AMERICAN NATIONAL STANDARD

ANSI/ASSE Z359.13-2013
Personal Energy Absorbers and Energy Absorbing Lanyards

Part of the Fall Protection Code

3

American Society of Safety Engineers

Approved American National Standard
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ANSI/ASSE Z359.13 – 2013

American National Standard

Personal Energy Absorbers and Energy Absorbing Lanyards

Secretariat

American Society of Safety Engineers
1800 East Oakton Street
Des Plaines, Illinois 60018-2187

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American National Standard

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Foreword (This Foreword is not a part of American National Standard Z359.13-2013.)

This standard, national in scope, was developed by an Accredited Standards Committee functioning under the procedures of the American National Standards Institute, with the American Society of Safety Engineers (ASSE) as secretariat.

It is intended that every employer whose operations fall within the scope and purpose of the standard will adopt the guidelines and requirements detailed in this standard.

The need for this standards activity grew out of the continuing development of a series of fall protection related standards. The focus is to tie the elements of those standards together and provide the tools with which employers may develop the programs that incorporate those elements. This standard also brings together the administrative requirements of those fall protection standards. It should be noted, as in all Z359-series standards, that this standard applies to occupational activities. It does not apply to sports activities such as mountaineering.

Neither the standards committee, nor the secretariat, states that this standard is perfect or in its ultimate form. It is recognized that new developments are to be expected, and that revisions of the standard will be necessary as the state-of-the-art progresses and further experience is gained. It is felt, however, that uniform guidelines for fall protection programs are very much needed and that the standard in its present form provides for the minimum criteria necessary to develop and implement a comprehensive managed fall protection program.

The Z359 Committee acknowledges the critical role of design in influencing the use of proper fall protection equipment. Designs which eliminate fall hazards through the proper application of the hierarchy of safety controls are the preferred method for fall protection. Design deficiencies often increase the risk for employees who may be exposed to fall hazards: examples are (1) lack of rail systems to prevent falls from machines, equipment and structures; (2) failure to provide engineered anchorages where use of personal fall arrest systems are anticipated; (3) no provision for safe access to elevated work areas; (4) installation of machines or equipment at heights, rather than floor/ground level to preclude access to elevated areas; (5) failure to plan for the use of travel restriction or work positioning devices. To that end, this series of standards also provides guidance for design considerations for new buildings and facilities.

Basic fall safety principles have been incorporated into these standards, including hazard survey, hazard elimination and control, and education and training. The primary intent is to ensure a proactive approach to fall protection. However, the reactive process of accident investigation is also addressed to ensure that adequate attention is given to causation of falls.

The Z359 Committee solicits public input that may suggest the need for revisions to this standard. Such input should be sent to the Secretariat, ASC Z359, American Society of Safety Engineers, 1800 E. Oakton Street, Des Plaines, IL 60018-2187.

This standard was developed and approved for submittal to ANSI by the American National Standards Committee on Standards for Fall Protection, Z359. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the Z359 Committee had the following members:

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Contents

STANDARD REQUIREMENTS

EXPLANATORY INFORMATION

(Not part of American National Standard Z359.13)

1. SCOPE, PURPOSE, APPLICATIONS, EXCEPTIONS AND INTERPRETATIONS

1.1 Scope.

1.1.1 This standard establishes requirements for the performance, design criteria, marking, qualification and verification testing, instructions, inspections, maintenance and removal from service of personal energy absorbers and energy absorbing lanyards for users within the capacity range of 130 to 310 pounds (59 - 140 kg.).

E1.1.1 *It is the intention of this standard to require all personal energy absorbers and energy absorbing lanyards to reduce the forces implied on the user to less than 10 G's (10 times the normal gravitational pull of the Earth). Users below 130 pounds may experience forces higher than 10 G's.*

1.1.2 This standard is for use by organizations where employees are exposed to fall hazards.

1.2 Purpose and Applications.

1.2.2 Before any equipment shall bear the marking Z359.13 (personal energy absorbers and energy absorbing lanyards) or be represented in any way as being in compliance with this standard, all requirements of this standard shall be met.

E1.2.2 *This is a voluntary consensus standard. The legal requirements for protection against falls from heights are established by applicable regulatory bodies governing occupational safety.*

1.3 Exceptions. The requirements of this standard do not address window cleaning belts and sports related activities.

1.4 Interpretations. Requests for interpretations of this standard shall be in writing and addressed to the Secretariat of this standard.

