soft link

3.3 Metal fasteners with locking device

3.3.1 Manual locking device

Connectors with manual locking devices (e.g., screw carabiners) must be actively closed. Therefore, their handling is significantly slower than that of carabiners with an automatic locking device.
An overview of some possible locking devices can be seen in the figure below.

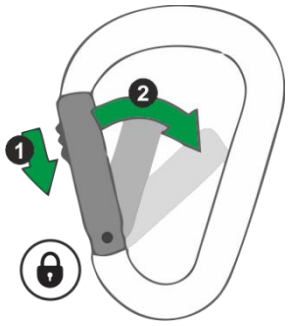


Screw carabiner

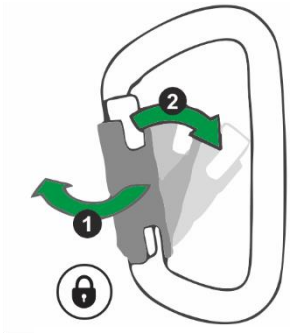
3.3.2 Automatic locking device

Carabiners with automatic, spring-loaded locking mechanisms lock automatically as soon the gate is released. This means these carabiners are faster to handle and are immediately closed securely.

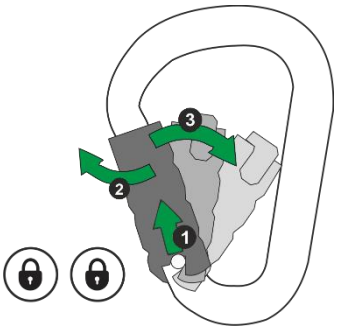
An overview of the types of locking device can be seen in the figure below.



Slide lock



Twist lock

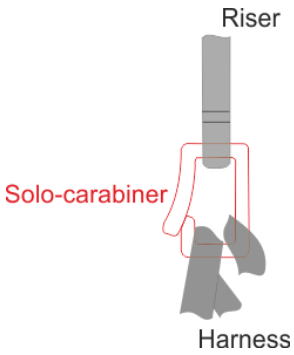


Triple lock

3.3.3 Usage

3.3.3.1 Solo

The pilot's harness is attached directly to the paraglider by means of a carabiner/softlink.

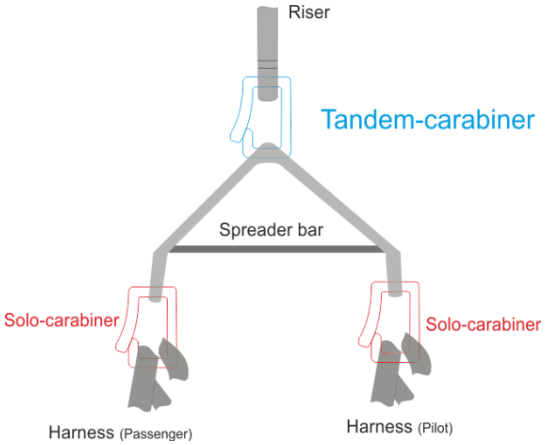


3.3.3.2 Double-seated (tandem)

For double-seated operation, two individual harnesses are connected to the risers of the paraglider via a tandem spreader.

Usually, the paraglider and the connection to the rescue parachute are connected to the upper attachment point of the tandem spreader.

Tandem spreaders are also used without a rigid middle section as "soft spreaders".



3.3.4 MTOM – maximum take-off mass

MTOM, or maximum take-off mass, is the maximum take-off weight of an aircraft. This is the mass at which the paraglider can take off without violating the prescribed safety margins. The MTOM is determined on the basis of design and practical flight criteria during type testing.

4 Reflections

The tests for the strength of paragliders, rescue parachutes and paraglider harnesses are carried out according to different EN standards.

