Dyneema incident on Mt. Świnica

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Contents

4 March 2023

- 20:11 TOPR HQ receives a call from two climbers who got stuck in the north face of Mt. Świnica

- team departs from Zakopane, reaches nearby peak by cable car, follows the ridge and traverses into the north face of Świnica

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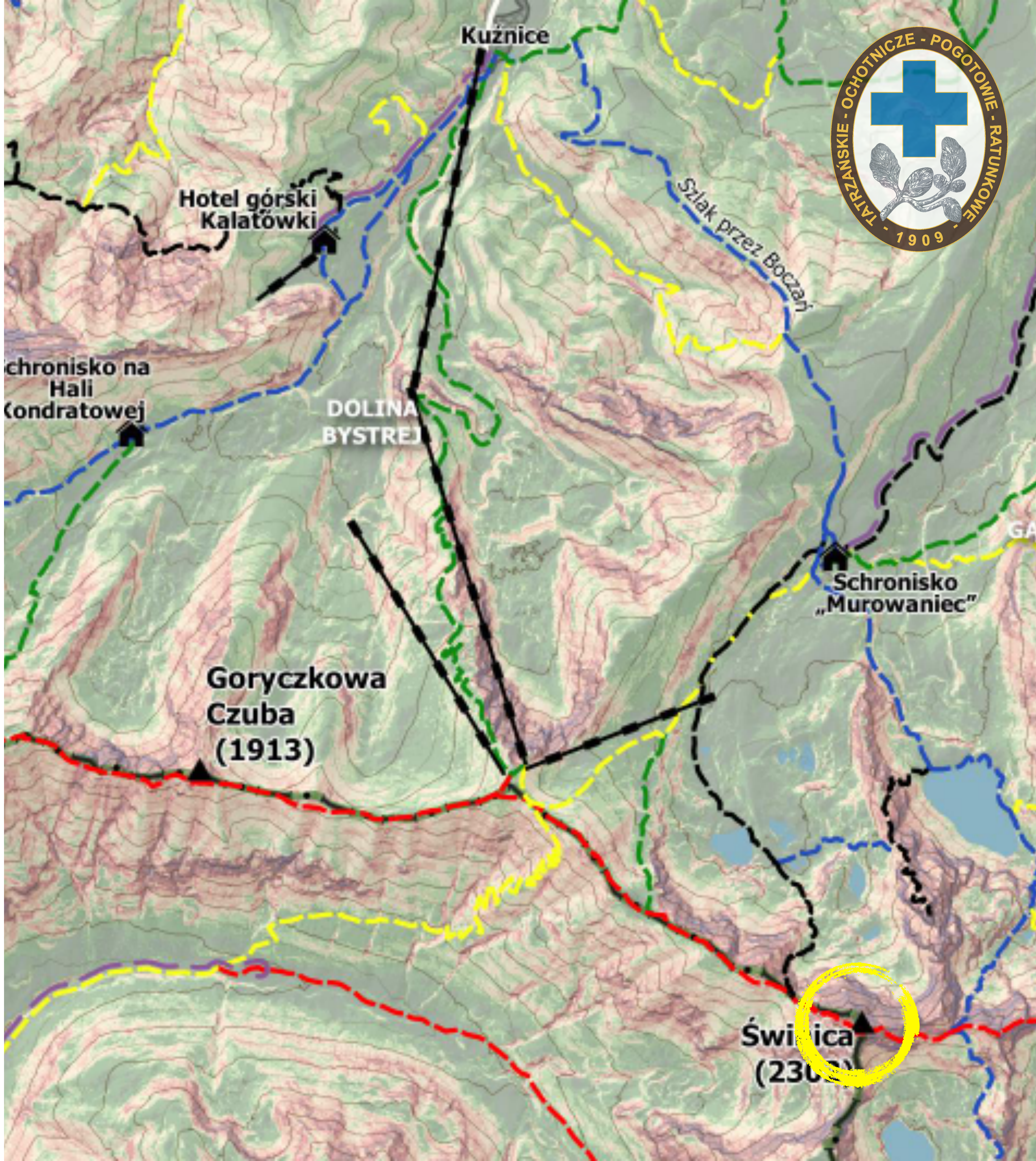
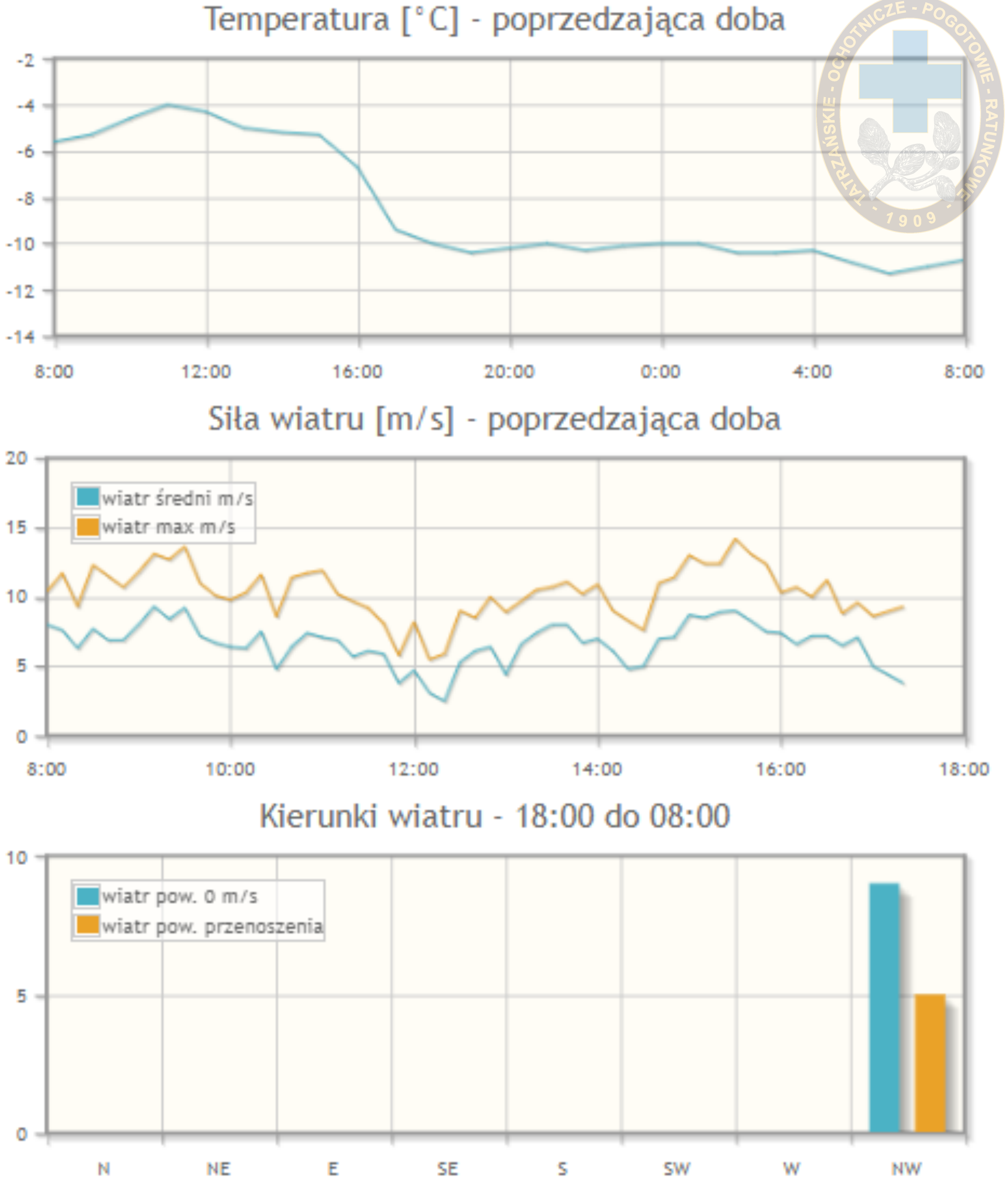


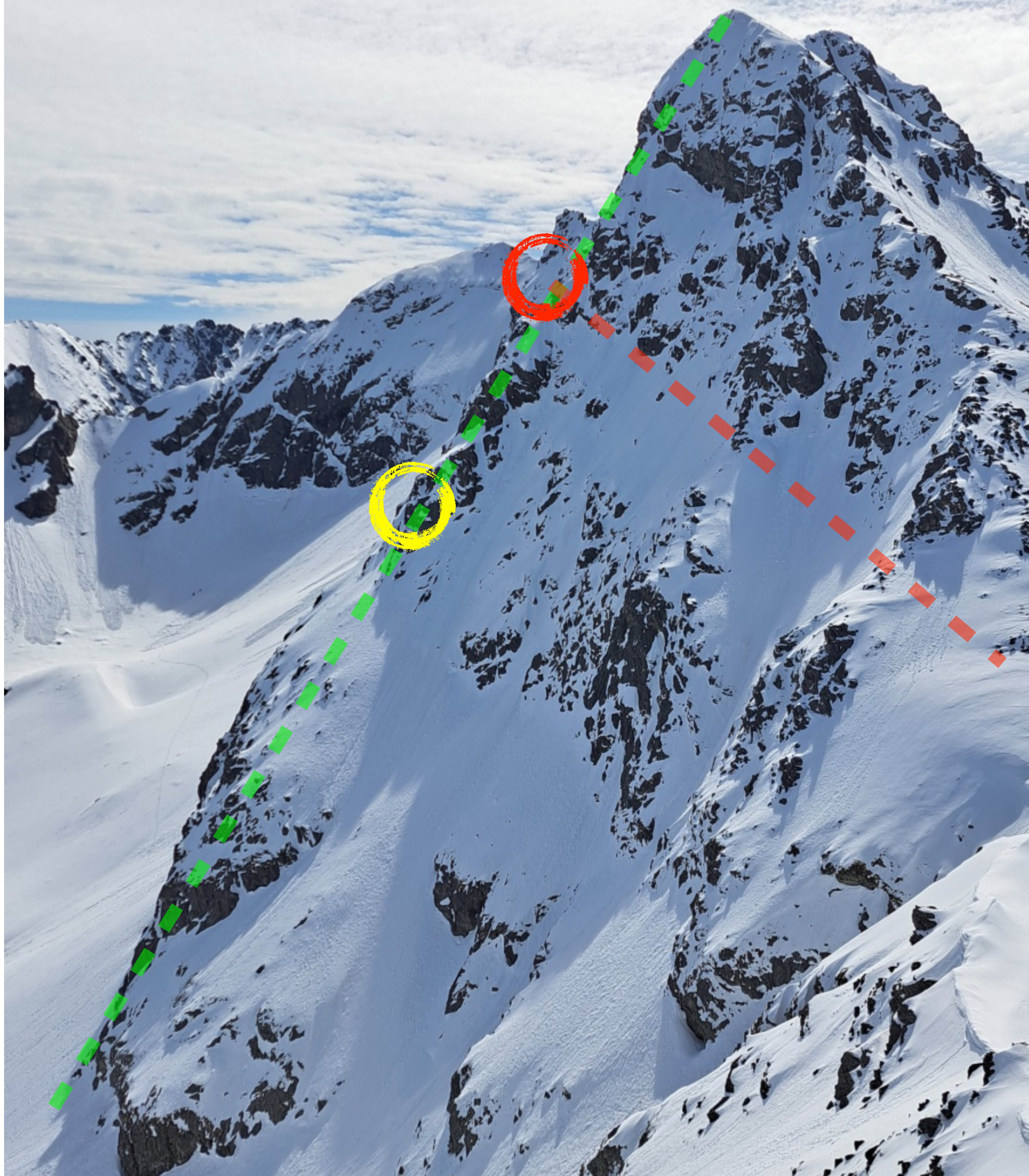
4 March 2023

- the weather conditions are unfavorable
- at night the temperature drops to -10°C
- the wind and reduced visibility additionally complicate the local avalanche danger evaluation



Mt. Świnica, northern pillar

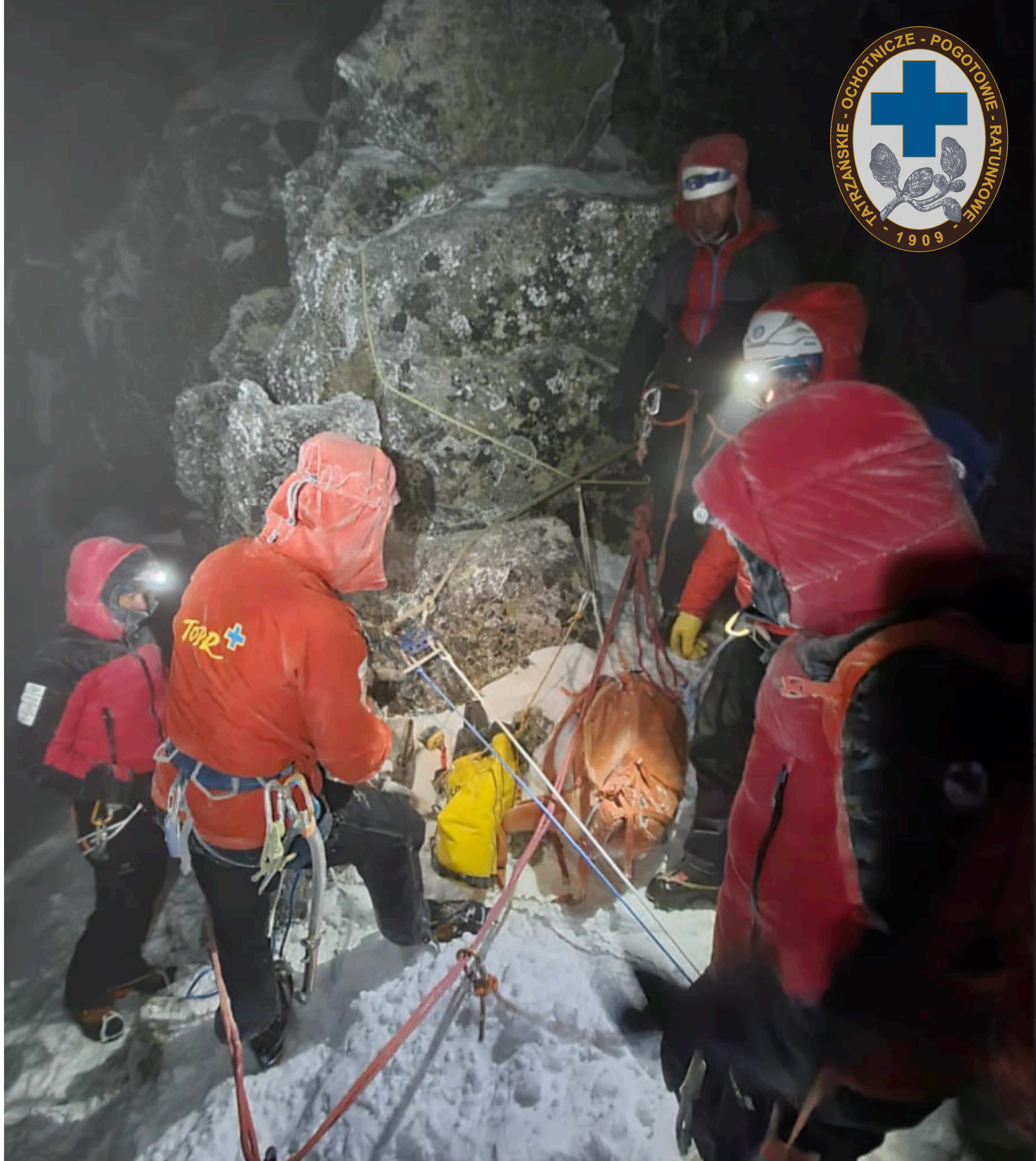
- the northern pillar route: 400 m length, IV+ UIAA,
- the rescuers safely reach a convenient spot above the climbers in 2/3 of the pillar,
- the belay station is set up,
- a rescuer is lowered on two dyneema ropes towards the climbers,



lowering occurs in bad condtions

Mt. Świnica, northern pillar

- after maneouvering on the pillar the rescuer reaches the climbers,
- decision is made to hoist the three persons (two climbers and the rescuer) to the belay station,
- the rationale behind the decision is the avalanche danger at the bottom of the pillar (likely high, difficult to evaluate),
- additionally the topography of the pillar is complicated, and the distance to the belay station in relatively small
- hoisting set up is implemented (1:4 ratio), main hoisted rope is the blue one, white one is the backup,



