# FREEDIVING SAFETY LANYARD TESTING

## A method for the strength check that §5.1.15 requires

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> **Safety notice**
>
> A lanyard is a backup system for trained freedivers. It only works if it is maintained and closed properly. None of this replaces your own responsibility, diving within your training, or having a buddy.
>
> The Tier 2 checks in §4 are safe to do at a competition. The Tier 1 tests in §5 use falling and suspended weights and can injure you. Wear eye protection. Stay out of the drop path and away from anything under tension. The current AIDA World Apnea rulebook always takes precedence over this document.

## 1. What is missing from the rules

AIDA World Apnea rules require the jury to check every athlete's lanyard strength at registration, but do not say how.

§5.1.15 lists what the jury must check and ends with: "The strength of the lanyard will be checked." No test, load, duration or pass criterion is given. §5.1.14 says the lanyard is checked for construction "and strength during registration as described in provision 5.1.15 **and 5.1.16**". **There is no §5.1.16 in V17.8.** The provision that would define the test does not exist.

Every jury therefore does the check its own way. Two athletes with the same lanyard can get different answers at different competitions. No manufacturer has to publish strength data either, so a judge who wants to be thorough has nothing to check against. This document proposes two things: a non-destructive strength check a judge can run at the registration table, and a destructive test programme for manufacturers.

> **For AIDA World Apnea.** Three cross-references in V17.8 look wrong and are worth fixing in the next revision. §5.1.14 cites a §5.1.16 that does not exist. §5.1.15 opens "Following the provisions in 5.1.15", which should probably be 5.1.14. §4.1.17.1 cites §5.1.15 for lanyard construction, which is in §5.1.14.

## 2. What the rules already require

These requirements are clear and are not in question. They are listed so the strength check in §4 has its context.

| Part | Requirement | Provision |
|---|---|---|
| Carabiner | No screws, no locking mechanism. Opening **at least 16 mm**. Maximum internal size small enough that it **cannot pass the lanyard stopper**. | §5.1.14 |
| Lanyard stopper | 1 m above the bottom plate, at least **60 mm** across. | §4.1.18.1 |
| Link | **Non-elastic**, **30–120 cm** stretched, made of a material that does not knot (cord or plastic-covered cord). | §5.1.14 |
| Wrist or ankle band | Cannot come off by accident. | §5.1.14 |
| Waist belt | **CNF only.** A separate belt from the weight belt, worn above it, non-stretch, cannot come off by accident. | §4.1.17.1, §5.1.14 |
| Quick release | Required. A Velcro wrist or ankle band counts. Without one, a quick-release snapper on the athlete's side. | §5.1.14 |
| When worn | All depth disciplines (CWT, CWTB, CNF, FIM), in **warm-up and performance**. Depth gauge on the other wrist. | §4.1.17.1 |
| Competition line | Static rope, 9–14 mm. Retrieval system that lifts a blacked-out diver at **1 m/s or faster**. | §4.1.18.1 |

> **Bungee and elastic links are not legal.** §5.1.14 requires a non-elastic link. Nothing here suggests otherwise. Stiffness still varies a lot inside the legal range, and that matters (§6.2).

## 3. Two tiers

| Tier | Who and when | Type | What it shows |
|---|---|---|---|
| **Tier 2**<br>Competition check | Judge or organiser, at registration, every athlete | Non-destructive | This lanyard is legal, undamaged, correctly assembled, and holds a real service load without slipping. Satisfies §5.1.15. |
| **Tier 1**<br>Manufacturer test | Manufacturer, per batch or design change | Destructive | This design survives repeated shock loading and reaches a stated breaking strength, with the failure mode known. Published. |

Tier 2 comes first because it is what a judge needs tomorrow morning. Tier 1 is what gives Tier 2 meaning: an inspection shows a lanyard is not visibly damaged, but only published test data shows the design was strong enough to begin with.

## 4. Tier 2 — the competition check

### 4.1 Construction (§5.1.14)

Check against the table in §2. The two most commonly missed items are the carabiner opening ($\geq$16 mm) and the maximum internal size. A carabiner that fits past the 60 mm stopper makes the whole lanyard pointless.

### 4.2 Measuring the link

The 30–120 cm limit applies to the non-elastic link only, from where the cord starts to the carabiner. The band, quick release and fittings do not count. Measure with the link lightly stretched.

