Carabiners breake during flight

Facts, reasons and consequences

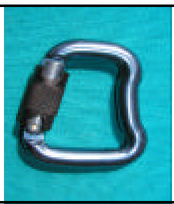
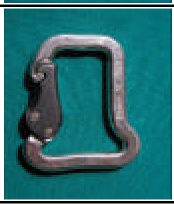
A summary from Reiner Brunn

A paragliding carabiner of a DHV testpilot breakes into two peaces during takeoff. After the DHV technic branch inspected the broken peaces and made sure that the carabiner was used the way it was designed for, they ordered a detailed material inspection by experts, to find the cause for the failure and take the neccessary actions. The peaces were given to the material test and damage analysis branch of the TÜV-South Germany for extensive testing. The responsible expert immideately comes up with a first suspicion for the reason of the malfunction. „As a matter of fact, chrome plating of metals is a delicate procedure, especially on aluminum, and was actually a player in different damage analyses in the past". That was the initiation for the DHV technic branch to order an additional material inspection for the same type of carabiner without chrome plating. This carabiner was also permanently used for testflights during the last couple of years. The DHV technic branch simultaneously conducts an own tear strenght testing of all connecting elements of harnesses (chrome plated, polished, surface treated carabiners, SIL-system, screw shackles, and so on...). In this series, they test brand new carabiners and well used ones for their actual break resistance.
The manufacturer of the broken carabiner, Austrialpin, and other carabiner manufcturers conduct own tear strenght tests and artificial aging trials on new and used carabiners. The preliminary test results are very positive for the time beeing, the connecting elements reach their minimum published tear strenght numbers and exceed the DHV-set strenght minima for harness testing by far.
During the type testing, every connecting element, together with the harness has to stand nine times the maximum allowable load for 10 seconds.
After that we got the official results from the damage analysis of the chrome plated carabiner from the TÜV:
„The malfunctioning of the carabiner was caused by an oscillating crack... The cracks were initiated by smaller cracks in the finishing layer on the surfaceof the aluminum material.Both the metalographic found cracks and the microplastic deformations in the material layers close to the surface, have been identified as crackreasons that caused the breaking of the carabiner. "

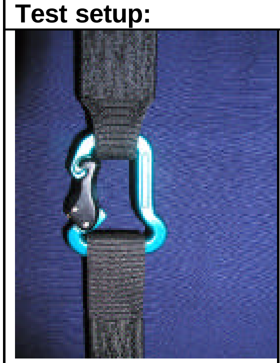
Additionally we got the result from the damage analysis of the non metalic finished carabiner:
„The tests showed in spite of microscopic surface damages, due to manufacturing and usage, no developing or existing cracks in the heavily used zones of the carabiner. Comparing these actual tests with older ones, made on metalic fnished surfaces of carabiners, it is an obvious conclusion that the danger of cracks in carabiners is very distant if the suface is non metalic fnished... ."

The results from the damage analysis led the DHV in accordance with the manufacturer Austrialpin to the AIRWOTHINESS DIRECTIVE (AD) as of Dec. 2001.
http://www.dhv.de/DHVonlineDB/sourcelegacy/legacynotespage.php?sublang=EN
During additional DHV tear strenght tests with chrome plated Austrialpin parafly carabiners, one of them broke at only 529daN (ca. 529kg) instead of the published 18kN (ca.1800kg).
It also seemed that the carabiner AD of the DHV did not reach all pilots or was not taken serious by all pilots. There was an additional broken chrome plated Austrialpin parafly carabiner during takeoff. It was bigtime luck that nobody was injured.
The reason why the carabiners break during takeoff and not inflight is suspected in the fact that the crarabiner locks completely up under force and there is no travel at all (the actuel locking mechanism travel is gone if there is force/weight on the carabiner). The cracks grow bigger and bigger continously when using damaged carabiners and in the end a short snappy pull with an existing travel leads to a brute force break. The reason for a certain travel in the locking mechanism is based in the specifications for mountaineering carabiners EN 12275, that guarantees the function of the locking mechanism under a load of 80daN (i.e. when recovering a hooked in person) and takes manufacturing tolerances into account. Since the manufacturers produce mostly mountaineering carabiners and there are no specific guidelines for airsports, neither in europe nor internationally, the airsport carabiners have been developed by the special needs of the airsport itself and the experiences of the specifications for mountaineering carabiners. A certain specification for example is the way of the application of the force during a tear strenght test, that is done with harness belts for a paragliding carabiner and not with centered steelbolts like it is done for mountaineering carabiners. The harness belts cause a significantly increased force application on the weaker locking side of the carabiner. That leads to a notably lower strenght of the carabiner which asks for either lower published strenght specifications or bigger dimensions for the respectife specifications. DHV tests with airsport carabiners showed 18kN break resistance with harness belts in comparison to 25kN-29kN with steelbolts (the mountaineering specs).
The carabiner manufacturers aply a lot of quality control and quality guarantee procedures ending up in the final individual test where every single carabiner has to stand a load of 1000daN, but it has to be mentioned that even aluminum carabiners go through a natural aging process and should be replaced every 500 flighthours. Needles to say that appropriate usage of connecting links, visual inspection in regular intervals and proper handling are a prerequisite.