1.5 The requirements of this standard supersede any corresponding requirements in the ANSI/ASSE Z359.1-2007, *Safety Requirements for Personal Fall Arrest Systems, Subsystems, and Components.*

2. DEFINITIONS

Definitions relating to personal energy absorbers and energy absorbing lanyards can be found in ANSI/ASSE Z359.0, *Definitions and Nomenclature Used for Fall Protection and Fall Arrest.*

3. REQUIREMENTS

3.1 Personal Energy Absorber Component. All personal energy absorbers bearing this standard number shall meet the design and testing requirements of this standard. See Figures 5a and 5b.

E3.1 *Energy absorbers for horizontal lifelines are not addressed here because horizontal lifelines are outside the scope of this standard.*

3.1.1 Classifications. Personal energy absorbers shall be categorized as follows:

3.1.1.1 "6 ft FF" personal energy absorbers shall be designed for up to 6 foot (1.83 m) free fall (FF indicates free fall) applications and users weighing between 130 and 310 pounds (59 -140 kg).

3.1.1.2 "12 ft FF" personal energy absorbers shall be designed for up to 12 foot (3.66 m) free fall applications (FF indicates free fall) and users weighing between 130 and 310 pounds. (59 – 140 kg).

E3.1.1.2 *It is recommended that alternative means of fall protection be investigated prior to using systems that allow for free falls greater than 6 feet (1.83 m). Local governing bodies regulate free fall distances and the employer may be required to prove infeasibility before allowing free falls in excess of 6 feet (1.83 m).*

3.1.2 Material. Material used in the construction of personal energy absorbers shall be made of virgin synthetic material having strength, aging, abrasion resistance and heat resistance characteristics equivalent or superior to polyamides.

3.1.3 Terminations. Personal energy absorbers shall have end terminations which meet the following requirements.

3.1.3.1 Spliced. Formed eye terminations in rope shall be made in accordance with the rope manufacturer's recommendation, subject to the following requirements. Eye splices in twisted rope having three or more strands shall have a minimum of four tucks. A properly sized thimble shall be part of a formed eye termination. Knots shall not be used to form energy absorbing lanyard end terminations. Terminations (including cut ends) and splices shall be seized, whipped or otherwise integrally finished to prevent the termination or splice from unraveling or unsplicing. See Figure 1.

3.1.3.2 Stitched. Stitched eye terminations on strap energy absorbers shall be sewn using lock stitches. Thread shall be of the same material type

E3.1.3.2 *Contrasting colors should be strikingly different so an inspector, from a normal distance, shall be able to see obvious distinctions between the color*

as the webbing and shall be of a contrasting color to facilitate inspection. Webbing shall be protected from concentrated wear at all interfaces with load bearing connector elements. Webbing ends shall be seared or otherwise prevented from unraveling. See Figure 2.

3.1.3.3 Wire Rope. Formed eye terminations of wire rope shall have a minimum breaking strength of 80% of the wire rope when tested in accordance with ASTM E8/8M-11, *Standard Test Methods of Tension Testing of Metallic Materials*. The following methods may be used for forming eyes in wire rope: (a) spliced eye with one swaged fitting, or (b) return eye with a minimum of two swaged fittings. All formed eyes shall incorporate a properly sized thimble. See Figure 3.

3.1.3.4 Terminations other than splicing, stitching and swaging are permitted when it can be demonstrated by testing that the requirements of this standard can be met and additionally, that the durability, reliability, strength and other properties pertinent to the intended uses have been evaluated and determined suitable by the manufacturer.

3.1.4 Connectors. Personal energy absorbers shall have integrally attached connectors or be integral to the energy absorbing lanyard. Connectors used on all personal energy absorbers shall meet the requirements of ANSI/ASSE Z359.12, *Safety Requirements for Connecting Components for Personal Fall Arrest Systems (PFAS) Connectors*. See Figures 4a, 4b, 4c.

3.1.5 Deployment Indicator. Personal energy absorbers shall be designed such that it is obvious if they have been activated or by a warning flag or label that indicates activation.