### 4.3 Visual check (§5.1.15)

| | Check | Reject if |
|---|---|---|
| ☐ | **Carabiner gate** | Does not open with light pressure or close on its own. Corrosion, stiffness, deformation, cracks. Screw or locking gate. |
| ☐ | **Wrist / ankle band** | Worn out. Velcro does not grip when pressed. Loop side clogged with sand, salt or hair. Band can come off by accident. |
| ☐ | **Joints** | Band-to-link or carabiner-to-link joint loose. Broken, worn, loose or discoloured stitching. Thread pulling out of a splice or sewn eye. |
| ☐ | **Link** | Cuts, fraying, thin spots, abrasion, glazing or melting anywhere. Stiff or flattened sections. Core showing through the sheath. |
| ☐ | **Quick release** | Missing. If a mechanical pin release is fitted, check it holds. These have been seen opening on their own; a Velcro band is better. |

### 4.4 Strength check: 15 kg static lift

This is the proposed method for the check §5.1.15 requires but does not define.

1. Close the band as it is worn in the water, around a round pole of roughly wrist diameter (Ø 55 ± 5 mm), with the Velcro pressed firmly shut along its full length. Both matter. A closure that is not pressed properly will pass a test it should fail, and a pole much thinner than a wrist makes the closure perform better than it will on a diver.
2. Clip the carabiner to a calibrated weight of **at least 15 kg**.
3. Lift the weight smoothly clear of the ground on the lanyard alone. **Hold for at least 15 seconds.**
4. Look at every part while it is loaded. This is when slipping closures and opening joints show up.
5. Lower it under control. Do not stand over the weight. Keep your footing.

| Result | Criterion |
|---|---|
| **PASS** | Holds ≥ 15 kg for 15 s with nothing slipping, tearing, opening or deforming. |
| **FAIL** | Velcro opens or creeps. Band or link tears. Link stretches past 120 cm under load. A joint slips. Carabiner deforms or the gate springs open. |

### 4.5 Why 15 kg

A slow static pull creates no force spike, so unlike a drop it does not weaken the lanyard. It can be run on the lanyard the athlete will then dive.

Two reasons give the same number. It is comfortably above the realistic steady retrieval load of about 13 kg (§6.1). And 15 kg is already used elsewhere in the rules: the minimum bottom weight where FIM is on the programme, and the minimum weight for measuring the competition line (§4.1.18.1, §4.1.18.4).

What it does not show: 15 kg is about a sixth of the worst-case service load of 99 kg in §6.1. It confirms the lanyard holds together and that closures and joints do not slip under a real load. It is not proof the lanyard would survive the worst case. Only published Tier 1 data can show that.

> **Do not drop-test at a competition.** The rules require a non-elastic link, so a legal lanyard stops a falling weight over a very short distance and generates a very high peak force (§6.2). That weakens or destroys it. Drop testing belongs in Tier 1, on samples that get thrown away. Use the static lift.

### 4.6 If a lanyard fails

Do not let the athlete warm up or compete with it. Write the reason on the check sheet. They must present a legal lanyard before being cleared. If in doubt, ask the Head Judge or Safety Officer.

## 5. Tier 1 — manufacturer testing

### 5.1 Conditions for all Tier 1 tests

Results only compare if the setup does. Fix these and report them.

| Parameter | Specification |
|---|---|
| Wrist-band anchor | Round pole, **Ø 55 mm ± 5 mm**, rigid, horizontal. Roughly a wrist in a thin sleeve. Band closed around it as worn. A thinner pole raises the pressure inside the closure and flatters the band. Where possible, cover the pole in neoprene of the thickness athletes wear and test it both uncompressed and compressed. |
| Carabiner anchor | Steel bar or ring, Ø 12 mm ± 1 mm, free to rotate. Inside the 9–14 mm rope range of §4.1.18.1. |
| Closures | All Velcro fully engaged and pressed along its full length before the test. |
| Drop release | Free drop, no sideways push. Height measured from the underside of the weight to where the lanyard goes tight. |
| Samples | At least 3 per model per batch, all must pass. Half new and dry, half after the conditioning in §5.4. Report both. |
| Conditions | 15–25 °C, reported. At least 60 s between repeat drops on the same sample. |
| Records | Photographs before and after. Link length measured before and after each drop. |

### 5.2 Drop test

Drop a **4 kg weight 1.0 m** onto the assembled lanyard, **five times** on the same sample.

This is a deliberately harsh dry-land screen for manufacturing quality. It loads the cord, stitching, terminations, swivel and closures well beyond any service load, the same way for everyone. It is not a simulation of an accident: a body in water cannot reach this impact speed (§6.3), and a real arrest is absorbed over metres of rope stretch, not centimetres of lanyard. Passing shows the lanyard survived a hard shock, and no more than that.

After five drops, none of the following:

- Broken, cut or pulled stitching, or thread pulling out at a termination.
- Permanent stretch over 5% of the original link length, or any stretch taking the link past 120 cm.
- Sheath damage showing the core. Melting, glazing or fusing anywhere.
- Carabiner deformed, or a gate that no longer closes fully on its own.
- Band slipping through its closure, or Velcro losing grip.

