Longarone 08/10/2018

FFR Project - Test on PETZL DUAL CONNECT ADJUST in according with EN 958:2017

Dolomiticert Job No. D180745 – R.p.: 181115

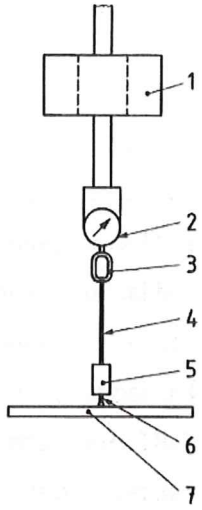
Summary

Aim of the tests

The purpose of the test is to evaluate the limit of performance of the device PETZL DUAL CONNECT ADJUST (Figure 2 and Figure 3) assembled with the PETZL EASHOOK OPEN type K carabiner, in order to investigate the limit of safety provided by the device when used for other scopes from those given by the manufacturer.

The tests have been performed in accordance with an internal test method for EN 958:2017[1], Clause 5.2.4.3. This test method, "Determination of impact force and braking length", is performed as in Figure 1 with the following deviations from the standard:

- Only 120 kg test mass has been used;
- The mass falling distance has been changed during the study, for the purpose of the study.



Key

1 falling rigid steel mass 40 kg or 120 kg (guided)
2 force measuring device
3 connecting device
4 arm(s)
5 energy absorber
6 harness attachment point
7 catch plate attached to the harness attachment point

Figure 1: Example of test configuration

Conditioning of the devices has been performed according to EN 958:2017 Clause 5.2.2.

The study involves the comparison between two different configurations of the device:

- Configuration A (Figure 3): device positioned so that the length of the device is **half** of the *full length of the device* (full length = device full extended, regulation system touching the stitched terminal, plus the connector length);
- Configuration B (Figure 4): device positioned so that the length of the rope from the stitched terminal to the device is 20 cm[2].

[1] EN 958:2017: Mountaineering equipment – Energy absorbing systems for use in klettersteig (via ferrata) climbing – Safety requirements and test methods.

[2] Note: this configuration has been chosen in accordance with the anthropometric studies conducted in the SAFERALPS project (see Appendix A for the data). From these studies is possible to assert that for a man:

- The arm length from the palm of the hand to the back of the shoulder is about 740 mm;
- The length from the pelvis to the shoulder is about 520 mm;

NB the *full length of the device* has been evaluated after 1 min from the application of the catch plate (that is required by EN 958:2017 test method used) weight of 8 kg. The length considered is the distance between the touching point of the connector on the test apparatus and the end of the connection of the device to the catch plate.

Tests have been performed with different Fall Factors for both the configurations, in order to compare the behaviour of the configurations of the device.

The Fall Factor is defined as $FC = \frac{Fall\ legth}{device\ length}$.

Considering the Fall Factor definition, for the two different configuration the same fall factor involves a different energy to be absorbed by the device.

After the first drop, has been performed a second test on the same device (when no breaking occurs) repositioning the device in the same position of the first test.

During the tests have been recorded:

- Maximum Arrest Force (F_{max});
- Slippage of the rope (rope passed throughout the device during the test);
- Elongation of the device after the fall (if possible).

The limit of safety considered is a 6 kN Maximum Arrest Force, as the EN 958:2017 gives as limit for 120 kg falling mass tests in dry condition.

Table 2 summarise all the tests performed.

Model / External code	Sample internal code
PETZL DUAL CONNECT ADJUST	181115_1
	181115_2
	181115_3
	181115_4
	181115_5
	181115_6
	181115_7
	181115_8
	181115_9

Table 1: Samples identification

Considering the arm extended perpendicular to the torso, the distance from the pelvis to the hand is about 930 mm. The 200 mm length of the rope from the stitched terminal to the regulation system has been chosen in order to have the *length of the device* of about 930 mm in accordance with these data (it is necessary to consider the length of the connector which must be divided by two and subtracted from the *full length of the device*, in fact users hold the connector in the middle to secure themselves during the progression).