Mt. Świnica, northern pillar

- the distance to the belay station is some 70 meters,

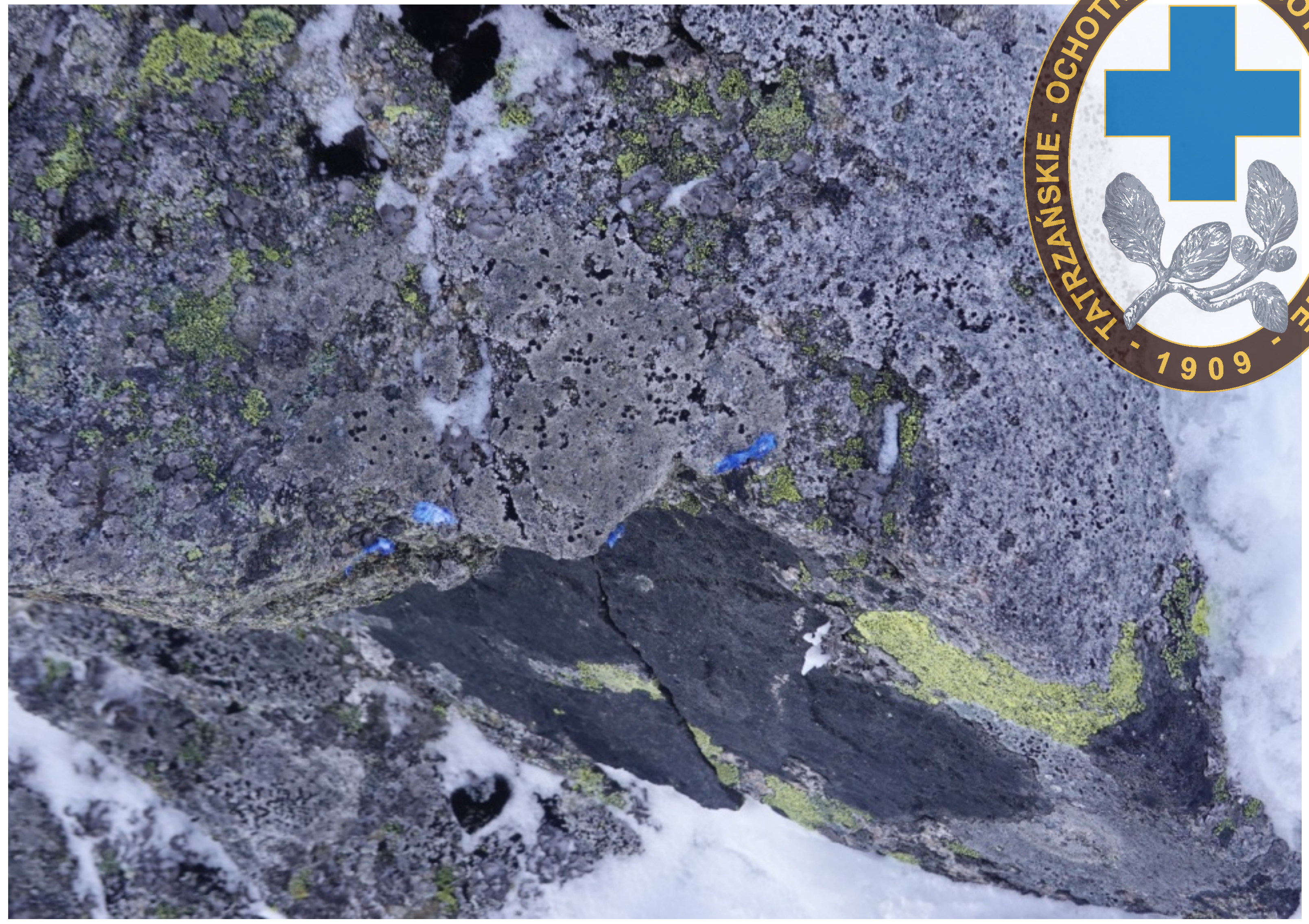
- the rope is being tautened,

- as the climbers are being lifted, and the rescuer is still standing on snow the rope becomes unstuck and brushes on rocks,

- suddenly the blue rope becomes loose, the rescuer reports that the climbers fell some 50 cms,

Mt. Świnica, northern pillar

- one of the rescuers on the belay station descends and finds out that the blue rope has been cut, he connects the loose ends of the rope,
- the hoisting scenario is deemed too risky,
- the rescuer and the climbers retreat from the face using elecric drill carried by the rescuer and climbers' ropes,
- no avalanche accident occurs,



on the following the days the rocks on the pillar are examined: some possess sharp, jagged features, the dyneema "fluff" is visible

causes of rope failure

- an assumption is made that **the rope became sheared on a sharp rocky feature studded with quartz crystals**,
- **the shearing occurred when rope was being tautened**, it left the positions it was placed when the rescuer was being lowered,
- when released it **most likely crossed a horizontal rocky “saw”**
- **the ease with which the rope failed fuelled a discussion about the actual hardiness of dyneema ropes**

AGH dyneema research

- scientists from AGH University of Science and Technology in Kraków, Poland were requested to test the rope used in Świnica rescue

Elongation at 10% of the breaking load: 0.60 %

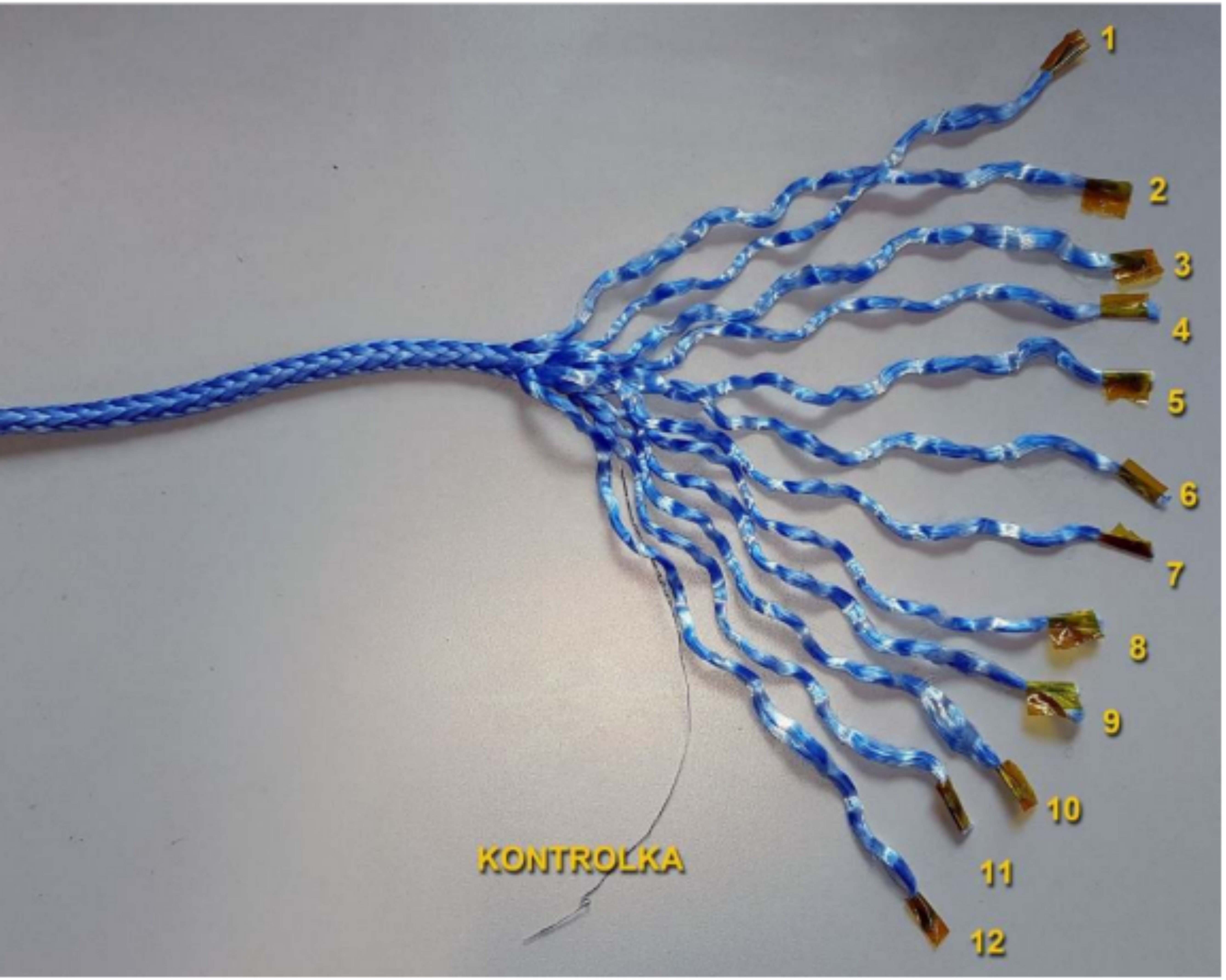
Ø [mm]	Weight [kg/100 m]	Bl. real in splice [kN]	Bl. linear DIN according to EN ISO 2307 [kN]
3 mm Ø	0.48	9.00	10.00
4 mm Ø	0.84	14.00	15.60
5 mm Ø	1.43	24.00	26.70
6 mm Ø	1.90	31.90	35.40
7 mm Ø	2.65	38.00	42.20
8 mm Ø	3.30	55.90	62.10
9 mm Ø	0.00	0.00	0.00
10 mm Ø	4.80	79.80	88.70

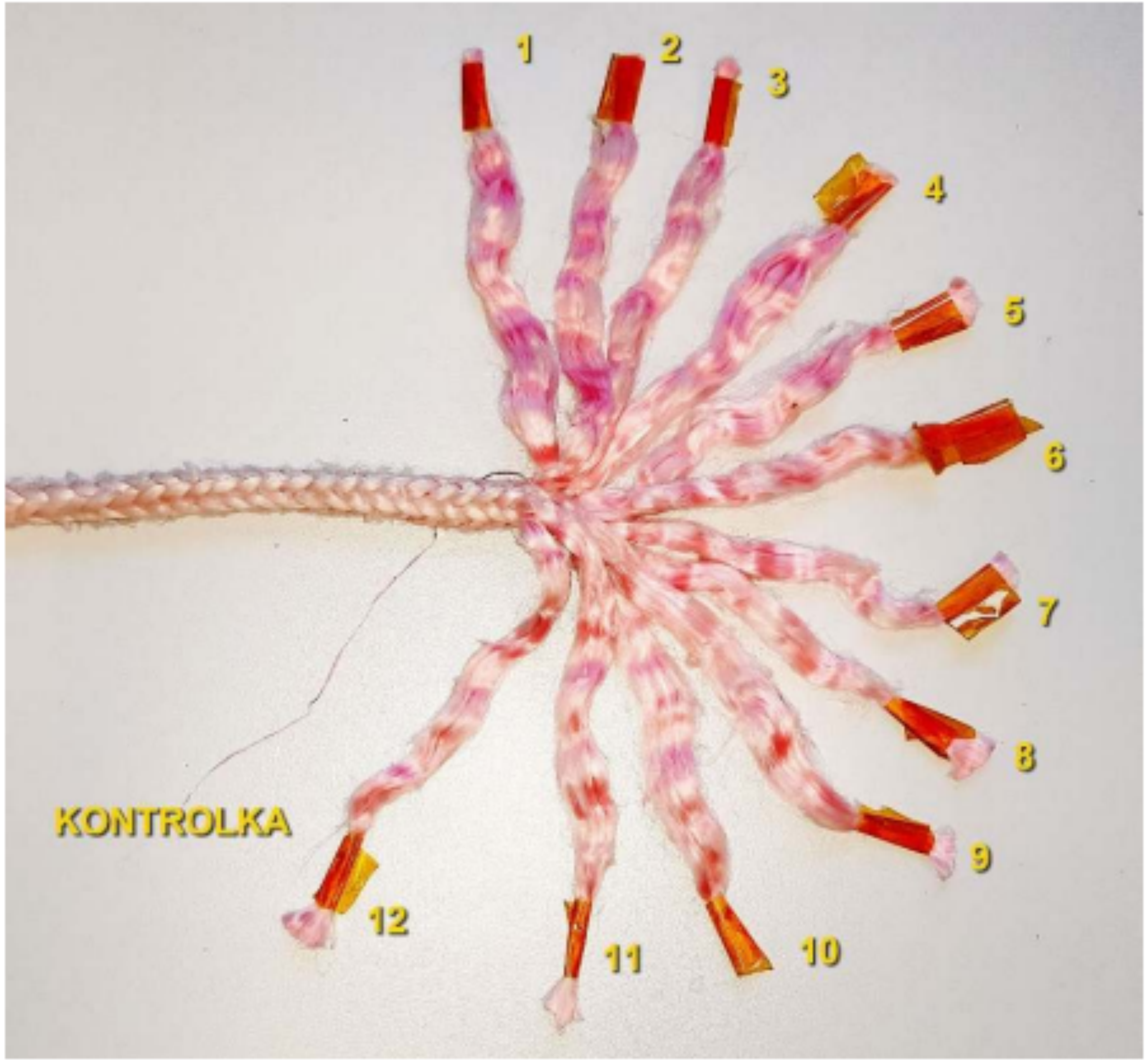
Dyneema®
UHMWPE - Ultra High Molecular Weight Polyethylene
8mm
manufactured in 2020

nominal parameters of the broken rope

AGH dyneema research

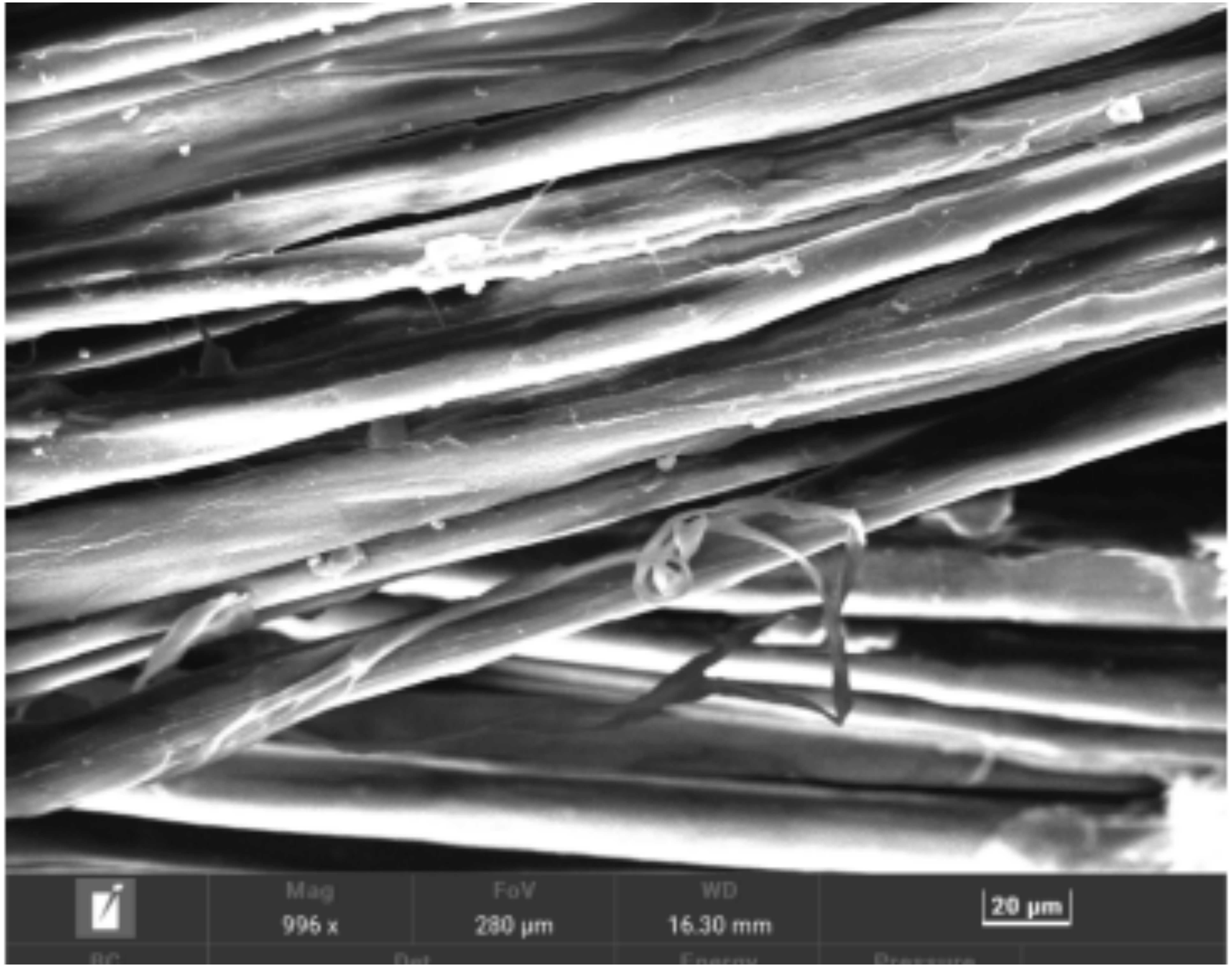
- two samples of dyneema ropes were provided for comparison
- the blue rope used in Świnica incident
- the faded pink rope used in the past, and currently retired
- both have a nominal thickness of 8mm
- the older rope became thicker with use