3.1.6 Activation Force. Personal energy absorbers when subjected to a static force no less than 450 pounds (2 kN) in accordance with 4.2 shall not show signs of activation or exhibit permanent elongation greater than 2 inches (51 mm).

3.1.7 Static Strength. Personal energy absorbers, when statically tested in accordance with 4.3 shall have a minimum breaking strength no less than 5,000 pounds (22.2 kN).

of the stitch pattern and the color of the webbing.

3.1.8 Personal Energy Absorber Dynamic Performance – Ambient Dry Test. Personal energy absorbers tested in accordance with 4.4 shall meet the following requirements:

E3.1.8 *Historically, energy absorbers and energy absorbing lanyards have had a maximum arrest force requirement during dynamic testing. Because of the occasional statistical outlier illustrating forces over 900 pounds (4 kN), producers of energy absorbers were forced to reduce the average deployment forces to ensure full statistical compliance with the standard. This standard requires that an average arrest force be used to measure energy absorber performance in addition to MAF rather than a single maximum data point to more accurately measure performance. See 4.1.10.*

3.1.8.1 6 ft FF personal energy absorbers shall have an average arrest force no greater than 900 pounds (4 kN) and a maximum deployment distance of 48 inches (1.2 m) without exceeding 1,800 pounds (8 kN) maximum arrest force.

3.1.8.2 12 ft FF personal energy absorbers shall have an average arrest force no greater than 1,350 pounds. (6 kN) and a maximum deployment distance of 60 inches (1.5 m) without exceeding 1,800 pounds (8 kN) maximum arrest force.

3.1.9 Personal Energy Absorber Dynamic Performance – Conditioning Tests. Personal energy absorbers shall be conditioned according to the requirements of 4.13.1, 4.13.2 and 4.13.3 and tested according to 4.4. Conditioning tests do not need to be performed when the energy absorber is integral to a lanyard and the energy absorbing lanyard is tested according to 3.2.5.

E3.1.9 *The maximum arrest forces realized in conditioning tests should be available to qualified, competent and authorized persons through the manufacturers instructions.*

It is intended that conditioning tests are performed on all personal energy absorbers and energy absorbing lanyards. To prevent testing duplication, conditioning testing of a personal energy absorber is not necessary when it is tested as an integral component of an energy absorbing lanyard.

3.1.9.1 Conditioned 6 ft FF samples shall have an average arrest force no greater than 1,125 pounds (5 kN) without exceeding 1,800 pounds (8 kN) maximum arrest force and a maximum deployment distance of 48 inches (1.2 m).

3.1.9.2 Conditioned 12 ft FF samples shall have an average arrest force no greater than 1,575 pounds (7 kN) without exceeding 1,800 pounds (8 kN) maximum arrest force and a maximum deployment distance of 60 inches (1.5 m).

3.2 Energy Absorbing Lanyard Component. All energy absorbing lanyards bearing this standard number shall be equipped with a personal energy absorber or have energy absorbing ability that meets the design and testing requirements of this standard.

E3.2 *All energy absorbing lanyards used for fall arrest are included under this standard. This includes, but is not limited to energy absorbing lanyards, Y-lanyards, wrap-around energy absorbing lanyards and combinations thereof.*

3.2.1 Material. Rope, webbing and tubular webbing used in the construction of energy absorbing lanyards shall be made of virgin synthetic material having strength, aging, abrasion resistance and heat resistance characteristics equivalent or superior to polyamides.

E3.2.1 *The elastic material used to reduce the carrying length of energy absorbing lanyards is not bound by this requirement.*

The internal webbing of the energy absorbers, is not bound by this requirement. Personal energy absorber material is specific to the strength requirements of 3.1.7 whereas 3.2.1 is specific to lanyard material.

3.2.2 Terminations. Energy absorbing lanyards shall have end terminations which meet the following requirements.

3.2.2.1 Spliced. Formed eye terminations in rope shall be made in accordance with the rope manufacturer's recommendation, subject to the following requirements. Eye splices in twisted rope having three or more strands shall have a minimum of four tucks. A properly sized thimble shall be part of a formed eye termination. Knots shall not be used to form energy absorbing lanyard end terminations. Terminations (including cut ends) and splices shall be seized, whipped or otherwise integrally finished to prevent the termination or splice from unraveling or unsplicing. See Figure 1.