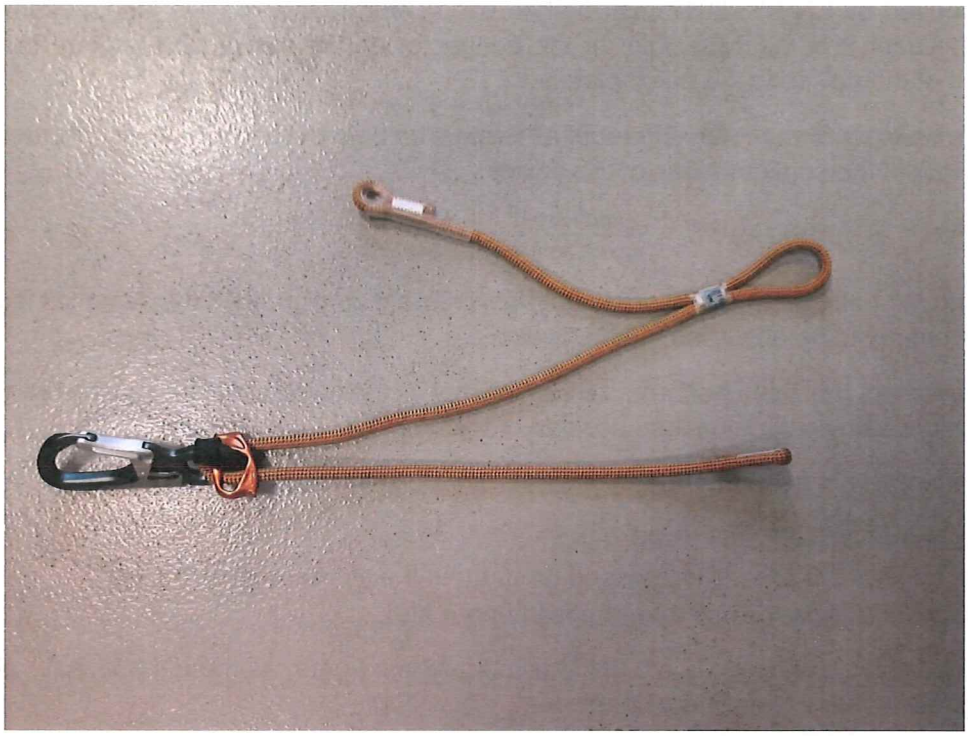


Figure 2: PETZL DUAL CONNECT ADJUST assembled with PETZL EASHOOK OPEN type K connector

Figure 3: Configuration A (regulation system positioned at half the length of the entire device)

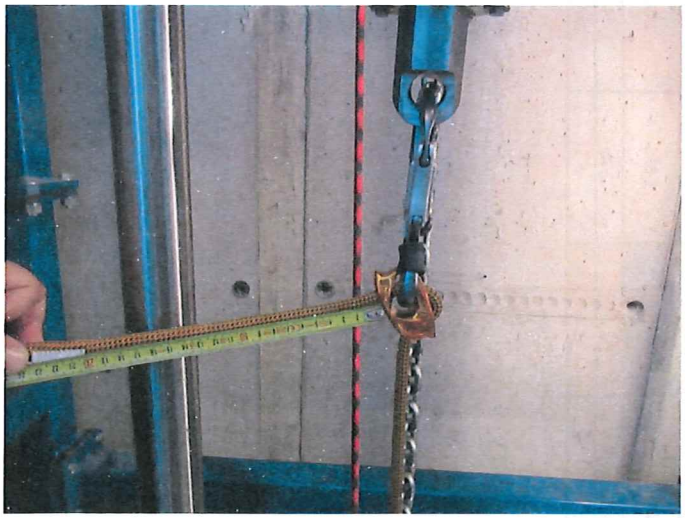


Figure 4: Configuration B (regulation system positioned at 20 cm from the terminal