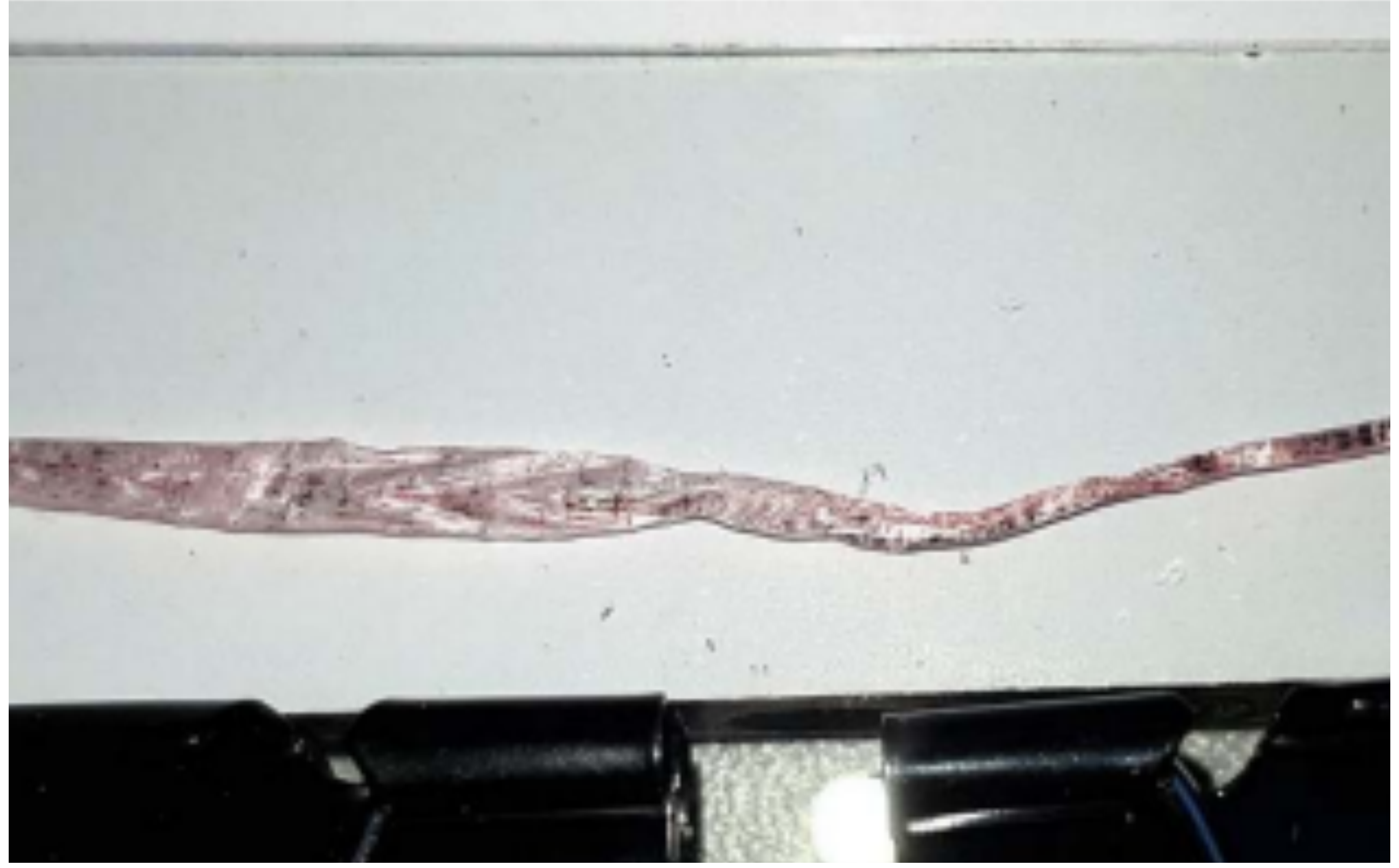


both ropes consist of 12 strands

marker threads visible



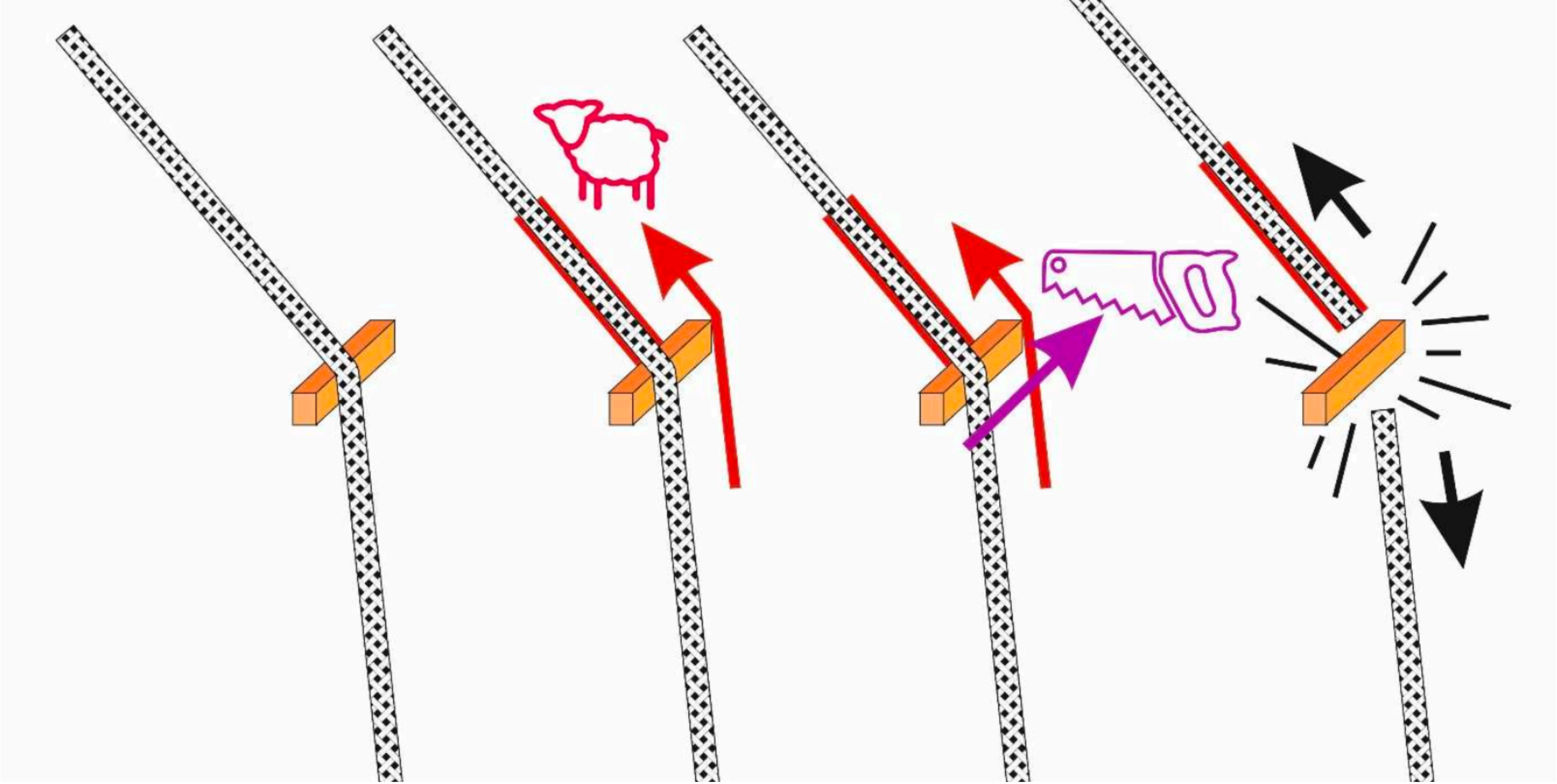
microscopic view of the (undamaged) structure of the blue rope



marker threads of both ropes

the research indicated that the rope was
in 90-95% cut (11 strands), only one strand broke

the entire damage occurred on total 9 cms of rope

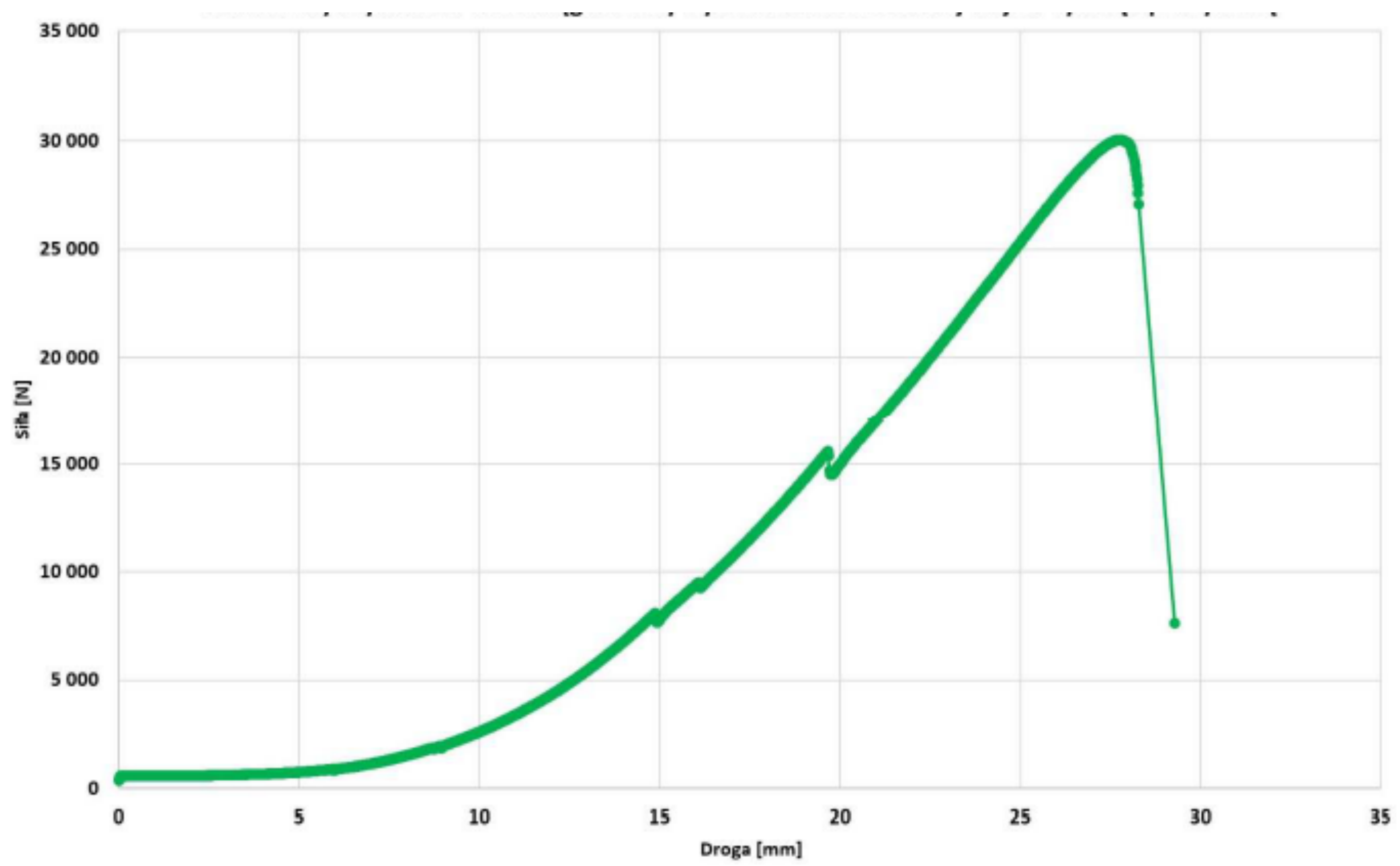


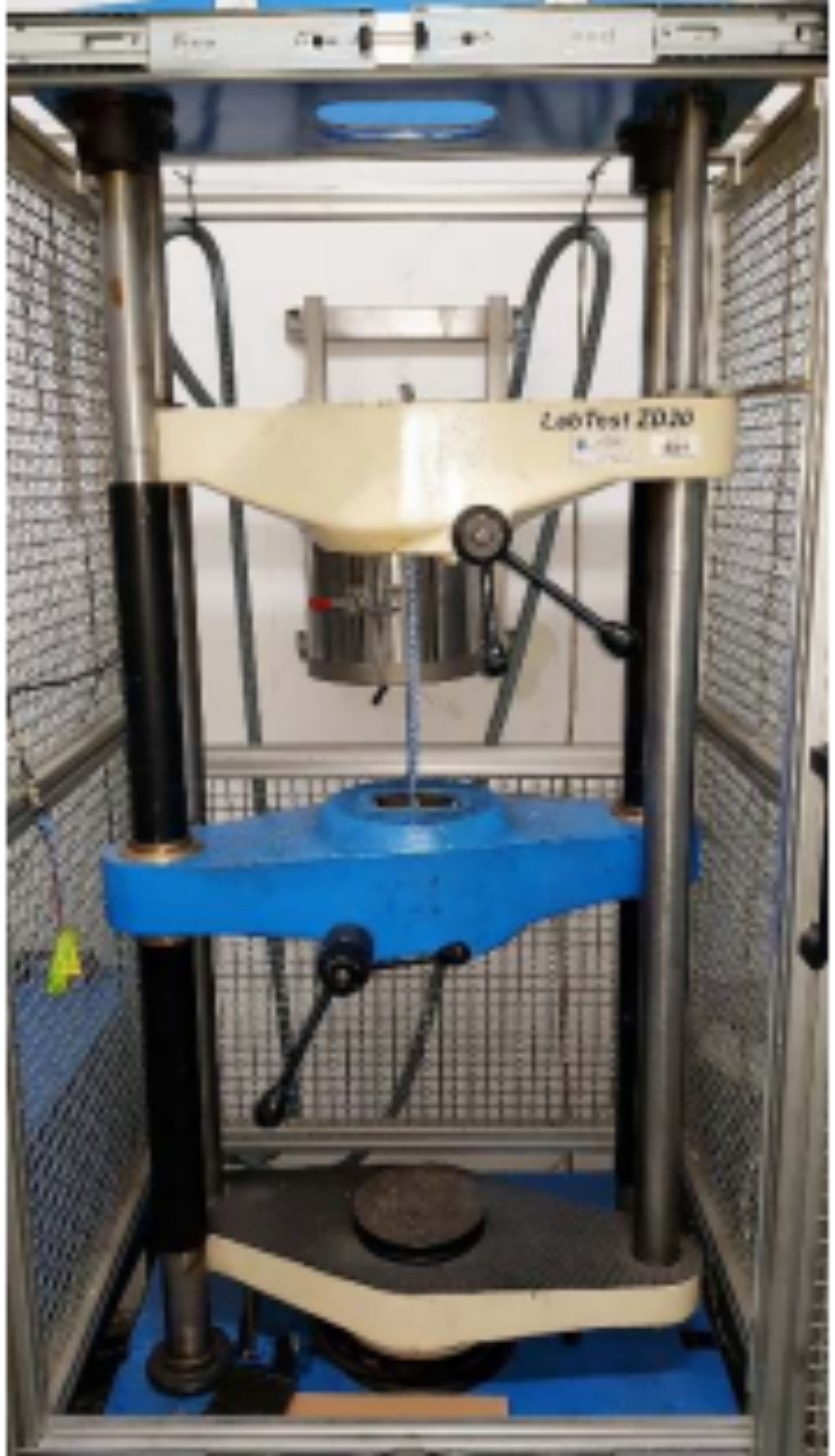
proposed mechanism of the
destruction of the rope