### 5.3 Breaking strength

The drop test is pass/fail on visible damage. It cannot tell a large safety margin from a small one. On separate samples, pull the whole assembly to failure at a constant rate and record the **breaking load** and **where it broke**. A lanyard that fails at the stitching at 4 kN is a different product from one that fails in the cord at 4 kN. Test the band closure separately: it fails by slipping, not by tearing.

> No minimum breaking strength is proposed here. Setting that number needs injury data and the authority to make it stick, which belongs to AIDA World Apnea rather than to any one manufacturer. What can be said now is that the number has to be **published**, or nobody can compare products.

### 5.4 Conditioning

Lanyards fail from a season of wear, not from one shock. Condition half the samples: 100 salt soak and dry cycles; UV exposure equal to one season; a set number of abrasion cycles against the carabiner anchor; 200 open and close cycles on every closure and the carabiner gate.

### 5.5 Component tests

A whole-lanyard test can pass with one weak termination. Test and report separately: Velcro peel strength, new and cycled; band-to-link joint; swivel rotation under load and axial retention; carabiner gate opening ($\geq$16 mm), self-closing, strength with the gate open, and that the maximum internal size cannot pass a 60 mm stopper.

### 5.6 What to publish

Per model: breaking strength and failure location; drop test result new and conditioned; measured stretch under load; materials; service life and retirement criteria; test date and batch. Unpublished test data helps nobody decide anything.

## 6. The physics

g = 9.81 m/s². Forces are in newtons, with the equivalent static load in kilograms where that helps. A force is not a mass; the kilogram figures are conversions at 1 g.

### 6.1 Loads during a counter-ballast retrieval

$$F_D = \tfrac{1}{2} \cdot \rho \cdot u^2 \cdot C_D \cdot A$$

$\rho$ = 1 025 kg/m³ for seawater. The rules allow salt or fresh water (§8.1.1); fresh water gives about 2.5% less drag, so seawater is the conservative choice. $C_D$ is 0.7–1.0 for a human body. Frontal area A runs from 0.1 m² (streamlined, one arm leading) to 0.8 m² (a large diver dragged sideways, which happens with a waist lanyard).

The rules require 1 m/s or faster (§4.1.18.1). Many systems run faster, so 1.5 m/s is used here as a typical working figure. Both are shown, because drag goes with the square of speed.

| Case | At 1.0 m/s (rule minimum) | At 1.5 m/s (typical) |
|---|---|---|
| Realistic: streamlined, $C_D$ 0.7, A 0.1 m² | 85 N (9 kg) | **130 N (13 kg)** |
| Worst case: large diver sideways, $C_D$ 1.0, A 0.8 m² | 459 N (47 kg) | **972 N (99 kg)** |

Steady retrieval load including up to 5 kg negative buoyancy. Negative buoyancy depends on depth and can be more than 5 kg at competition depth.

These are steady-state figures. The highest load in a retrieval comes during the initial acceleration from rest, when the lanyard has to overcome the diver's inertia plus the added mass of water moving with them, typically 20–50% of body mass. That transient is higher than the table and is not calculated here. The 0.8 m² sideways case is real rather than theoretical, and is the reason a waist lanyard is restricted to CNF.

### 6.2 Shock loads and link stiffness

A 4 kg weight dropped 1.0 m hits at 4.43 m/s carrying 39.24 J. The force depends entirely on the distance over which the lanyard stops it. Over a stopping distance d, the average force is:

$$F_{avg} = m \cdot g \cdot (h + d) / d$$

Average force is not what breaks things. For something behaving like a linear spring, the peak force at full stretch is twice the average, and the peak is what decides whether the hardware survives and what reaches the diver's wrist.

| Stopping distance | Average force | Peak force | Peak as static load |
|---|---|---|---|
| 5 cm | 824 N | **1 648 N** | 168 kg |
| 2 cm | 2 001 N | **4 002 N** | 408 kg |
| 1 cm | 3 963 N | **7 926 N** | 808 kg |
| 0.5 cm | 7 887 N | **15 774 N** | 1 608 kg |
| 0.2 cm | 19 659 N | **39 318 N** | 4 008 kg |
| 0.1 cm | 39 279 N | **78 558 N** | 8 008 kg |

Peak assumes linear-elastic behaviour (peak = 2 × average). Real materials vary. A constant-force element like peeling Velcro is closer to 1×; a stiffening cord like Dyneema can exceed 2×.