SAMPLE	TEST No.	FALLING MASS (kg)	FALL FACTOR	CONFIGURATION	FALL EIGHT (m)	ENERGY (kJ)	DROP No.	DEVICE LENGTH (mm)		SLIPPAGE (mm)	MAXIMUM ARREST FORCE (kN)	NOTES
								Initial	Final			
181115_1	1	120	1	A	0,563	0,66	1	563	766	157	4,577	
	2						2	563	806	197	4,198	
181115_2	3	120	1	B	0,93	1,09	1	930	1230	Not Evaluated	5,162	SLIPPAGE TO TERMINAL, SEAM OK
	4						2	930	1250	Not Evaluated	5,952	SLIPPAGE TO TERMINAL, SEAM OK
181115_3	5	120	2	A	1,125	1,32	1	563	1200	Not Evaluated	3,739	SLIPPAGE TO TERMINAL, SEAM OK
	6						2	563	Not Evaluated	Not Evaluated	4,883	SLIPPAGE TO TERMINAL, SEAM OK
181115_4	7	120	2	B	1,86	2,19	1	930	1286	Not Evaluated	9,38	SLIPPAGE TO TERMINAL, BREAKING FIRST TWO POINT OF SEAM
	8						2	930	Not Evaluated	Not Evaluated	11,445	SLIPPAGE TO TERMINAL
181115_5	9	120	1,5	A	0,844	0,99	1	563	955	342	4,245	
	10						2	563	966	355	3,934	
181115_6	11	120	2,5	A	1,406	1,66	1	563	1200	Not Evaluated	3,98	SLIPPAGE TO TERMINAL, SEAM OK
	12						2	563	1200	Not Evaluated	5,798	SLIPPAGE TO TERMINAL, SEAM OK
181115_7	13	120	1,5	B	1,395	1,64	1	930	1300	Not Evaluated	7,221	SLIPPAGE TO TERMINAL, SEAM OK
	14						2	930	1300	Not Evaluated	8,75	SLIPPAGE TO TERMINAL, SEAM OK
181115_8	15	120	4	A	2,25	2,6487	1	563	1250	Not Evaluated	7,86	SLIPPAGE TO TERMINAL, SEAM OK
181115_9	16	121	8,9	A	5	5,93505	1	563	Not Evaluated	Not Evaluated	8,524	BREAKING OF THE DEVICE

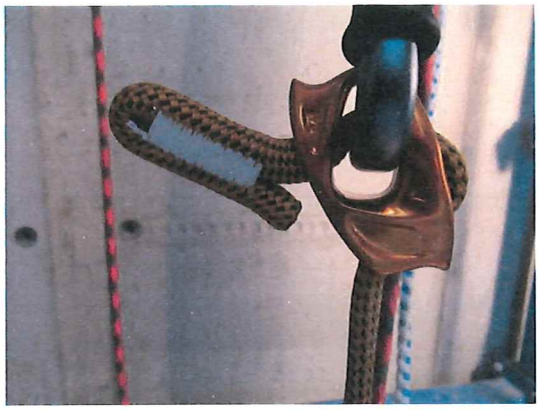
Table 2: All tests configurations and outcomes

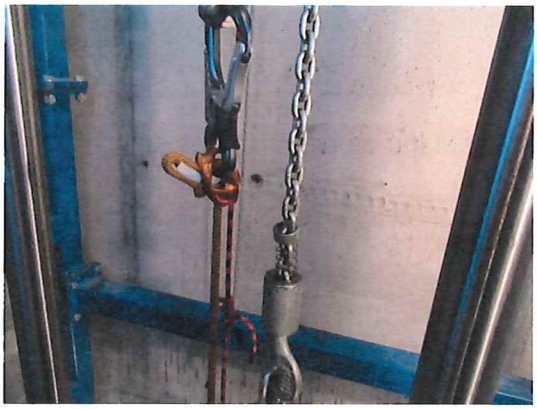
Tests outcomes

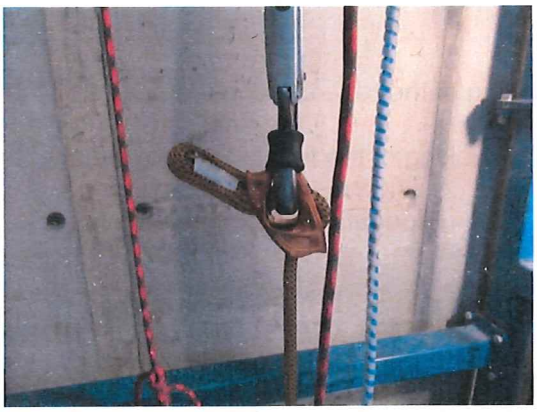
The length of the entire device, measured after 1 minutes from the application of the weight of the catching plate (8 kg) and with the method specified above, is 1125 mm.

Test No.1: Configuration A, Fall factor 1, sample 181115_1, first drop	
	FALL HEIGHT (mm): 562.5 DEVICE ENTIRE LENGTH (mm): 562.5 FALLING ENERGY (kJ): 0.66
	**Outcomes:** Slipping of the rope through the device (175 mm). Elongation of the entire device. No breaking but permanent micro fusion of the ropes sheath. F_{max}: 4.58 kN