AGH dyneema research

AGH dyneema research

- test device designed for other kinds of rope
- researchers found it hard to fixate the rope
- at 30 kN the ropes slipped from the attachment points



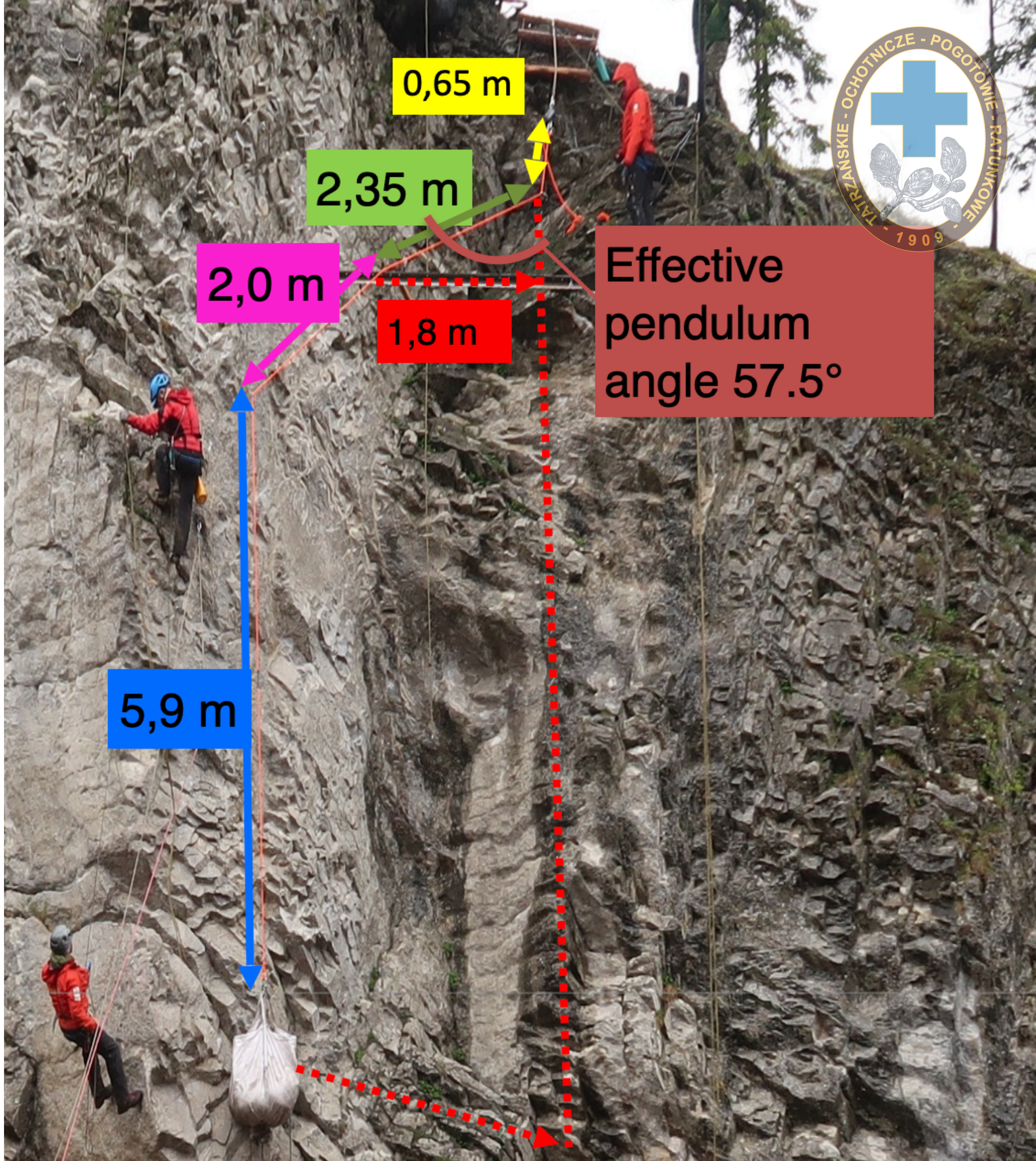


Testing of cut resistance of ropes on sharp edge

- Lejowa crag, Polish Tatras
- May-June 2023
- **Evaluation of measurements, photos and movies by PhD Eng. Michał Ciszewski**
- **Test rig: Pendulum over a sharp edge with load 140 kg or 200 kg, initial free fall**

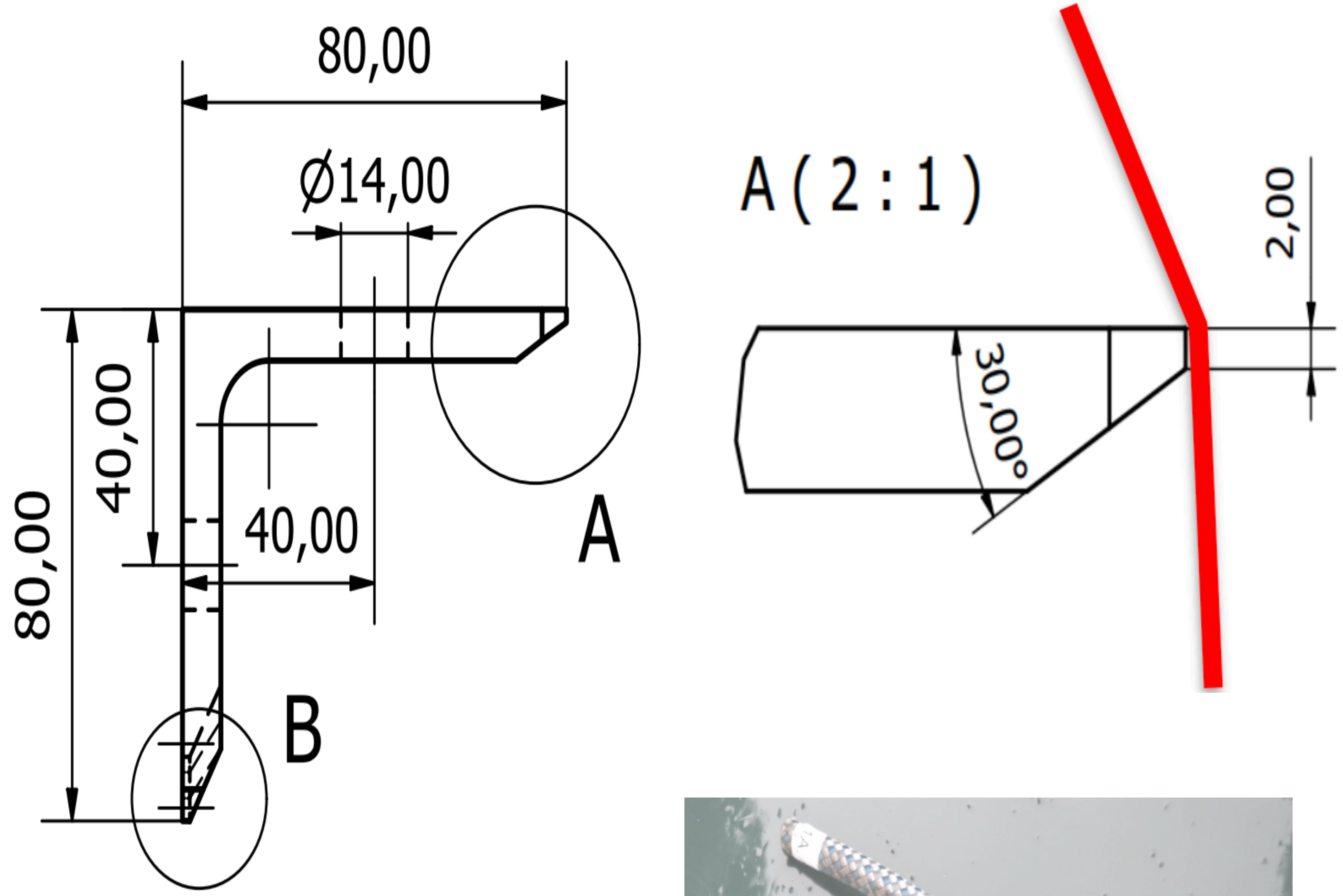
Testing of cut resistance of ropes on sharp edge

- test series A, B, C



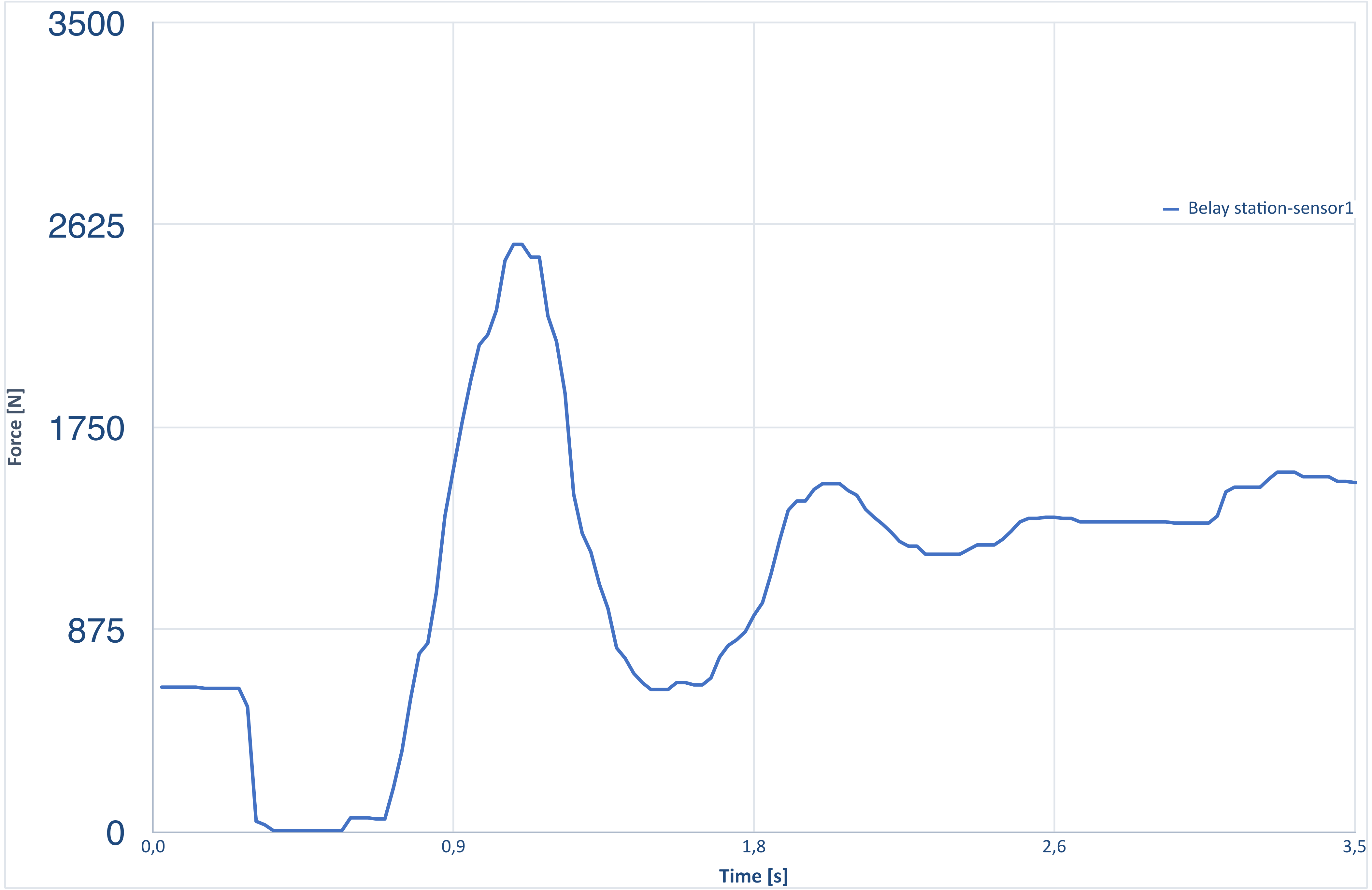
Testing of cut resistance of ropes on sharp edge - series A, B

- 3 m long L-profile with sharp edge
- ultrastatic belay station made with 2-strands of Dyneema
- rope sliding distance varying up to 2 m
- attachment of all ropes without knots – only braids
- MOVIE 1



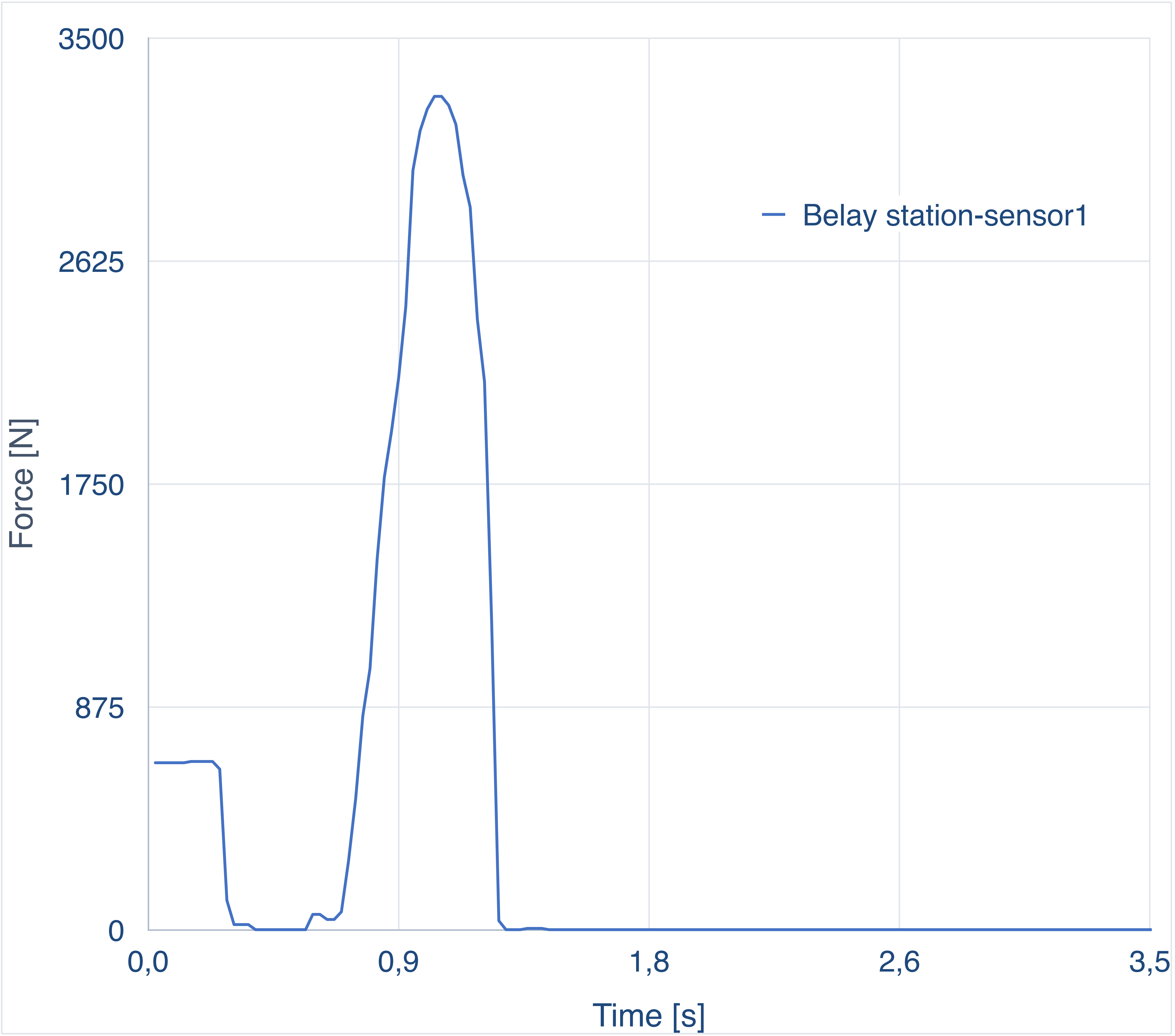
Sharp edge test with a pendulum
- rope 2B
Aramid/polyamide 10,5 mm - 140 kg load

- **THE ROPE DID NOT BREAK!**
- **The best cut resistance among semi-static ropes, densely braided aramid sheath**



Sharp edge test with a pendulum
- rope 3B
Polyester/polyamid 10,5 mm - 140 kg load