DHV carabiner and connecting links strenght trials (as of Nov/2001)

Carabiner	Type / Manufacturer	Published minimum strenght	Test 1 Minimum strenght	Test 2 Breaking point
	Sup´Air	15 kN	positive	16512 N
	Parafly Automatic / Austrialpin	18 kN	positive	18255 N
	**Fly Automatic** / Stubai	18 kN	positive	17768 N
	Woddy valley / Camp	20 kN	positive	20967 N
	SIL / Finsterwalder	20 kN	positive	31140 N

Test setup:



The test setup is done with the DHV harness test bench, the application of the force to the brandnew carabiners/connecting elements was done with standardised harness belts.
Test 1: Checking of the manufacturer published minimum strenght over a 10 second timespan.
Test 2: Finding the breaking point for the carabiner that has already gone through the first test (average value from 3 tested carabiners).

Based on the events of the last months the DHV technic branch has formulated a draft of extended technical demands for connecting elements between harness and glider and planned a expeditious realization in cooperation with interested carabiner manufacturers.
Following is a summary of the preliminary results of the commision:

1. **Strenght demands for connecting elements glider/harness**

- the connecting element will be loaded (if applicable with closed snap lock mechanism) with 1000 daN
- the very same part will be put under an oscillating force of 0 to maximum 200 daN with a frequency of 1Hz or less (the number of repititions has to be determined through pretrials)
- after that the part has to be tested for strenght like in the beginning with values of
    - minimum 18 kN for single seat connecting elements
    - minimum 24 kN for connecting elements used with biplace gliders
- the part has to stand a load of 5kN with open snap lock mechanism (if applicable)

The force application is done with standardised harness belts.

2. **Functional features of the connecting element**

- Single hand operation is a must
- The part has to have an autmatic locking mechanism and a minimum of two safety features (with different manual actuations) til opening the lock, or takeoff with open connecting element has to be impossible

3. **Marking of the conncting element**

- The connecting element has to be marked clearly, permanently and uneraseable with following minimum informations:
    - Name and hallmark of the manufacturer, import company or dealer
    - Production series identification
    - Minimum kN strenght value in tear direction – closed lock
    - Minimum kN strenght value in tear direction – open lock
    - Mark „MONO“ for single seat connecting element
    - Mark „BI“ for biplace connecting element

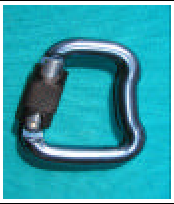
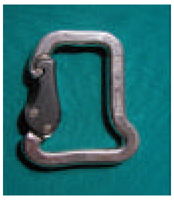
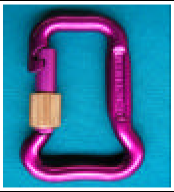
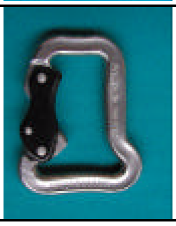
4. **General**

- Manufacturer information for safe maximum usage time and how to determine it
- These connecting elements will be published as „DHV – recommended connecting elements for glider/harness combination“
- These connecting elements are part of the DHV – type testing of paragliding harnesses
- The technical standard of airsport carabiners should be incorporated into the DHV airworthiness specifications as soon as possible

Configuration examples for biplace mountings

It seems that a lot of biplace pilots and flight schools and some manufacturers don´t know the appropriate configurations for biplace mountings since on some biplace gliders there are main connecting elements with a minimum break resistance of 15 kN to 20kN! This is in most cases only limited suitable or totally inadequate,because the official minimum break resistance is also nine times the maximumu takeoff weight of the biplace glider.Below is a listing of suitable main connecting elements for biplace gliders.