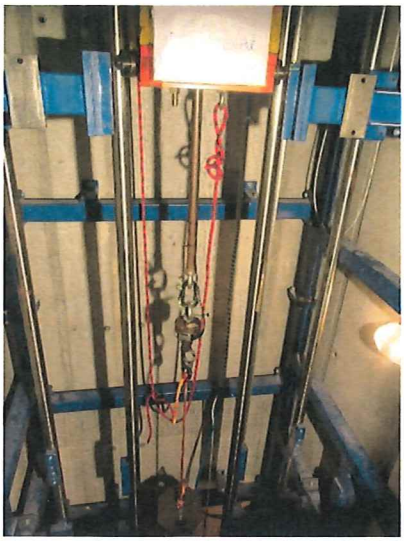
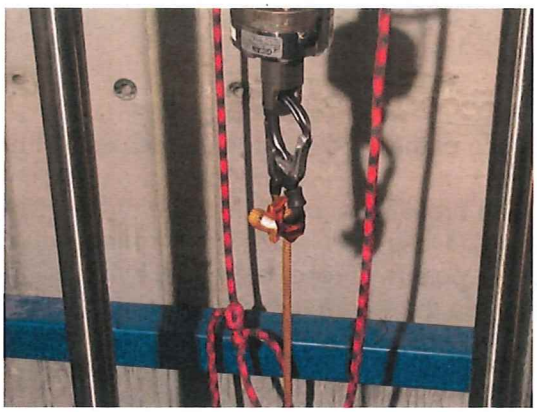
Test No.2: Configuration A, Fall factor 1, sample 181115_1, second drop	
	FALL HEIGHT (mm): 562.5 DEVICE ENTIRE LENGTH (mm): 562.5 FALLING ENERGY (kJ): 0.66
	**Outcomes:** Slipping of the rope through the device (197 mm). Elongation of the entire device. No breaking but permanent micro fusion of the ropes sheath. F_{max}: 4.20 kN The breaking force recorded is less than the force recorded in Test 1 (both tests performed on the same sample) because of the more rope length that passed through the device during the test: the diameter of the rope after the first drop decreased, so the slipping became easier.

Test No.3: Configuration B, Fall factor 1, sample 181115_2, first drop	
	FALL HEIGHT (mm): 930.0 DEVICE ENTIRE LENGTH (mm): 930.0 FALLING ENERGY (kJ): 1.09
	**Outcomes:** Slipping of the rope through the device till the sewn terminal. Elongation of the entire device. No breaking but permanent micro fusion of the ropes sheath. F_{max}: 5.16 kN

Test No.4: Configuration B, Fall factor 1, sample 181115_2, second drop	
	FALL HEIGHT (mm): 930 DEVICE ENTIRE LENGTH (mm): 930 FALLING ENERGY (kJ): 1.09
	**Outcomes:** Slipping of the rope through the device till the sewn terminal. F_{max}: 5.95 kN

Test No.5: Configuration A, Fall factor 2, sample 181115_3, first drop	
	FALL HEIGHT (mm): 1125.0 DEVICE ENTIRE LENGTH (mm): 562.5 FALLING ENERGY (kJ): 1.32
	**Outcomes:** Slipping of the rope through the device till the sewn terminal. No breaking and the damage on the ropes appeared less than in test N.1 (probably due to the fact the portion of rope interested by the slippage is more, so the load and the energy absorbing effect is distributed). F_{max}: 3.74 kN

Test No.6: Configuration A, Fall factor 2, sample 181115_3, second drop
FALL HEIGHT (mm): 1125.0 DEVICE ENTIRE LENGTH (mm): 562.5 FALLING ENERGY (kJ): 1.32
Outcomes: Slipping of the rope through the device till the sewn terminal. F_{max}: 4.89 kN The Breaking force higher than test N.5 of about 1 kN, due to the ropes increased stiffness after test 5, so the rope energy absorbing capacity decreased.

Test No.7: Configuration B, Fall factor 2, sample 181115_4, first drop	
	FALL HEIGHT (mm): 1860.0 DEVICE ENTIRE LENGTH (mm): 930.0 FALLING ENERGY (kJ): 2.19
	**Outcomes:** Slipping of the rope through the device till the sewn terminal. Breaking of the first two raw of seam of the terminal. Elongation of the entire device. Fmax: 9.38 kN

Test No.8: Configuration B, Fall factor 2, sample 181115_4, second drop
FALL HEIGHT (mm): 1860.0 DEVICE ENTIRE LENGTH (mm): 930.0 FALLING ENERGY (kJ): 2.19
Outcomes: Slipping of the rope through the device till the sewn terminal. Fmax: 11.45 kN

Test No.9: Configuration A, Fall factor 1.5, sample 181115_5, first drop	
	FALL HEIGHT (mm): 843.8 DEVICE ENTIRE LENGTH (mm): 562.5 FALLING ENERGY (kJ): 0.99
Outcomes: Slipping of the rope through the device (342 mm). Elongation of the entire device. No breaking of the device and no significative damage to the rope. Fmax: 4.25 kN	