- **THE ROPE WAS CUT!**

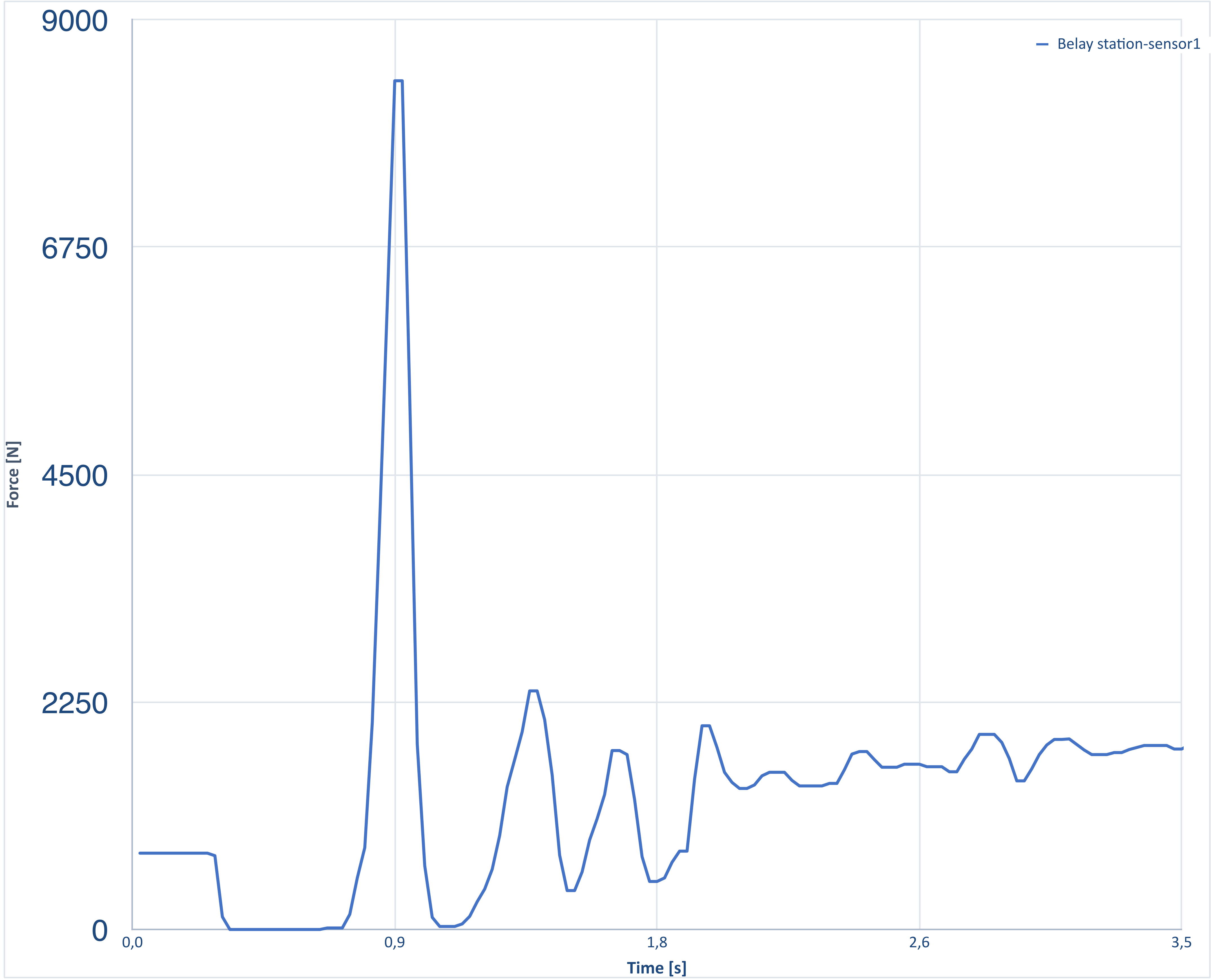


Sharp edge test with a pendulum
200 kg load
UHMWPE 8 mm <u>additionally heat treated</u>

- **THE ROPE DID NOT BREAK!**
  The best cut resistance among the tested ropes

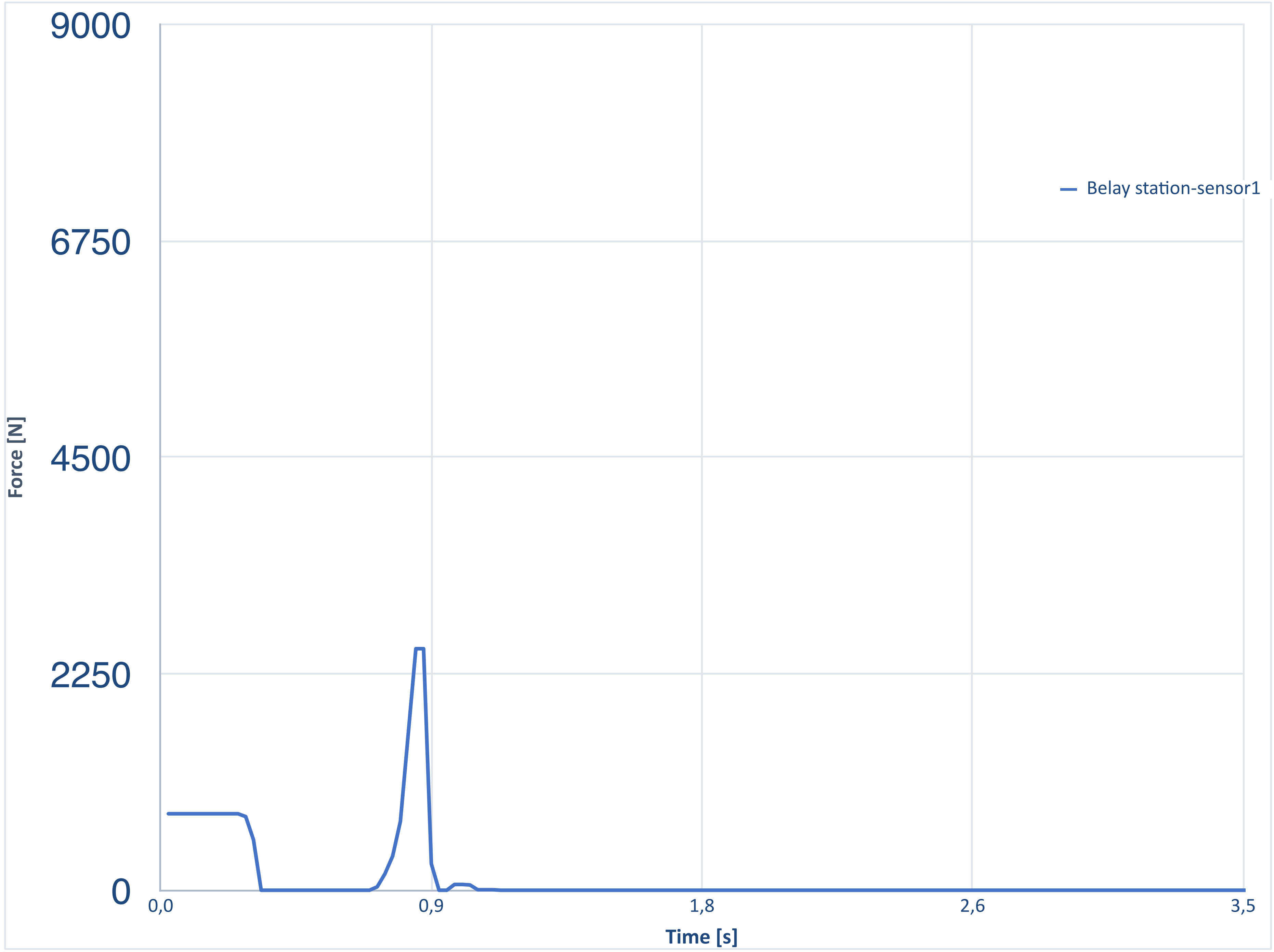
Sharp edge test with a pendulum - rope 11B Dyneema 8 mm - 140 kg load
<u>additionally heat treated</u>

- **THE ROPE DID NOT BREAK**
  Medium damage of the rope structure



Sharp edge test with a pendulum - rope 12B
8 mm Dyneema - 140 kg load

- **THE ROPE WAS CUT!**
- **Rapid melting of material with very low force compared to other Dyneema ropes!**

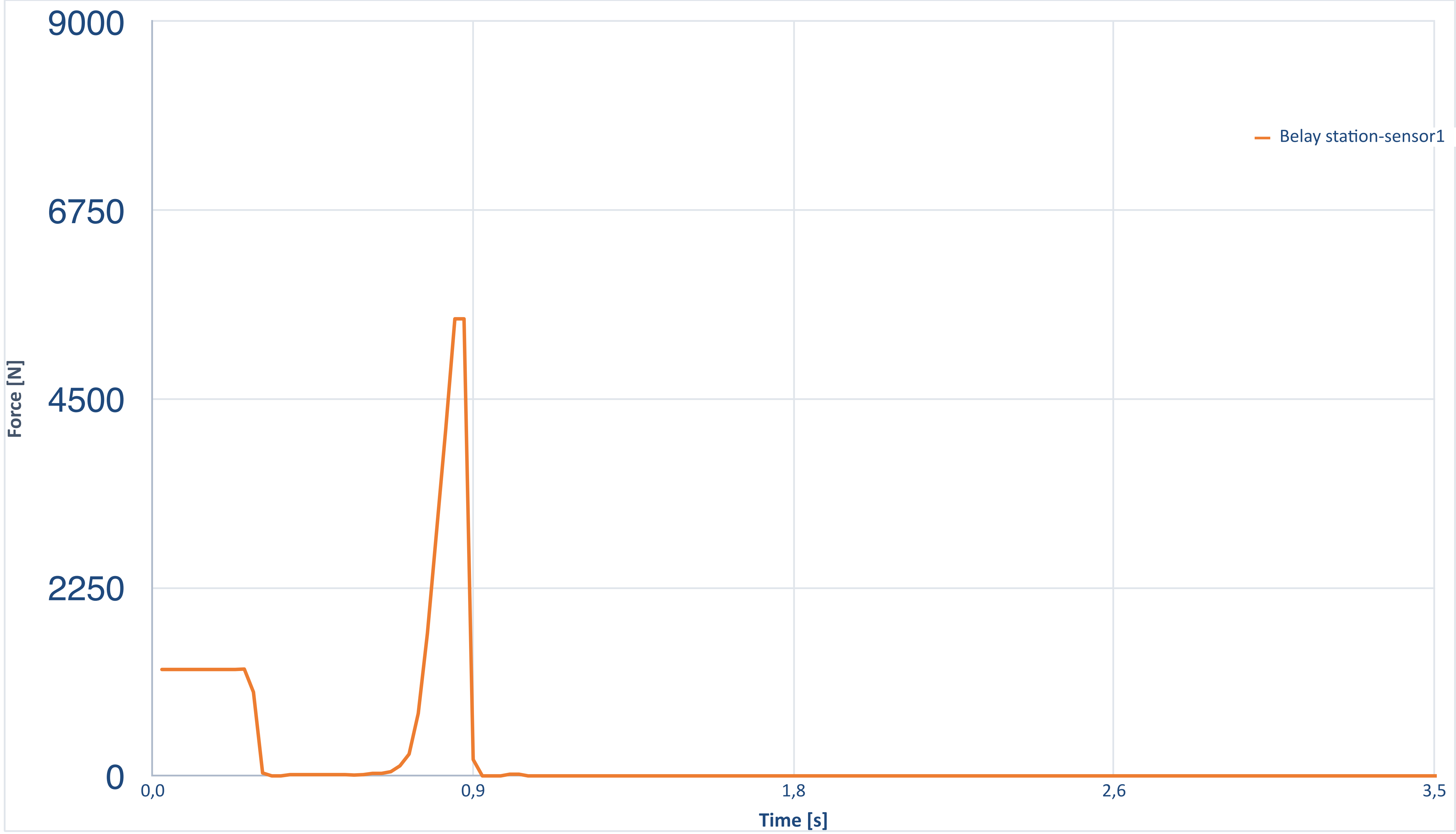


2 mm test edge after the rope failure

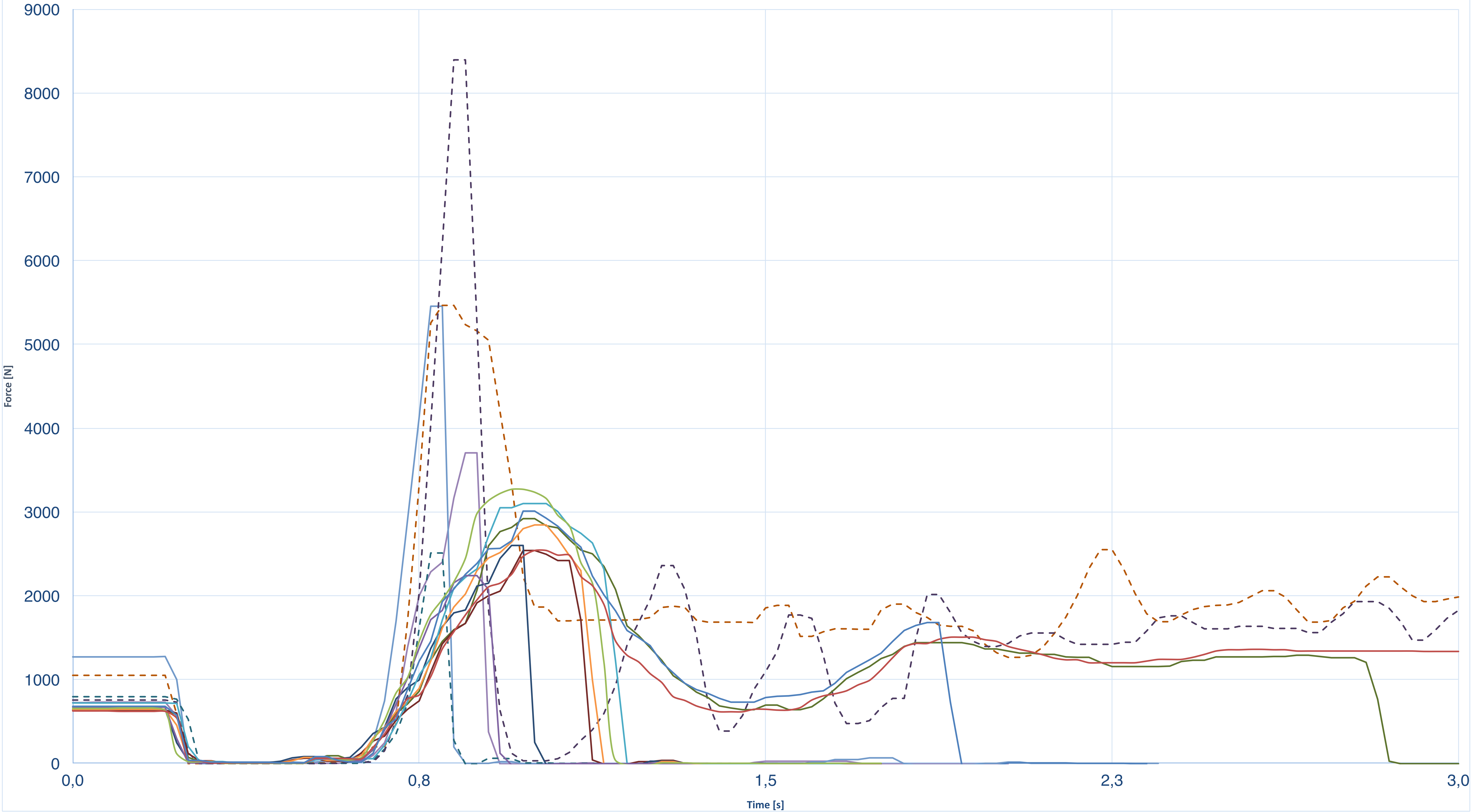
rope 12B, 8 mm Dyneema - 140 kg load

Sharp edge test with a pendulum - rope 14B
Steel rope 5,6 mm - 200 kg load

- THE ROPE WAS CUT!
- Breakage of the rope structure after the first touch of the sharp edge
- Time: 0.2 s from the contact of the edge to the complete breakage