E3.2.2.1 *It is permissible on adjustable length lanyards to exclude the thimble on the adjustable end of such lanyards.*

3.2.2.2 Stitched. Stitched eye terminations on strap energy absorbing lanyards shall be sewn using lock stitches. Thread shall be of the same material type as the webbing and shall be of a contrasting color to facilitate inspection. Webbing shall be protected from concentrated wear at all interfaces with load bearing connector elements. Webbing ends shall be seared or otherwise prevented from unraveling. See Figure 2.

E3.2.2.2 *Sewn joints should: (a) be in accordance with Reference 7.3.3 and (b) be back sewn no less than 0.08 inches (2mm) from the webbing edge.*

3.2.2.3 Wire Rope. Formed eye terminations of wire rope shall have a minimum breaking strength of 80% of the wire rope when tested in accordance with E8/8M-11, *Test Methods of Tension Testing of Metallic Materials*. The following methods may be

E3.2.2.3 *Wire rope ends should be brazed, whipped or have equivalent finish to prevent unraveling. Brazing should be accomplished prior to forming the return eye.*

used for forming eyes in wire rope: (a) spliced eye with one swaged fitting, or (b) return eye with a minimum of two swaged fittings. All formed eyes shall incorporate a properly sized thimble. See Figure 3.

3.2.2.4 Terminations other than splicing, stitching and swaging are permitted when it can be demonstrated by testing that the requirements of this standard can be met and additionally, that the durability, reliability, strength and other properties pertinent to the intended uses have been evaluated and determined suitable by the manufacturer.

3.2.3 Energy Absorbing Lanyard Connectors. Energy absorbing lanyards shall have integrally attached connectors. Connectors used on all personal energy absorbers shall meet the requirements of ANSI/ASSE Z359.12, *Safety Requirements for Connecting Components for Personal Fall Arrest Systems (PFAS) Connectors*. See Figures 4a, 4b, 4c.

3.2.4 Energy Absorbing Lanyard Dynamic Performance - Ambient Dry Test. Energy absorbing lanyards shall be tested as a complete system according to 4.5. The results of the tests shall meet the requirements of 3.2.4.1 and 3.2.4.2 respectively.

3.2.4.1 6 ft FF energy absorbing lanyards shall have an average arrest force no greater than 900 pounds (4 kN) and a maximum deployment distance of 48 inches (1.2 m) without exceeding 1,800 pounds (8 kN) maximum arrest force.

3.2.4.2 12 ft FF energy absorbing lanyards shall have an average arrest force no greater than 1,350 pounds. (6 kN) and a maximum deployment distance of 60 inches (1.5 m) without exceeding 1,800 pounds (8 kN) maximum arrest force.

3.2.5 Energy Absorbing Lanyards Dynamic Performance – Conditioning Tests. Energy absorbing lanyards shall be conditioned according to the requirements of 4.13.1, 4.13.2 and 4.13.3 and tested according to 4.5.

3.2.5.1 Conditioned 6 ft FF samples shall have an average arrest force no greater than 1,125 pounds (5 kN) without exceeding 1,800 pounds (8 kN) maximum arrest force and a maximum deployment distance of 48 inches (1.2 m).

3.2.5.2 Conditioned 12 ft FF samples shall have an average arrest force no greater than 1,575 pounds (7 kN) without exceeding 1,800 pounds (8 kN) maximum arrest force and a maximum deployment distance of 60 inches (1.5 m).

3.2.6 Static Strength. Energy absorbing lanyards when statically tested in accordance with 4.6 shall have a minimum breaking strength no less than 5,000 pounds (22.2 kN). Energy absorbing lanyards that incorporate a means for length adjustment, shall be tested in accordance with 4.6.1 and shall maintain their adjusted length (disregarding elastic stretch) up to a load of 2,000 pounds (8.8 kN).

3.2.7 Abrasion Test. Wrap-around energy absorbing lanyards shall be additionally tested in accordance with 4.12. The wrap-around energy absorbing lanyard shall have a minimum breaking strength no less than 3,600 pounds (16 kN) after being abraded.

3.2.8 Static Test – Wrap-Around Energy Absorbing Lanyards. Energy absorbing lanyards that are designed to wrap-around a structure and connect back onto themselves shall be tested in accordance with 4.11. The energy absorbing lanyard shall have a minimum breaking strength no less than 5,000 pounds (22.2 kN) when connected as designed and instructed for use.