Where a legal lanyard sits on this table has been measured. A complete competition lanyard stretches **85–90 mm** before breaking, at 1.4–2.2 kN depending on the sample, with yield around 630 N (Espotel Oy tension test report, 23 April 2018, 60 mm/min). Working back from the load-extension curve, a 4 kg weight dropped 1.0 m is stopped at roughly 50–55 mm, giving a peak of about 1.2 kN under slow loading. Dynamic loading stiffens the response, so the real peak is higher: 1.2–2.5 kN.

Two things follow. First, this is why drop testing destroys lanyards and has to stay in Tier 1. A measured breaking load of 1.4–2.2 kN against a drop test peak of 1.2–2.5 kN leaves almost no margin, and five repeats add up. Being close to the limit is what a proof test is for, and it is why the sample gets thrown away.

Second, stiffness varies inside the legal non-elastic range, and less stiff is safer. A link that stops the weight over 5 cm generates about a tenth of the peak force of one that stops it over 0.5 cm, and that force goes into a wrist. Designing for controlled stretch at the softer end of the legal range protects the lanyard and the diver.

For scale: EN 355, the European standard for fall-arrest energy absorbers, caps the force reaching the user at 6 kN, for a full-body harness tested with a 100 kg weight. A wrist is a much weaker attachment point than a harness, so 6 kN is already too high here rather than a target. The comparison is indicative only. EN 355 covers harnessed equipment used in air.

### 6.3 Why the drop test is not a simulation

A diver sinking unconscious reaches terminal velocity when drag balances negative buoyancy. Using $C_D$ 0.7, A 0.1 m², ρ 1 025 kg/m³:

| Negative buoyancy | Terminal sink speed |
|---|---|
| 3 kg | 0.91 m/s |
| 5 kg | 1.17 m/s |
| 10 kg | 1.65 m/s |
| 15 kg | 2.03 m/s |

A body in water never reaches the 4.43 m/s of the drop test, because water damps the fall and air does not. In energy terms the drop test is milder than a real arrest: an 80 kg diver, realistically 100 kg once the water moving with them is counted, carries 90–112 J at 1.5 m/s against the drop test's 39 J. Real arrests are survivable because the load path

includes the competition line. Even a static 9–14 mm rope stretches a few percent, which over 50–100 m of deployed line is metres of travel, a hundred times more than the lanyard can give.

### 6.4 What this does not cover

- The transient load when the counter-ballast is released, which is the largest service load and is not calculated.
- The dynamics of the whole rope-and-lanyard system, which dominate real arrest forces.
- Injury thresholds for the wrist and forearm, which would set the ceiling on acceptable peak force. This is the most useful missing number in the field.
- Fatigue over a full service life, as opposed to the five-cycle screen in §5.2.
- The case where the carabiner jams at the stopper or bottom plate instead of sliding, which is what makes an arrest possible at all.

## 7. Conclusions

1. **The strength check in §5.1.15 needs a defined method.** The 15 kg static lift in §4.4 is proposed: non-destructive, safe on a boat, under a minute per athlete, and the same between juries.
2. **Fix the missing reference in V17.8.** §5.1.14 cites a §5.1.16 that does not exist. Whatever method is adopted needs a provision number.
3. **Never drop-test at a competition.** On a legal non-elastic lanyard a drop test produces kilonewton peak forces and damages the lanyard the athlete is about to dive.
4. **Inside the non-elastic requirement, less stiff is safer.** Stopping distance varies by a factor of ten across legal designs, and so does the peak force reaching the wrist.
5. **Manufacturers should publish breaking strength, failure location and load-extension data.** Without it a judge can only check visible condition, and divers buy safety equipment blind. Setting minimum acceptable numbers is then work for AIDA World Apnea, which has authority this document does not.

### Author and disclosure

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**Interest:** FreeXperience makes and sells freediving lanyards and would be affected commercially by any standard adopted in this area. That is stated openly so you can weigh it. The physics in §6 can be checked from the equations given without trusting the author. The procedures in §4 and §5 are offered for anyone to adopt, change or reject.

**FreeXperience practice:** our lanyards are tested to the Tier 1 procedure above using a 5 kg weight rather than the 4 kg minimum recommended here. Results and full specifications are published at freexperience.com.

**Sources.** AIDA World Apnea Competition Rules & Regulations V17.8 (March 2026, in force 25 May 2026), §4.1.17.1, §4.1.18.1, §4.1.18.4, §5.1.14, §5.1.15, §8.1.1. EN 355:2002 for the comparison in §6.2. Espotel Oy tension test report, 23 April 2018, for the measured lanyard figures in §6.2. Drag and shock calculations are the author's own and follow from the equations given.

Corrections to the physics, the procedure or the pass criteria are welcome.