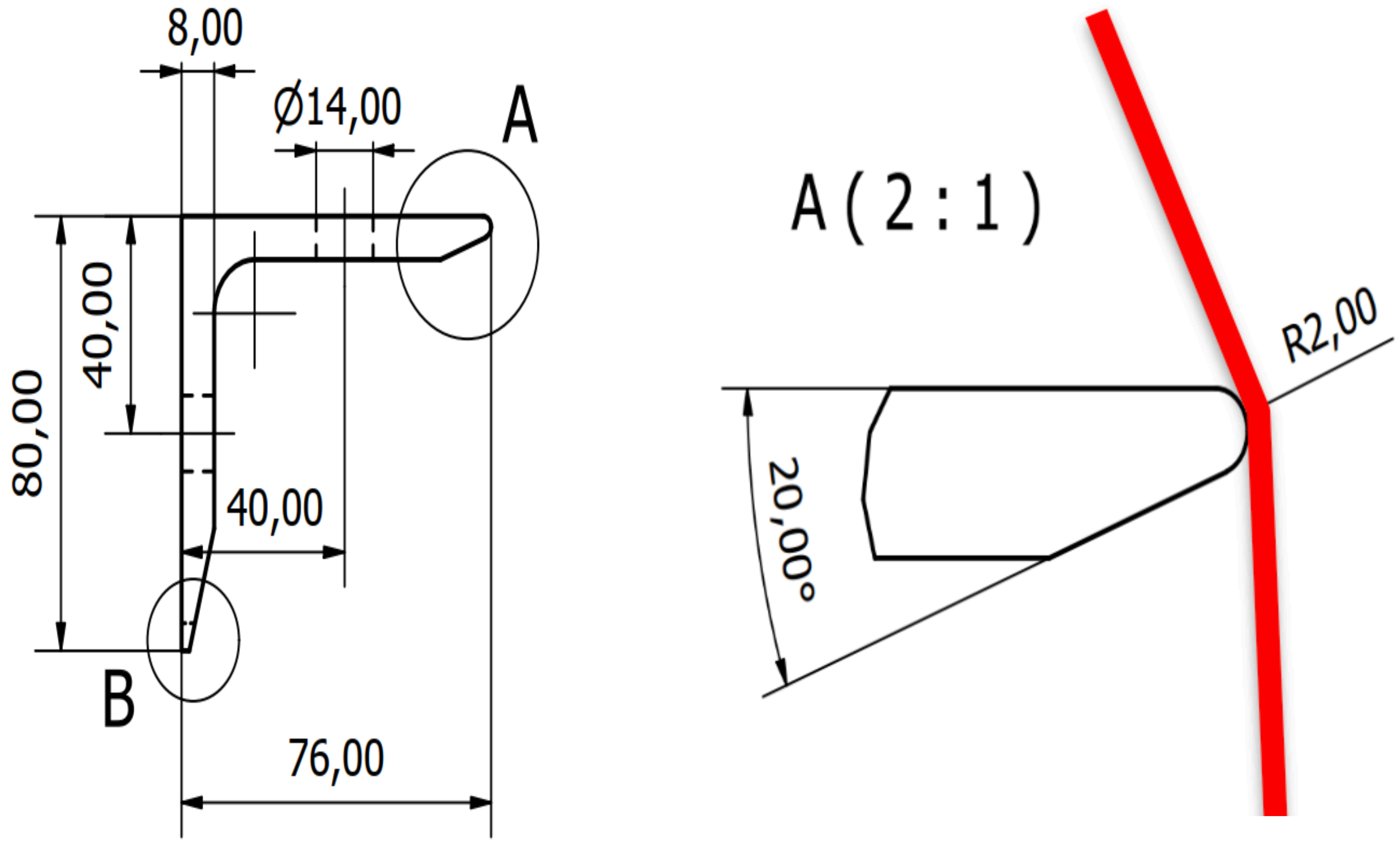


Sharp edge test with a pendulum, 140 kg load (or 200 kg as indicated) - force on belay station



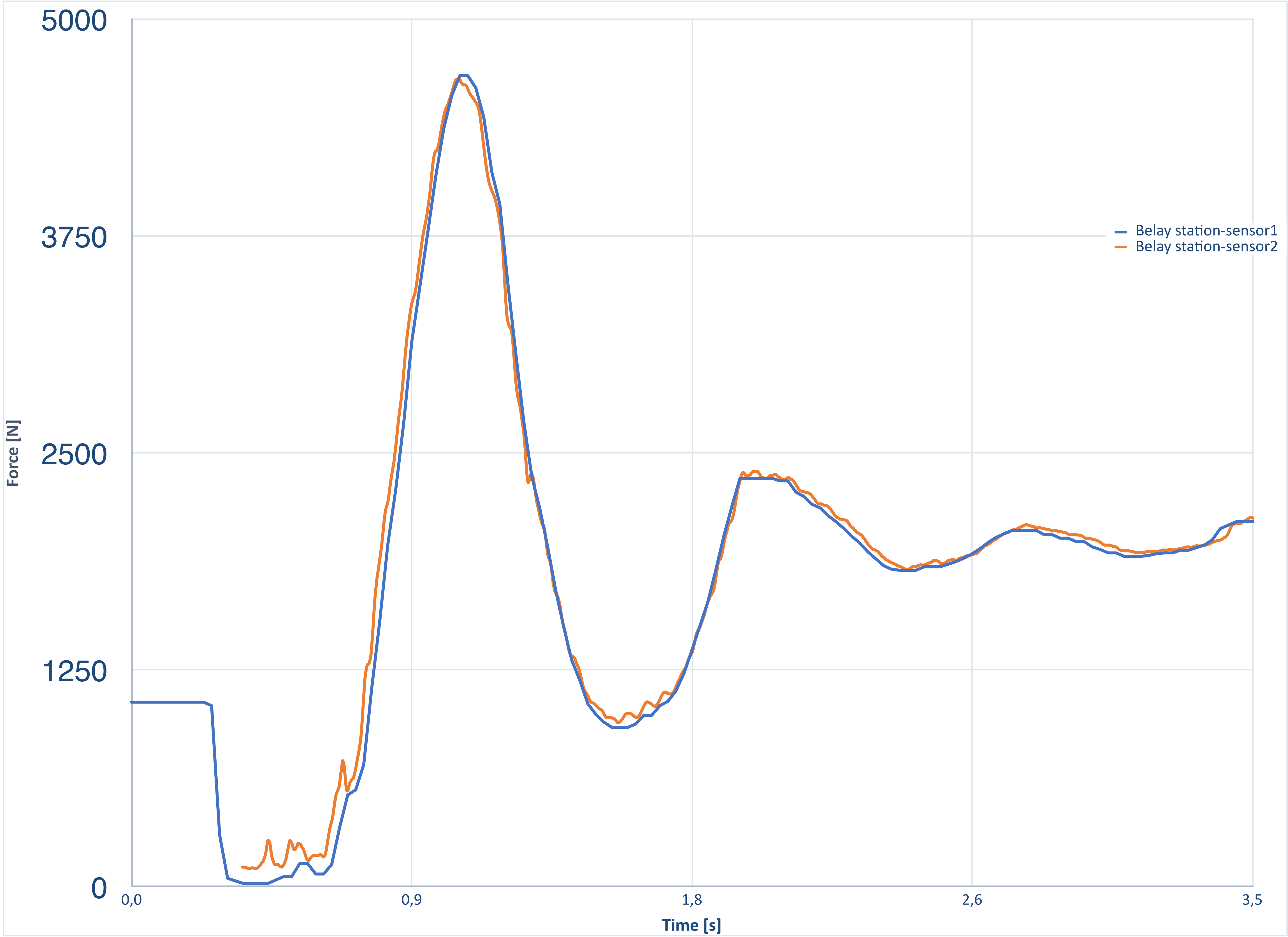
Testing of cut resistance of ropes on blunted edge - series C

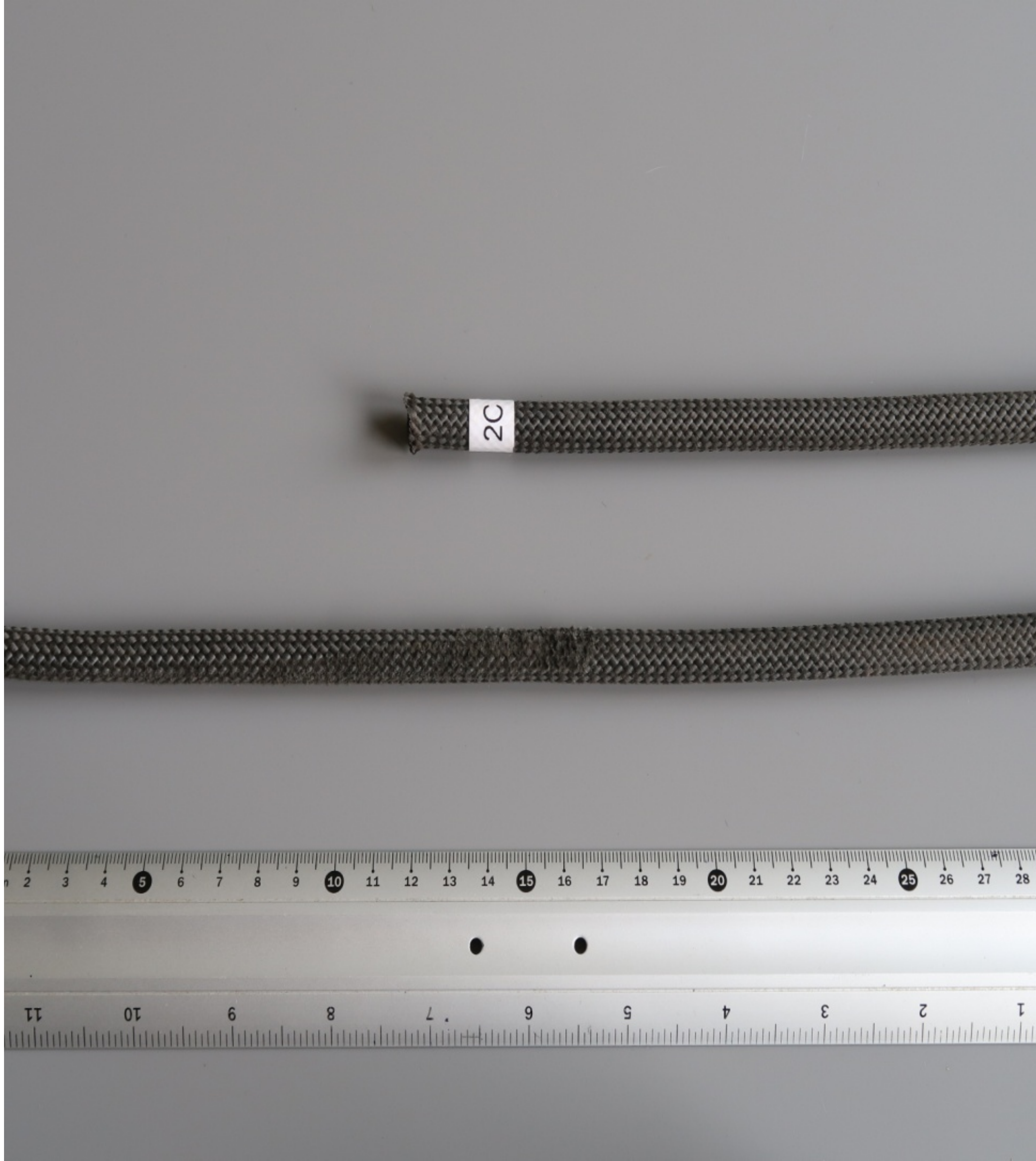
- 3 m long L-profile with sharp edge
- 2 mm radius on the edge (detail A)
- ultrastatic belay station made with 2-strands of 8 mm Dyneema rope
- rope sliding distance up to 2 m
- attachment of all ropes without knots – only braids
- MOVIE 2



Sharp edge test with a pendulum
- rope 2C
Aramid/polyamide 10,5 mm - 200 kg load

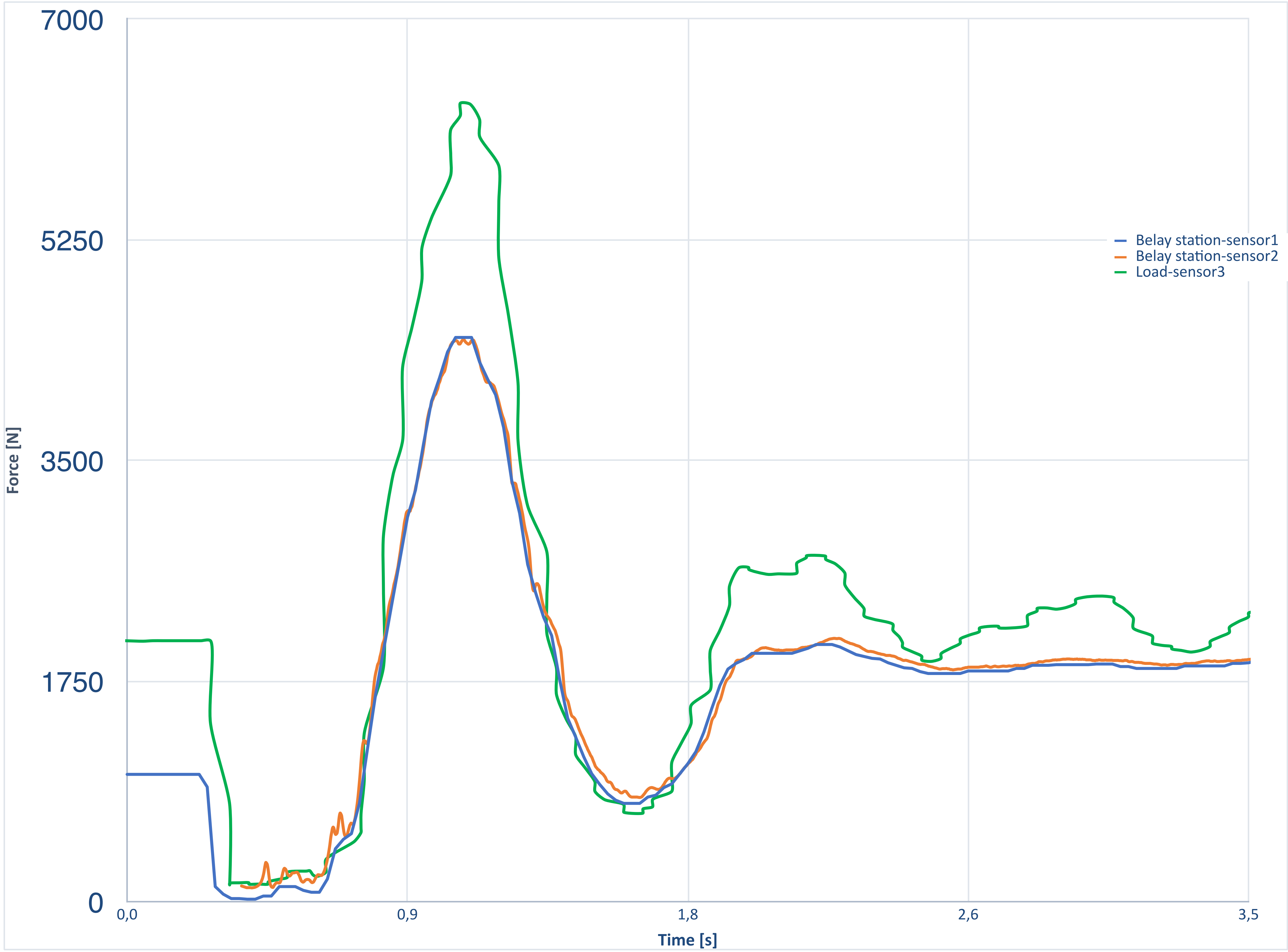
- **THE ROPE DID NOT BREAK - sheath damage is very small**