3.2.9 Static Test – Y-Lanyards. Y-lanyards shall be statically tested in accordance with 4.7 and shall have a minimum breaking strength no less than 5,000 pounds (22.2 kN).

E3.2.9 *The deployment of the personal energy absorber or stretch of the energy absorbing lanyard material is not considered permanent deformation for purposes of this test providing the personal energy absorber or energy absorbing lanyard is deploying as intended. Failure of the test would be in cases of stitch patterns breaking, lanyard webbing tearing, connectors permanently bending or other physical damage.*

3.2.10 Dynamic Performance Testing of Y-Lanyards. Y-lanyards shall be tested in accordance with 4.8, 4.9 and 4.10 and shall meet the following requirements:

3.2.10.1. Y-Lanyards Single Connection: 6 ft FF and 12 ft FF Y-lanyards shall be tested in accordance with 4.8 and meet the respective requirements of 3.1.8.1 and 3.1.8.2.

3.2.10.2. Y-Lanyards Dual Connection: 6 ft FF and 12 ft FF Y-lanyards shall be tested in accordance with 4.9 and shall not at any time exceed a force reading over 1,800 pounds (8 kN). See Figure 17c.

E3.2.10.2 *The intention behind this test is to ensure that the maximum arrest force is not exceeded when the two legs of the energy absorbing lanyard are anchored.*

3.2.10.3 Dynamic Test – Hip Connection. Y-lanyards shall be tested in accordance with 4.10. If the energy absorbing lanyard breaks the nylon keeper during the test, the energy absorbing lanyard shall include a warning label on each lanyard leg according to 5.2.2.

4. QUALIFICATION TESTING

4.1 Test Equipment and Test Specimens.

4.1.1 Qualification and Verification Testing. Personal energy absorbers and energy absorbing lanyards shall undergo qualification and verification testing according to ANSI/ASSE Z359.7, *Qualification and Verification Testing of Fall Protection Products.*

4.1.2 Drop Test Structure. The drop test structure shall meet the requirements of ANSI/ASSE Z359.7, *Qualification and Verification Testing of Fall Protection Products.*

4.1.3 Test Weight. The test weight shall be of a rigid construction, weighing 282, +2 / -2, pounds (128, +0.9 / -0.9 kg). The center of gravity shall be 15 inches, +0.5 / -0.5, (381 mm, +13 / -13) from the upper bearing point of the test weight. The distance from the upper bearing point to the connection of the hip test shall be 30 inches, +0.5 / -0.5, (762 mm, +13 / -13). An example of a test weight is illustrated in Figure 6.

E4.1.3 *A conversion factor of 1.1 is being used when comparing the rigid test weight to the human body.*

4.1.4 Test Lanyard. The test lanyard to be used in performing dynamic tests of personal energy absorbers shall be fabricated from Type 302 stainless steel, 7x19 aircraft cable construction in accordance with MIL-W-83420D. It shall have a diameter of 0.375 inch (9.5 mm) and shall have a length required by the test to be conducted, equipped with eye splices at each end and measured from bearing point to bearing point between connectors when the lanyard is under a tension of 10, +0.5 /

E4.1.4 *The connector used for the test lanyard should be appropriate size, shape and strength for the test being conducted. Shackles with a 5:1 margin of safety are commonly used.*

-0, pounds, (44, +2.2 / -0, N). To prevent slippage, the lanyard eyes shall be formed by Flemish eye splices and secured with swaged fittings.

4.1.5 Test Instrumentation. The dynamic test instrumentation shall meet the requirements of, and have a corner frequency complying with ANSI/ASSE Z359.7, *Qualification and Verification Testing of Fall Protection Products.*

4.1.6 Quick Release Mechanism. The quick release mechanism shall meet the requirements of ANSI/ASSE Z359.7, *Qualification and Verification Testing of Fall Protection Products.*

4.1.7 Static Tensile Test Equipment. The static tensile test equipment shall pull at a uniform rate of not greater than 2 inches per minute (51 mm) and shall measure force within an accuracy of +/- 3 percent of the specified load.