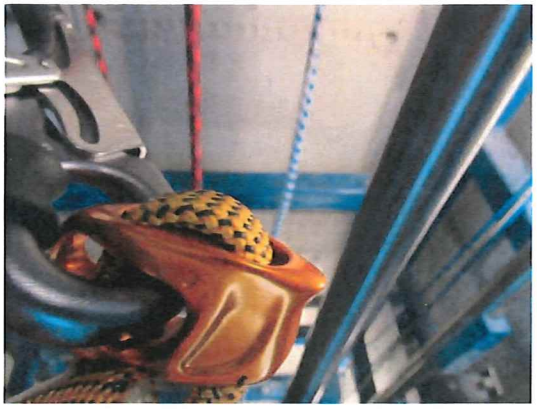
Test No.10: Configuration A, Fall factor 1.5, sample 181115_5, second drop
FALL HEIGHT (mm): 843.8 DEVICE ENTIRE LENGTH (mm): 562.5 FALLING ENERGY (kJ): 0.99
Outcomes: Slipping of the rope through the device (355 mm). Elongation of the entire device. No breaking of the device and no significative damage to the rope. Fmax: 3.93 kN NB see considerations regarding test N.2 to justify the decreasing arrest force compared to the breaking force recorded in test N.8.

Test No.11: Configuration A, Fall factor 2.5, sample 181115_6, first drop	
	FALL HEIGHT (mm): 1406.3 DEVICE ENTIRE LENGTH (mm): 562.5 FALLING ENERGY (kJ): 1.66
	**Outcomes:** Slipping of the rope through the device till the sewn terminal. No breaking of the seam. Elongation of the entire device. Fmax: 3.98 kN

Test No.12: Configuration A, Fall factor 2.5, sample 181115_6, second drop
FALL HEIGHT (mm): 1406.3 DEVICE ENTIRE LENGTH (mm): 562.5 FALLING ENERGY (kJ): 1.66
Outcomes: Slipping of the rope through the device till the sewn terminal. No breaking of the seam. Elongation of the entire device. Fmax: 5.80 kN

Test No.13: Configuration B, Fall factor 1.5, sample 181115_7, first drop	
	FALL HEIGHT (mm): 1395.0 DEVICE ENTIRE LENGTH (mm): 930.0 FALLING ENERGY (kJ): 1.64
	**Outcomes:** Slipping of the rope through the device till the sewn terminal. No breaking of the seam. Elongation of the entire device. Fmax: 7.22 kN

Test No.14: Configuration B, Fall factor 1.5, sample 181115_7, second drop
FALL HEIGHT (mm): 1395.0 DEVICE ENTIRE LENGTH (mm): 930.0 FALLING ENERGY (kJ): 1.64
Outcomes: Slipping of the rope through the device till the sewn terminal. No breaking of the seam, but heavy fusion of the external sheath of the rope. Elongation of the entire device. Fmax: 8.75 kN NB see considerations regarding test N.6 to justify the increasing arrest force compared to the breaking force recorded in test N.12.

Test No.15: Configuration A, Fall factor 4, sample 181115_8	
	FALL HEIGHT (mm): 2250.0 DEVICE ENTIRE LENGTH (mm): 563.0 FALLING ENERGY (kJ): 2.65
	**Outcomes:** Slipping of the rope through the device till the sewn terminal. No breaking of the seam. The rope decreases the diameter inside the device Elongation of the entire device. Fmax: 7.83 kN

Test No.16: Configuration A, Fall factor 8.88, sample 181115_9	
	FALL HEIGHT (mm): 5000.0 DEVICE ENTIRE LENGTH (mm): 563.0 FALLING ENERGY (kJ): 5.94
	**Outcomes:** Breaking of the device. Fmax: 8.52 kN

As outcomes summary see graphs in the following section: all data collected are represented in graphs of various nature:

- Arrest Force VS Falling height for both configurations A and B;
- Arrest force VS Falling Factor for both configurations A and B.