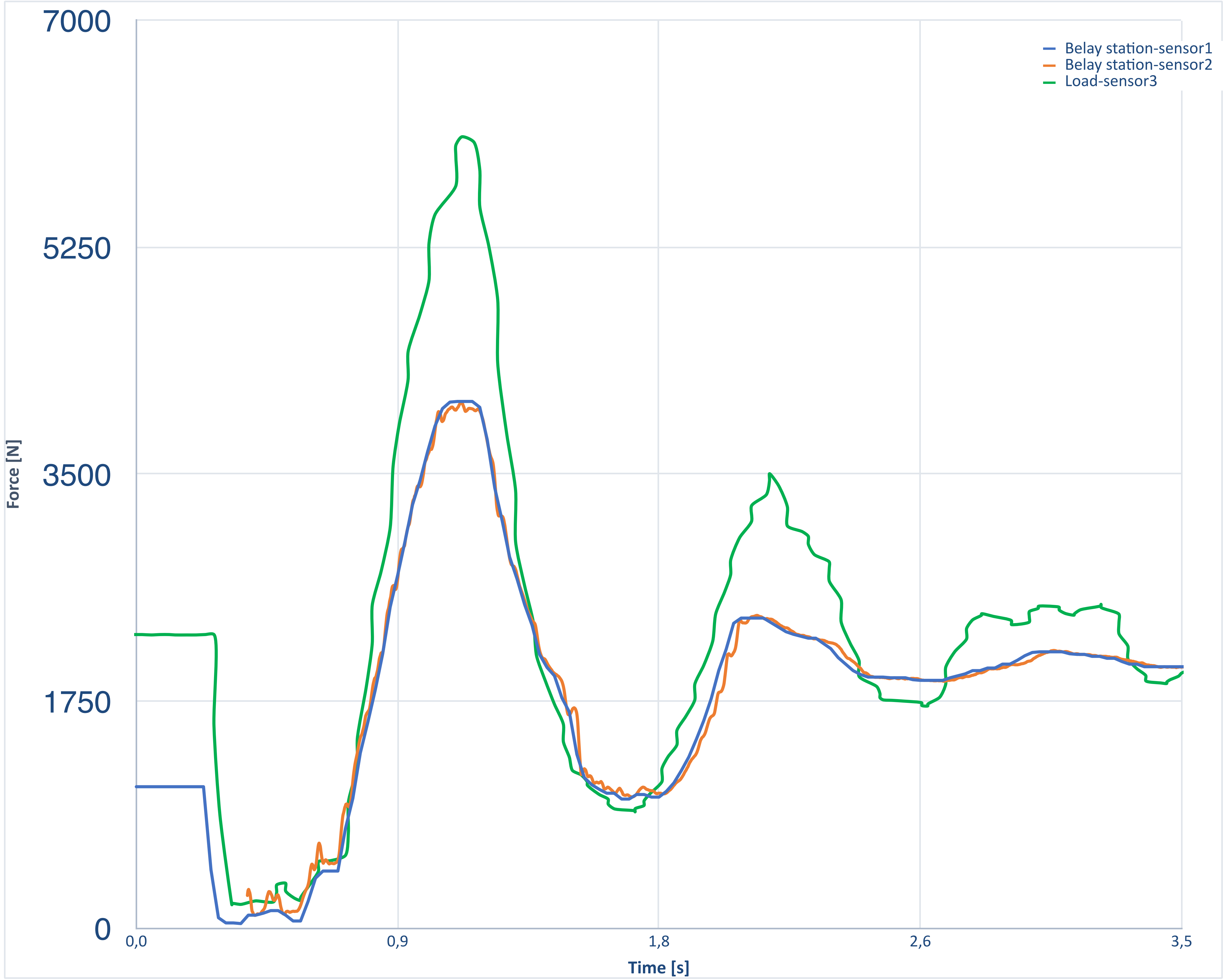
Sharp edge test with a pendulum - rope 3C Polyester/polyamid 10,5 mm - 200 kg load

- **THE ROPE DID NOT BREAK – medium sheath damage**



Sharp edge test with a pendulum - rope 7C
Polyamid/steel/polyamid 10 mm
200 kg load

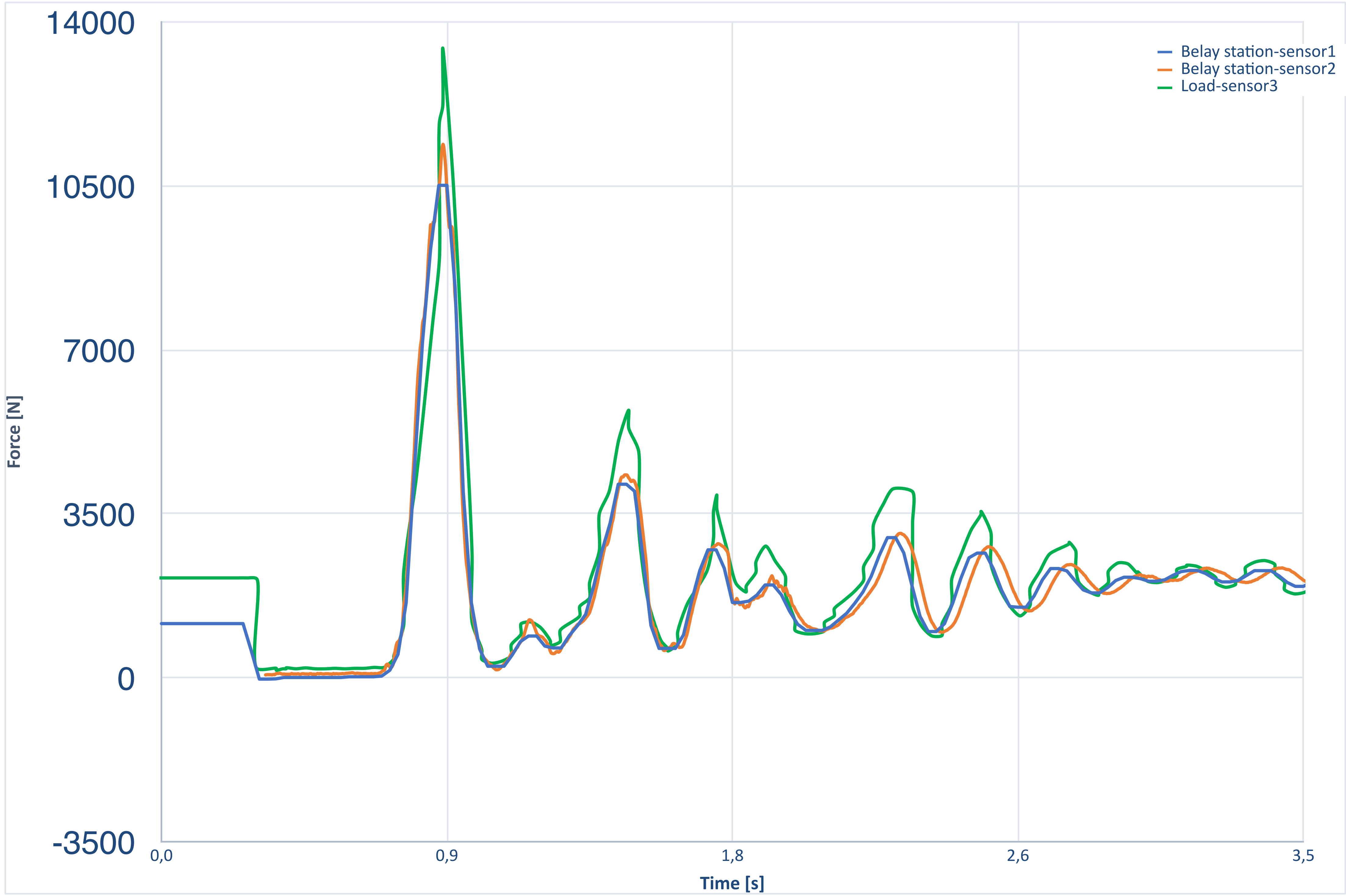
- **THE ROPE DID NOT BREAK – medium sheath damage**



Sharp edge test with a pendulum - rope 10C UHMWPE 8 mm additionally heat treated 200 kg load

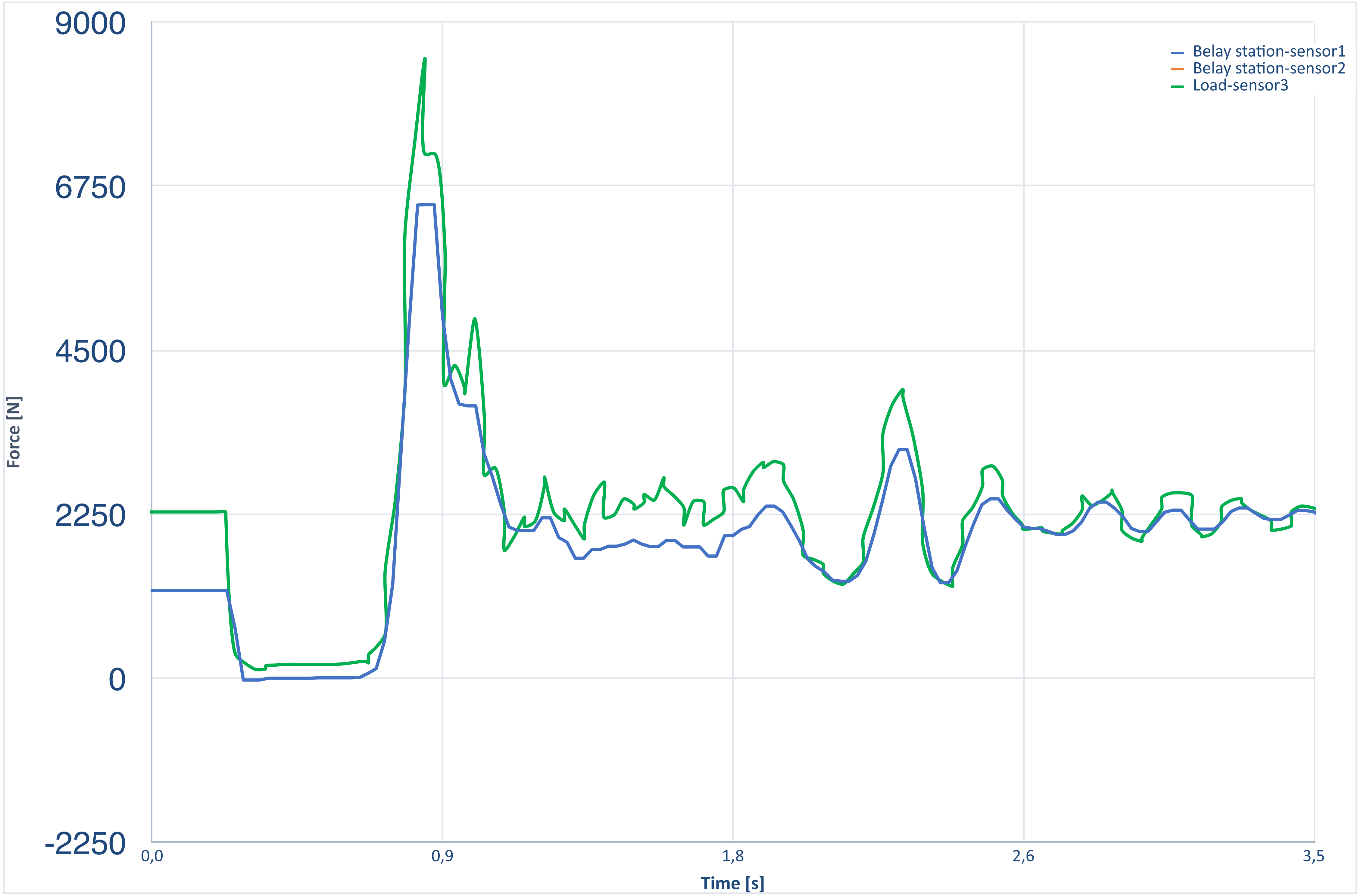
- **THE ROPE DID NOT BREAK – sheath damage is very small**

- **Very high impact force!**



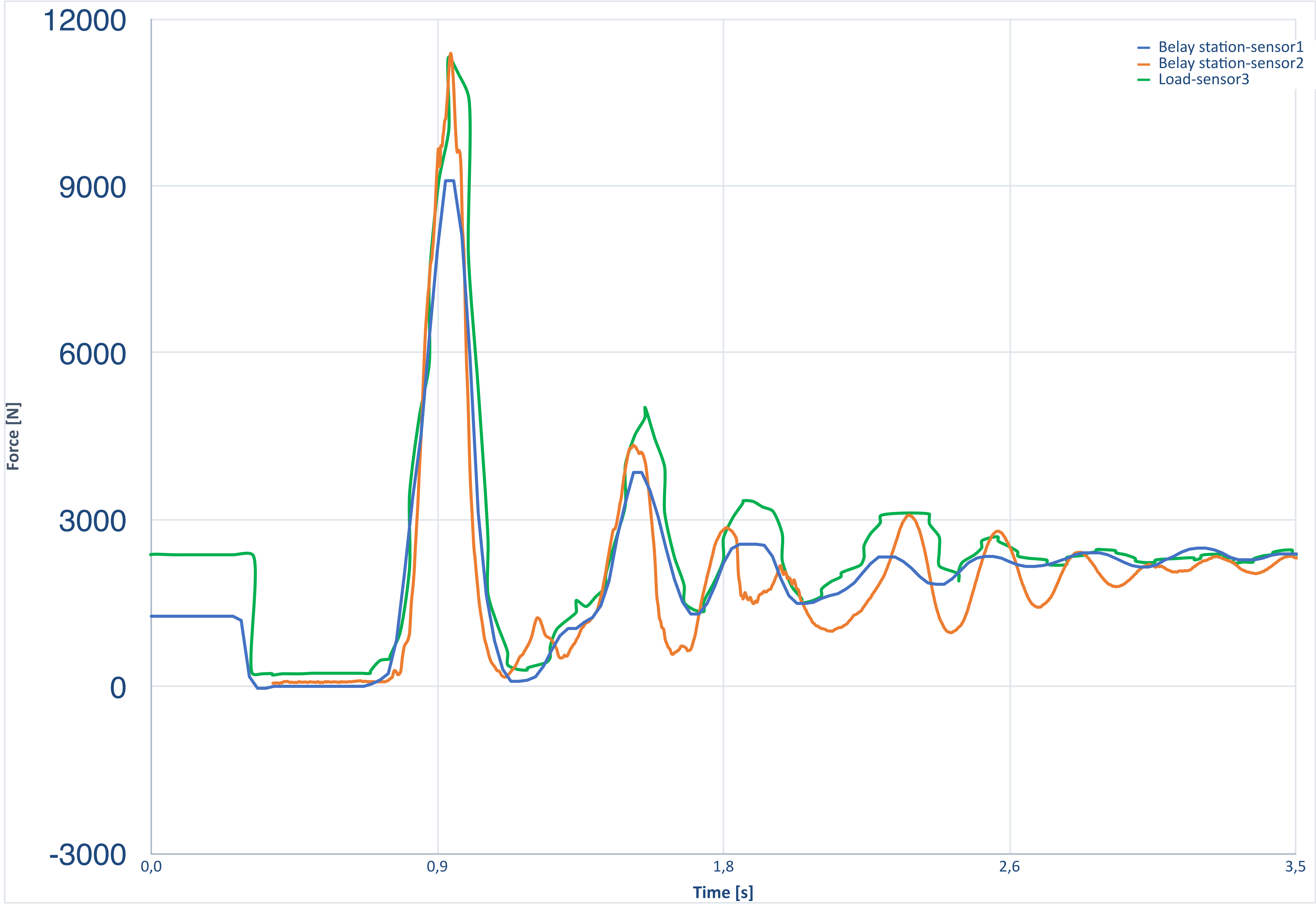
Sharp edge test with a pendulum - rope 11C
8 mm Dyneema additionally heat treated
200 kg load

- **THE ROPE DID NOT BREAK – sheath damage is very small**
- **Very high impact force!**



Sharp edge test with a pendulum - rope 12C
8 mm Dyneema - 200 kg load

- THE ROPE DID NOT BREAK – sheath damage is very small
- Very high impact force!