4.1.8 Test Specimens. Test specimens shall meet the requirements of ANSI/ASSE Z359.7, *Qualification and Verification Testing of Fall Protection Products.*

4.1.9 Abrasion Tester. Abrasion tests and the abrasion tester will be arranged in accordance with Federal Test Method STD. No. 191A, Method 5309, *Abrasion Resistance of Textile Webbing.* The abrasion tester shall consist of a power driven steel drum that oscillates a test specimen over a hexagonal steel rod. The drum shall have an outside diameter of 16 inches (406 mm) and a means of attaching the edge of the test specimen without damage to the specimen. The hexagonal steel rod shall have a cold drawn finish and a Rockwell hardness of B-97 to B-101. The edges of the hexagonal rods shall not have any burrs, nicks or scale. The hexagonal rod shall measure 0.25 inch, +/- 0.001 inch (6.35 mm, +/- 0.03 mm) and the radius of the edges shall be 0.020 inch, +/- 0.004 inch (0.5 mm, +/- .1 mm). The hexagonal rods will be arranged so that the webbing will abrade across two adjacent edges as the drum oscillates. The hexagonal rod will be rotated or replaced for each test so no abrading edge is used more than once. The test specimen shall be attached to the drum, placed over the hexagonal rod and have a test weight of 5.2 pounds, +/- 0.25

pounds (2.4 kg, +/- 0.06 kg) suspended from the end of the test specimen. The drum will oscillate so the specimen is abraded over the bar 12 inches, +/- 1 inch (305 mm, +/- 25mm), per stroke at a rate of 60 strokes, +/- 2 strokes (30 cycles +/- 1 cycle) per minute. See Figure 7.

4.1.10 Calculating Average Force. For dynamic performance and conditioning tests, the average force shall be calculated. Throughout the drop test, until the first rebound of the test weight, every data point over 500 pounds (2.2 kN) on the Force / Time graph (see Figure 18a) shall be averaged. The sum of the force data points above 500 pounds (2.2 kN) shall be divided by the total number of samples above 500 pounds (2.2 kN), resulting in a force average. See Figure 17b.

E4.1.10 *Any data points below 500 pounds (2.2 kN) will be ignored and not included in the average force calculation.*

4.1.11 Nylon Keeper. The nylon keeper used for the Y-lanyard hip test shall be a nylon cable tie, PLT5S-C0, or equivalent, 0.19 inch (4.8 mm) wide, 0.06 inch (1.6 mm) thick with a loop tensile strength of 50 pounds (222 N), Mil Spec MIL-S-23190.

4.1.12 Wrap-Around Test Beam. For static strength and abrasion resistance testing of wrap-around energy absorbing lanyards, a steel W10x33 beam shall be used. The beams edge shall not be modified.

4.1.13 Free Fall Distance. The free fall distance for testing samples shall be as follows:

4.1.13.1 When testing the 6 ft FF samples, the test weight shall free fall 6, +0.1 / -0, feet (1.8, +0.03 / -0, m). See Figures 8 and 10.

4.1.13.2 When testing the 12 ft FF samples the test weight shall free fall 12, +0.1 / -0, feet (3.6, +0.03 / -0, m). See Figures 9 and 11.

4.2. Activation Force Testing of Personal Energy Absorbers. Measure and record the length of the personal energy absorber from bearing point to bearing point when it is under a tension of 10, +0.5 / -0, pounds, (4.5, +0.2 / -0, kg). Connect the personal energy absorber test specimen between the connectors of the tensile test equipment specified in 4.1.6 by means of the connectors at each end

of the personal energy absorber. If the test specimen is a component of a subsystem or system, and does not have an integral connector at its end, simulate as closely as possible the intended means of assembling it into its subsystem or system. Subject the personal energy absorber to a force no less than 450 pounds (2 kN) for a period no less than 1 minute. Examine the personal energy absorber for signs of activation. Record the results of this examination. Remove the personal energy absorber from the tensile test equipment and allow the personal energy absorber to recover in an untensioned position for a period of one hour. Measure and record the length of the personal energy absorber when it is subjected to a tension of 10, +0.5 / -0, pounds, (44, +2.2 / -0, N). Calculate the permanent personal energy absorber elongation. Compare the test results set forth in the requirements of 3.1.6.