- DIN EN 926-1: Paragliding equipment - Paragliders - Part 1: Requirements and test methods for structural strength
- DIN EN 1651: Paragliding equipment - Harnesses - Safety requirements and strength tests
- DIN EN 12491: Paragliding equipment - Emergency parachutes - Safety requirements and test methods

The strength of the type to be tested depends in each case on the possible load multiple of the maximum suspended load. The tests for paragliders and paraglider harnesses are each carried out, or calculated, with two attachment points.

In the German airworthiness requirements for paragliders and hang-gliders (LTF 565-20), connecting elements or connecting components are only dealt with in general terms.

> *1.1.4 Harness in the sense of these airworthiness requirements is* the harness system *with the connection element to the hang-glider, or* the connection elements for the risers of the paraglider *including the elements for an impact absorption (harness protector). For all parts of the harness with influence on the function of the rescue system the airworthiness requirements for rescue systems apply analogously, but without reference to a specific rescue system.*
> *1.2.4 Closures, separation points and other connecting components shall be secured against unintentional opening.*
> *3.2.4 Connecting parts between riser and harness for two-seater paragliders*
> *In the case of two-seater paragliders, each individual connecting part between the riser and the harness must have sufficient strength. Sufficient strength can be assumed if each individual connection part withstands a breaking load of nine times the permissible take-off weight, but at least 1350 daN at a load duration of 10 sec.*
> *4.2.3 For fasteners referred to in point 1.1.4 of these airworthiness requirements, the fatigue strength shall be demonstrated by testing in a test laboratory with appropriate expertise.* *

None of the standards/requirements describe a load test or fatigue test for the carabiners/connecting elements to be used. For this reason, it seems appropriate and correct for manufacturers of carabiners and connecting elements for paragliders to make their own considerations about appropriate tests.

In order to be able to accept the use of carabiners in all areas of paragliders, the maximum load in practice must be assumed. For double-seated operation, the maximum load on connectors is between the tandem spreader and the risers of the tandem paraglider.

* NfL 2-565-20: Notice of Airworthiness Requirements for Hang Gliders and Paragliders (LTF 565-20)

5 Minimum requirements for connecting elements

5.1 Vibration test

A vibration test is only required for metal carabiners.

5.1.1 Continuous vibration test

Carabiners used in the paragliding sector are exposed to oscillating loads during operation. Publications by some associations and some carabiner manufacturers regarding the risk of breakage of paraglider carabiners due to oscillating loads show various approaches and test criteria.

Basically, a distinction is made in operation and thus also in the test load between solo and double-seated use. If the carabiner is hooked directly into the harness, the solo load is taken as the test load. Double-seated operation is when the carabiner connects two harnesses to the paraglider by means of a spreader. These carabiners must be tested according to the test criteria for double-seated operation.

Solo operation	<150 daN MTOM
Double-seated operation	≥150 daN MTOM up to 250 daN MTOM

Explanation:

- All measurements and thus also the resulting data of the following specifications refer to a single-sided carabiner.
- Based on test flights of the PMA and previous investigations, maximum forces of approx. 65 daN (at 100 daN take-off weight) occur during a normal solo thermal flight with an average frequency of 26 load changes per minute.
- During a flight, the carabiner is loaded and unloaded. The unloading forces correspond approximately to ¼ of the basic load of the suspension load. In-flight measurements have shown load cycles between 0.23 and 0.37 Hz for both solo and tandem paragliders. This corresponds to a load change cycle of about 15 to 25 cycles per minute.
- For a frequent flyer, approx. 200 flight hours per year are assumed from flight evaluations. Considering the maximum service life of a carabiner of 5 years or 1000 flight hours, a carabiner has to withstand 900,000 to 1,500,000 load change cycles.
- The maximum value of 1.5 million is taken as the basis for calculation.

5.1.2 Safety factors

A safety factor Zs is applied to the derived cycle number.