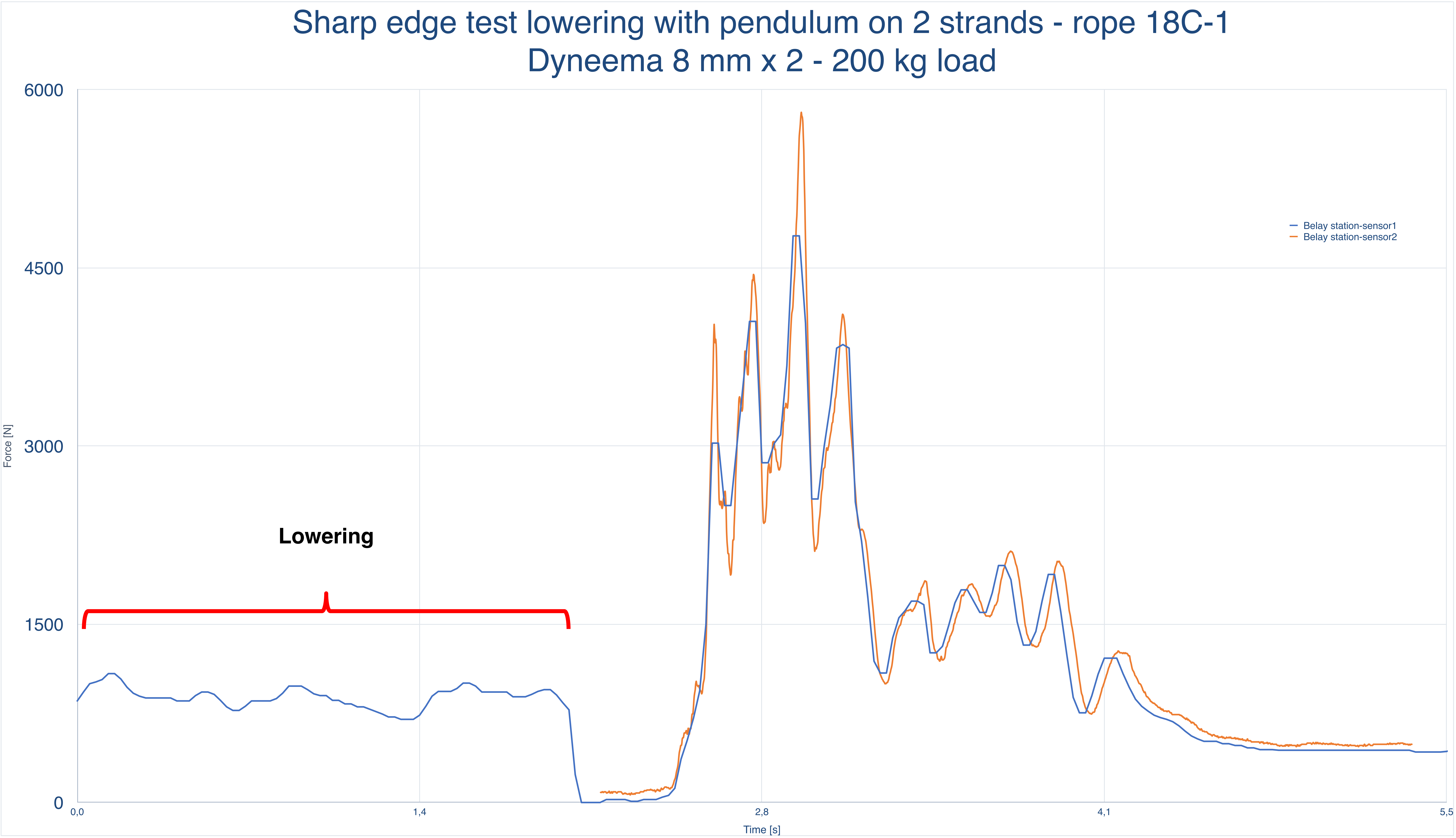


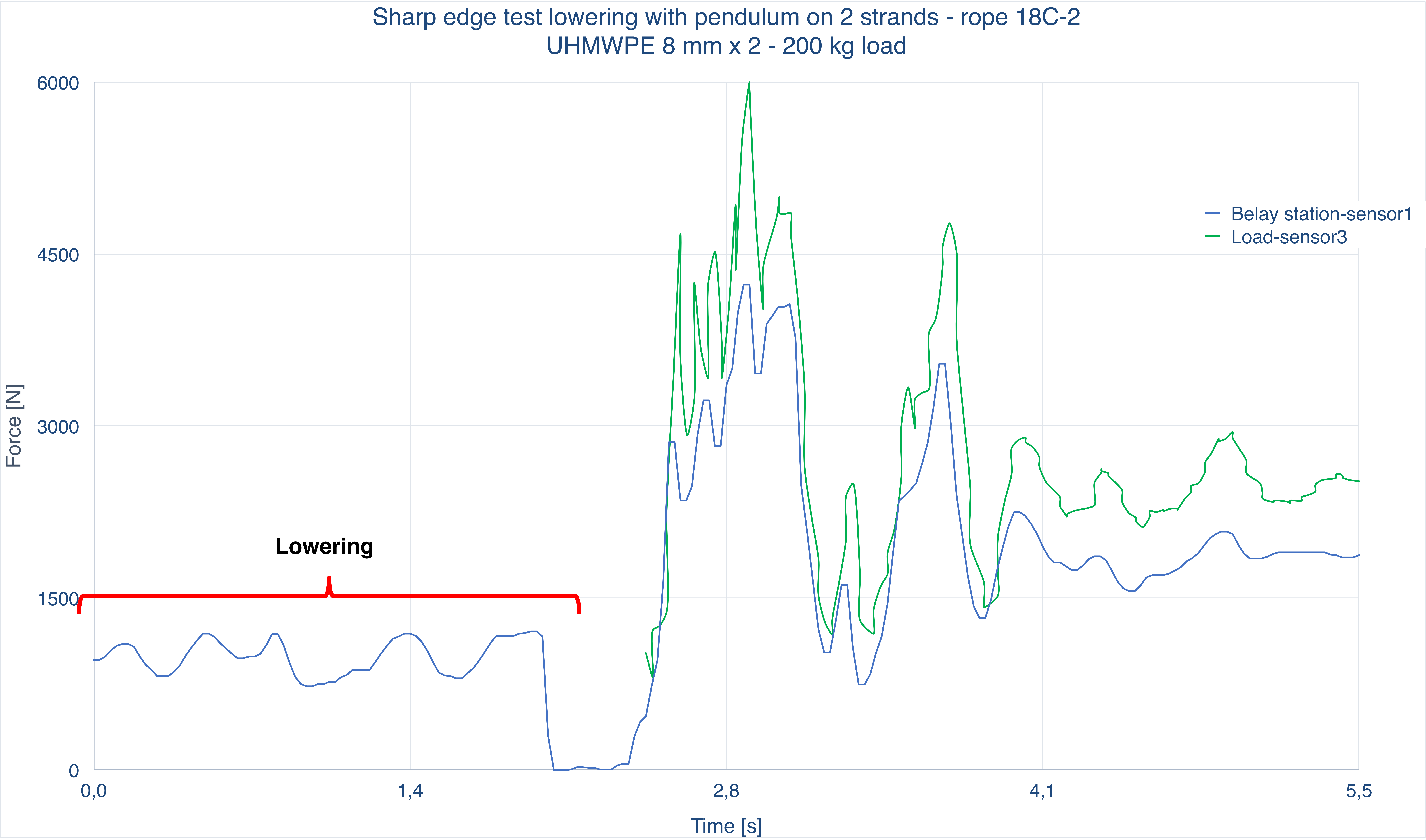
Sharp edge test with a pendulum, 200 kg load - force on belay station

dyneema high impact force

- high impact force causes heat damage to the rope in belay station

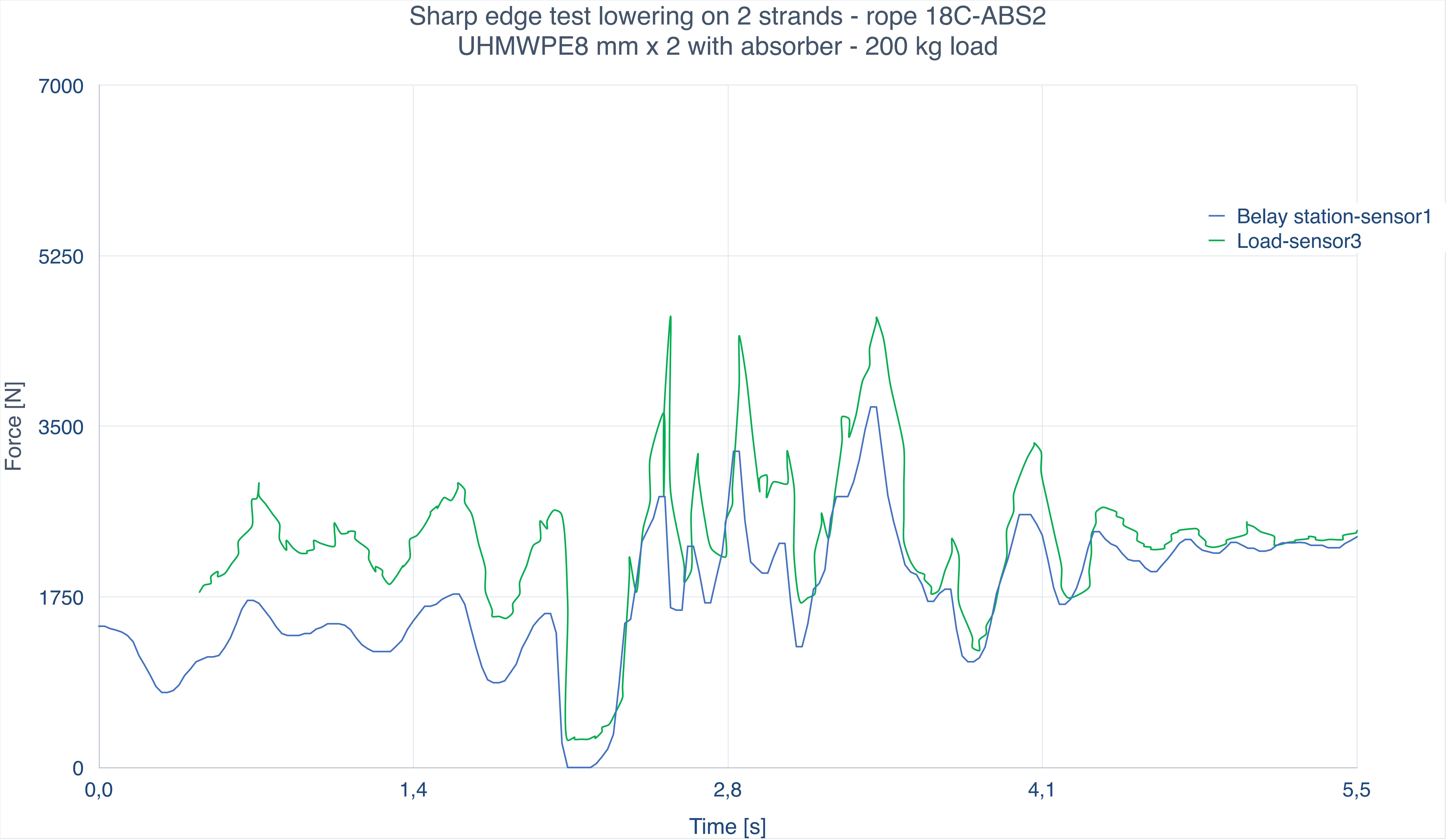
MOVIE 3


Sharp edge test lowering with pendulum on 2 strands - rope 18C-1
Dyneema 8 mm x 2 - 200 kg load
6000
4500
3000
1500
0
Force [N]
Lowering
Belay station-sensor1
Belay station-sensor2
0,0
1,4
2,8
4,1
5,5
Time [s]

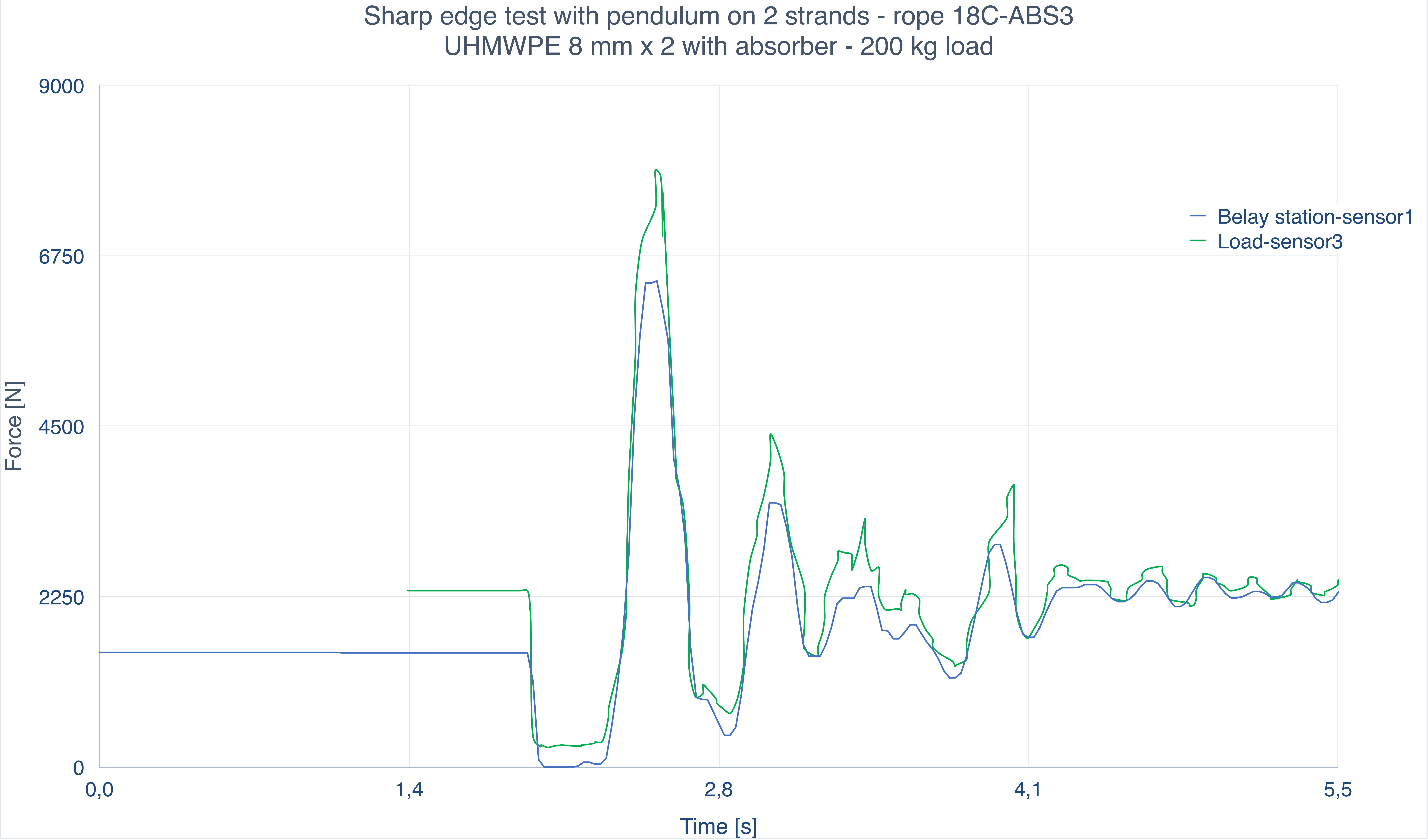


Sharp edge test lowering with pendulum on 2 strands - rope 18C-2
UHMWPE 8 mm x 2 - 200 kg load
6000
4500
3000
1500
0
Force [N]
0,0
1,4
2,8
4,1
5,5
Time [s]
Lowering
Belay station-sensor1
Load-sensor3


Sharp edge test lowering with pendulum on 2 strands - rope 18C-ABS1
UHMWPE 8 mm x 2 with absorber - 200 kg load
7000
5250
3500
1750
0
Force [N]
0,0
1,4
2,8
4,1
5,5
Lowering
Belay station-sensor1
Load-sensor3



Sharp edge test lowering on 2 strands - rope 18C-ABS2
UHMWPE8 mm x 2 with absorber - 200 kg load
Force [N]
7000
5250
3500
1750
0
0,0
1,4
2,8
4,1
5,5
Time [s]
Belay station-sensor1
Load-sensor3


Sharp edge test with pendulum on 2 strands - rope 18C-ABS3
UHMWPE 8 mm x 2 with absorber - 200 kg load
9000
6750
4500
2250
0
Force [N]
0,0
1,4
2,8
4,1
5,5
Time [s]
Belay station-sensor1
Load-sensor3

Sharp edge test pendulum on 2 strands - rope 18C-ABS4
UHMWPE 8 mm x 2 with absorber - 200 kg load
Force [N]
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
Time [s]
0,0
1,4
2,8
4,1
5,5
Belay station-sensor1
Load-sensor3

Conclusions

- **Uncontrolled pendulum on a rope that goes through a sharp edge can lead to severe damage or breakage of the rope**
- **Semi-static ropes made of polyamide generate much smaller forces** on the belay station and the load but **are not as resistant** in general as dyneema ropes
- Specific structure and diameter allows semi-static ropes to avoid cutting on a sharp edge, but only **dense braiding and aramide sheath can give very high cut resistance**
- **Dyneema ropes with untreated yarns do not have high cut resistance**, **compared to the same diameter ropes with additional treatment**
- **Dyneema ropes exert very high forces on belay station and on the load in case of any dynamic event** such as pendulum, so **usage of absorbers is obligatory**

Thank you for your attention