4.3 Static Strength Testing of Personal Energy Absorbers. This test shall be performed using activated personal energy absorbers dynamically tested in accordance with 4.4. Measurement of the personal energy absorber length and maximum arrest force need not be performed. Connect the energy absorbing lanyard test specimen between the connectors of the tensile test equipment by means of the connectors at each end of the personal energy absorber. If the test specimen is a component of a subsystem or system and does not have an integral connector at its end, simulate as exactly as possible the intended means of assembling it into its subsystem or system. Subject the personal energy absorber to a force no less than 5,000 pounds (22.2 kN) for a period no less than 1 minute. The time to reach this force shall be no less than 3 minutes to avoid dynamic effects. If the sample was not fully deployed during the dynamic testing of 4.4, complete the deployment during the application of force during this test. Begin the 1 minute timing period upon complete deployment of the sample.

E4.3 *It is acceptable for any non-deployed portions of the personal energy absorber to fully deploy during tensioning of this test.*

4.4 Dynamic Performance Testing of Personal Energy Absorbers. Use the drop test structure, test weight, test instrumentation, test lanyard and quick release mechanism specified in 4.1. Measure and record the length of the personal energy absorber from bearing point to bearing point when tensioned to 10, +0.5 / -0, pounds, (4.5, +0.2 / -0,

E4.4 *Measurements taken during testing of personal energy absorbers can be accurate within 1/8 inch.*

kg). Attach one end of the energy absorber to the load cell. Attach the other end of the energy absorber to the test lanyard. Attach the other end of the test lanyard to the test weight. If the personal energy absorber is a component of a subsystem or system, and does not have an integral connector at its end, simulate as closely as possible the intended means of assembling it into its subsystem or system. Attach the quick release mechanism to the test weight and raise the weight to the free fall distance indicated in 4.1.13.1 and 4.1.13.2. The test weight shall be released from a point no more than 12 inches (305 mm) horizontally from the quick release connection to the load cell connection. Release the test weight using the quick release mechanism. As a minimum, record the entire event and collect data to calculate force average and maximum arrest force. Measure and record the length of the personal energy absorber from bearing point to bearing point while the weight is still suspended. Calculate the personal energy absorber deployment distance. Compare the test results set forth in the requirements of 3.1.8 and 3.1.9 as applicable.

4.5 Dynamic Performance Testing of Energy Absorbing Lanyards. Use the drop test structure, test weight, test instrumentation and quick release mechanism specified in 4.1. Measure and record the length of the energy absorbing lanyard from bearing point to bearing point when tensioned to 20, +0.5 / -0, pounds, (9, +0.2 / -0, kg). Attach one end of the energy absorbing lanyard to the load cell and the other to the test weight. If the personal energy absorber is a component of a subsystem or system, and does not have an integral connector at its end, simulate as closely as possible the intended means of assembling it into its subsystem or system. Attach the quick release mechanism to the test weight and raise the weight to a level indicated in 4.1.13.1 and 4.1.13.2 The test weight shall be released from a point no more than 12 inches (305 mm) horizontally from the point of connection to the load cell. Release the test weight using the quick release mechanism. As a minimum, record the entire event and collect data to calculate force average and maximum arrest force. Measure and record the length of the energy absorbing lanyard from bearing point to bearing point while the weight is still suspended. Calculate the energy absorbing

E4.5 *Measurements taken during testing of energy absorbing lanyards can be accurate within 1/8 inch.*

lanyard deployment distance. Compare the test results with the applicable requirements of 3.2.4 and 3.2.5. See Figures 10 and 11.

4.6 Static Strength Testing of Energy Absorbing Lanyards. This test shall be performed using activated energy absorbing lanyards dynamically tested in accordance with 4.5. Measurement of the energy absorbing lanyard length and maximum arrest force need not be performed. Connect the energy absorbing lanyard test specimen between the connectors of the tensile test equipment by means of the connectors at each end of the energy absorbing lanyard. If the test specimen is a component of a subsystem or system and does not have an integral connector at its end, simulate as exactly as possible the intended means of assembling it into its subsystem or system. Subject the energy absorbing lanyards to a force no less than 5,000 pounds (22.2 kN) for a period no less than 1 minute. The time to reach this force shall be no less than 3 minutes to avoid dynamic effects. Compare the test results with the applicable requirements of 3.2.6.