Zs = 1.2

5.1.3 Cycle numbers

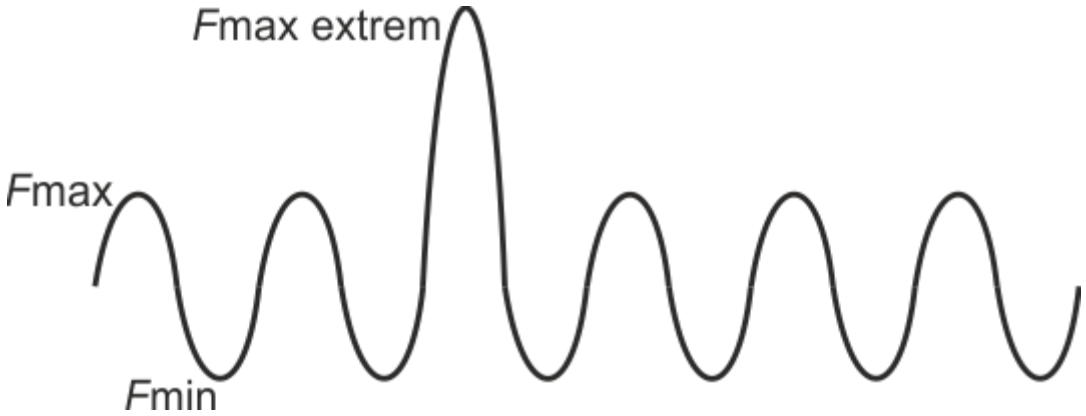
This results in the following parameters of the oscillation cycles to be tested for glider parameters

N = 1.500.000 x Zs = 1.800.000

The test cycle is rounded up and sampled with 2.000.000 (2 million) tests.

5.1.4 Test load in the vibration cycle

Operation	***Fmin***	***Fmax***	***Fmax extreme***
Solo	30 daN	100 daN	340 daN
Double seated	65 daN	170 daN	450 daN



In order to represent extreme flight maneuvers in the test area, the increased *Fmax extreme* values are integrated every 500 cycles. If inserted *Fmax extreme* cycles are not possible, then these are carried out continuously at the end.

Explanation:

- *Fmin* and *Fmax* are the two values between which the carabiners are loaded during a standard flight, with deep spiral, but without extreme maneuvers.
- *Fmax extreme* is the value which can be reached during extreme flight maneuvers such as asymmetrical SAT, infinity tumbling, etc.
- In previous investigations it could be determined that there are two essential factors for the fatigue strength loading:
  - Number of oscillation changes (cycles)
  - Load range during vibration changes
- The frequencies of 0.23 and 0.37 Hz occurring during a flight in solo or tandem flights and the required 2 million cycles require a very long test period if they are to be implemented in absolute practice. In order to limit the test time, comparative tests were carried out with 1 Hz and 10 Hz, whereby no differences in the result could be determined. Therefore, the test can be carried out in a range of 1 Hz to 10 Hz.

5.1.5 Test setup

The test is carried out with a 20 mm strap on the riser side and 25 mm on the harness side. No additional straps are allowed.

Three samples need to be tested.

Explanation:

- The "worst case scenario" with regard to the application of force on the carabiner occurs when almost the entire load and therefore almost the entire elastic deformation is absorbed by one leg. This results in the maximum stress drop at the carabiner.
- It should be noted that the force is applied at the largest possible lever, i.e., at the long leg of the carabiner. On the small side, the point of application of force is as close as possible to the webbing. This applies to carabiners with uniform profiles. If the carabiner profile shows strong differences, the max. stress drop must be explicitly determined.

5.2 Load test

A strength test is mandatory for both metal carabiners and softlinks.

Following the continuous vibration test, the carabiner is subjected to a load test appropriate to the required load.

A static tensile test is performed in the longitudinal direction of the locking element tested with 20 and 25 mm webbings, as described below.

The locking element is properly closed and, if necessary, secured according to the manufacturer's specifications.

Three samples are tested at a time. The tests must all be successfully completed without visible damage or failure.

Explanation:

- If the connecting element can no longer be opened after the tests, but otherwise shows no visible structural damage, the test is considered to have been passed positively.