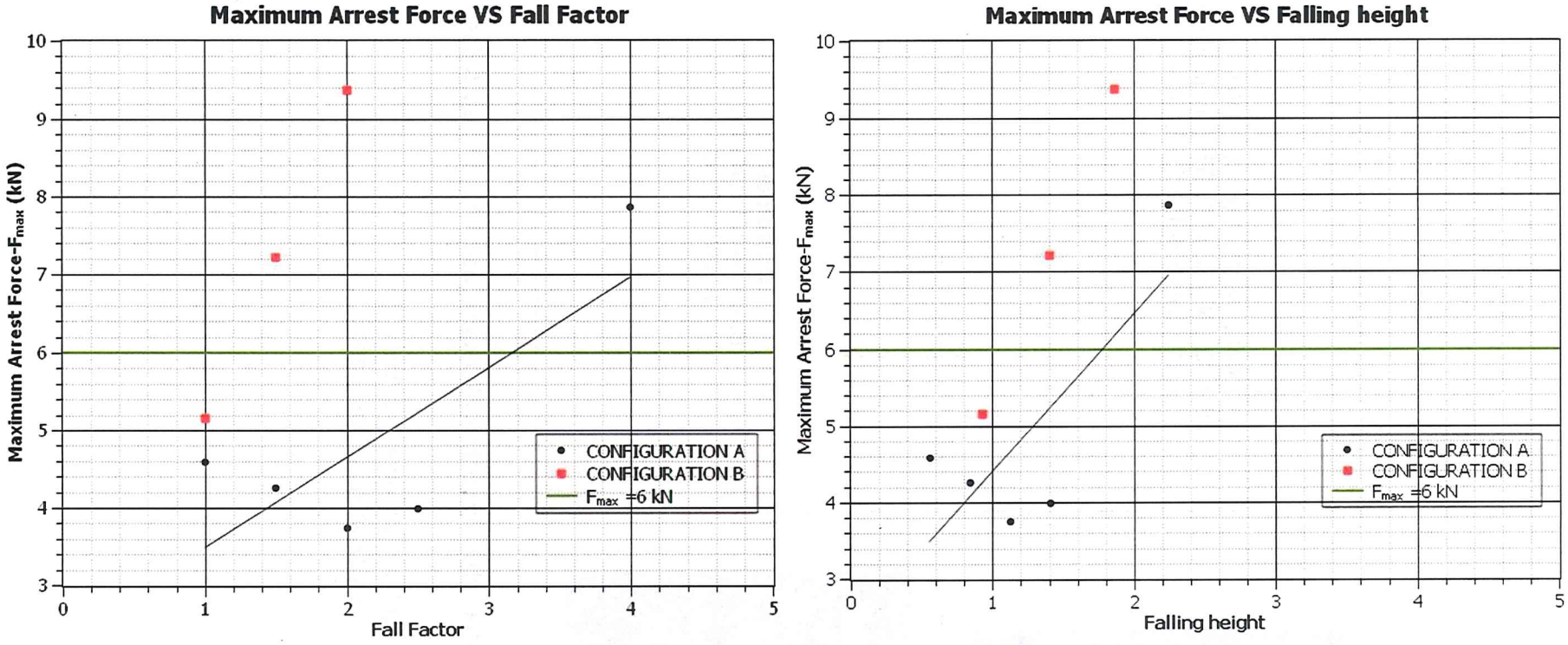


Figure 4: Outcomes plots

The plots above represent the recorded data of the tests. In every graph there's a green line representing the maximum arrest force permitted by EN 958:2017 for dynamic tests performed with the 120 kg falling mass. As we can see from data plotted in black, referred to behaviour of the device in the configuration A, the limit of 6 kN is reached with a fall factor of approximately 3.3, corresponding to a Falling height of 1.90 m.
On the other hand in the configuration B the device could reach very fast the 6 kN of maximum arrest force increasing from 1 the fall factor: in fact considering a 1.5 fall factor (that corresponds to about 1.5 falling height) the maximum arrest force recorded is almost 7.5 kN.
Looking to data in the plots, we can see that approximately with a falling height of 1.2 m 6 kN could be reached.

The evaluation has been conducted with the linear interpolation tendency of both configurations, but solely the linear interpolation tendency of configuration A has been reported on the plots.

APPENDIX A

Anthropometric data collected during the project SAFERALPS

PORTATA ORIZZONTALE (CM)

Gruppo	VM	95%	5%
Uomini	74	68	80
Donne	67	61	73
Bambini	57	50	64

ALTEZZA SPALLE (CM)

Gruppo	VM	95%	5%
Uomini	145	136	155
Donne	134	125	143
Bambini	127	115	139

LUNGHEZZA DELLE GAMBE (CM)

Gruppo	VM	95%	5%
Uomini	93	76	110
Donne	89	80	98
Bambini	81	71	90