Listing of different biplace suitable carabiners

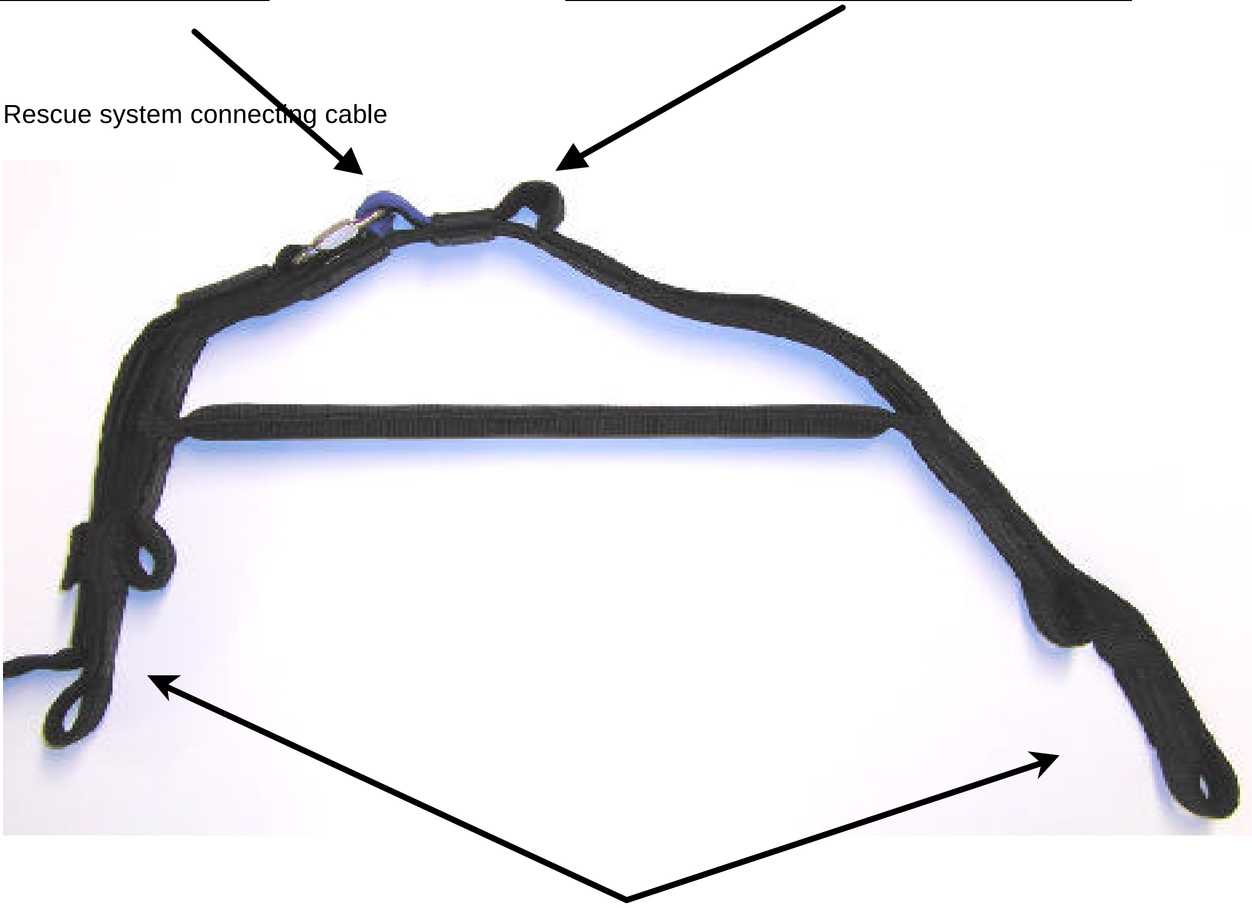
Carabiner	Type / manufacturer	Published minimum strenght	Biplace suitable[1]	Weight
	Sup´Air	15 kN	no	68 g
	Parafly Automatic / Austrialpin	18 kN	no	60 g
	Fly Automatic / Stubai	18 kN	no	58 g
	Woddy valley / Camp	20 kN	limited suitable, max takeoff weght 220 kg	66 g
	Fly / Stubai	22 kN	limited suitable, max takeoff weight 240 kg	104 g
	Powerfly / Austrialpin	26 kN	yes	140 g

	Delta Austrialpin	32 kN	yes	228 g
	Maillon Rapide 7mm / Peguet	5 x Nutzlast (WLL) = 31kN	limited useable, incorrect useage could lead to a significant loss of strenght	46 g

[1]**Note:** According to current DHV safety regulations (as of 1996) suitable as connecting element between biplace mounting/harness and biplace chute. According to future extended technical DHV specifications for glider/harness connecting elements, the minimum strenght for biplace suitable connecting elements will be at least 24 kN!

Maillon Rapide 6/7mm


Austrialpin Powerfly	Austrialpin Delta
	



Fly Automatic / Stubai	Woddy valley / Camp	SIL / Finsterwalder	Sup´Air	Parafly Automatic / Austrialpin