5.2.1 Test sample conditioning

a) Test samples without textile elements are tested without conditioning.

b) For test samples containing a textile element, the test sample shall be brought to a temperature range of (23 ± 5) °C and a relative humidity of between 40% and 60% for not less than 4 hours and the test must be started within 5 minutes after removal from the temperature range.

5.2.2 Conducting the static load test

In the tensile tests, during the application of force, the speed of application of force must be within the range of 50 mm to 200 mm per minute.

The force is applied via textile straps of 20 and 25 mm width of appropriate strength, as illustrated below.

The maximum take-off mass of single-seater paragliders is 150 daN, while that of two-seater paragliders is 250 daN

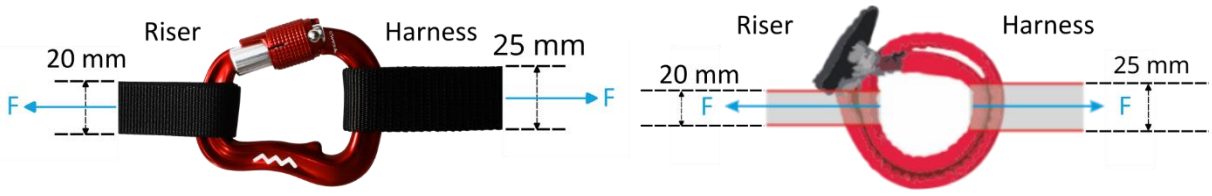
The strength test of a paraglider (EN 926-1) is carried out dynamically and statically with 8 g to the maximum suspension mass in total. Thus, the acting force increases by a factor of 8. LTF 565-20 requires a minimum breaking load of 9 times the permissible take-off weight, but at least 1350 daN at a load duration of 10 sec, for each individual connection part for two-seater paragliders. This standard follows the stricter of the two requirements, and while the load in normal flight is distributed over two carabiners, the strength test for each individual carabiner is still carried out at a factor of 9.

Solo: 1.5 kN * 9 = 13.5 kN (7.1)
Double seated: 2.5 kN * 9 = 22.5 kN

Operation	Minimum tensile load	G-Factor	Minimum strength
Solo < 150 daN	1.5 kN	9,0	13.5 kN
Double seated	2.5 kN	9,0	22.5 kN

The maximum tensile strength is measured without time determination.

Softlinks are tested with webbing, also 20 mm on the riser side and 25 mm on the harness side.



The recording rate of the measuring amplifier is in a range of 100 to 400 Hz.

6 Test report

The test report shall contain at least the following information:

a) Reference to this standard, i.e., PMA Standard – Connecting Elements for Paragliding (Version 1.0 – 01/2022)
b) Name and address of the manufacturer
c) Name and address of the person or company initiating the test
d) Sample designation and further details of the tested sample
e) Results of each test
f) Name and address of the inspection body
g) Name of the study director

7 Marking on the carabiners or softlinks

All connecting elements must be labelled with at least the following information:

a) The name or trade mark of the person or company who first placed the product on the market
b) Year of manufacture
c) Minimum strength value in kN guaranteed by the initial distributor

Additional information, such as a reference to this PMA Standard, symbol ISO 7000 – 1641, lifespan of the carabiner, etc., may be added.

8 Operating instructions

At least the following information, which is necessary for safe operation, must be included in the instruction handbook by the person and/or company placing the device on the market:

a) Intended Use
b) Special features (e.g., instruction or restrictions)
c) Information for commissioning, assembly, and disassembly of the device
d) Information for transport and storage
e) Details for maintenance
f) Technical data, operating limits, lifespan of the carabiner
g) Revision status
h) Reference to "PMA Standard Connecting Elements for Paragliding" and version of this standard.
i) Instruction to refer to the manual of harness and paraglider if there are specific recommendations regarding the compatibility of connecting elements, harness, and paraglider.

Additional information may be added to the operating instructions.