4.6.1 Static Strength Testing of Adjustable Length Energy Absorbing Lanyards. Connect the energy absorbing lanyard test specimen between the connectors of the tensile test equipment by means of the connectors at each end of the energy absorbing lanyard. If the test specimen is a component of a subsystem or system and does not have an integral connector at its end, simulate as exactly as possible the intended means of assembling it into its subsystem or system. Mark the location of the adjuster element on the lanyard. Subject the lanyard to a force no less than 2,000 pounds (8.9 kN) for a period no less than 1 minute. Remove the force and record any slippage that has occurred at the adjuster. Adjust the lanyard to its fully extended length. Reapply the load of the tensile test equipment and subject the lanyard to a force no less than 5,000 pounds (22.2 kN) for a period no less than 1 minute. The time to reach this force shall be no less than 3 minutes to avoid dynamic effects. Compare the test results with the applicable requirements of 3.2.6.

4.7 Static Strength Testing of Y-Lanyards. Connect the energy absorbing lanyard test specimen between the connectors of the tensile test equipment specified in 4.1. Subject the energy absorbing lanyard to a force no less than 5,000 pounds (22.2 kN) for a period no less than 1 minute. The time to reach this force shall be no less than 3 minutes to avoid dynamic effects. Test the Y-lanyard in the following three configurations and compare the test results to the requirements set forth in 3.2.9. A new lanyard may be used for each test configuration. See Figure 12a and 12b.

4.7.1 Attach the central connector intended to connect to the harness and one connector on one of the energy absorbing lanyard legs into the connectors of the tensile test equipment.

4.7.2 Conduct the same test using the alternate energy absorbing lanyard leg.

4.7.3 Conduct the same test between the two energy absorbing lanyard legs that are intended to connect to the anchorage. See Figure 12b.

4.8 Dynamic Performance Testing of Y-Lanyards – Single Connection. Use the drop test structure, test weight, test instrumentation and quick release mechanism specified in 4.1. Measure and record the length of the energy absorbing lanyard from bearing point to bearing point when tensioned to 20, +0.5 / -0, pounds, (9, +0.2 / -0, kg). Attach the anchoring end of the Y-lanyard leg to the load cell and the harness connection to the test weight. The unused leg of the Y-lanyard can be hung loosely not connected to the test weight or load cell. If the personal energy absorber is a component of a subsystem or system, and does not have an integral connector at its end, simulate as closely as possible the intended means of assembling it into its subsystem or system. Attach the quick release mechanism to the test weight and raise the weight to the applicable level described in 4.4.1 or 4.4.2. The test weight shall be released from a point no more than 12 inches (305 mm) horizontally from the point of connection to the load cell. Release the test weight using the quick release mechanism. As a minimum, record the entire event and collect data to calculate force average and maximum arrest force. Measure

E4.7 *The intent behind this test is to arrange the energy absorbing lanyard in all configurations that it may be connected. Although the test arrangement required in 4.7.3 is not a recommended configuration for use, it is desirable to test in this manner to guard against misuse.*

and record the length of the energy absorbing lanyard from bearing point to bearing point while the weight is still suspended. Calculate the personal energy absorber elongation. Compare the test results set forth in the requirements of 3.2.10.1.

4.9 Dynamic Performance Testing of Y-Lanyards – Dual Connection. Use the drop test structure, test weight, test instrumentation and quick release mechanism specified in 4.1. Attach both ends of the energy absorbing lanyard to the load cell and the harness connector to the test weight. Attach the quick release mechanism to the applicable level described in 4.4.1 or 4.4.2. The test weight shall be released from a point no more than 12 inches (305 mm) horizontally from the point of connection to the load cell. Release the test weight using the quick release mechanism. Compare the test results set forth in the requirements of 3.2.10.2. See Figure 13a and 14a.

4.10 Dynamic Performance Testing of Y-Lanyards – Hip Test. Use the drop test structure, test weight, and quick release mechanism specified in 4.1. Attach one end of the energy absorbing lanyard to the test structure, the harness connector to the test weight and the unused leg to the connector on the side of the test weight (as illustrated in Figure 13b and 14b) using the nylon keeper specified in 4.1.11 with a 3 inch (76 mm) diameter loop. Attach the quick release mechanism to the applicable level described in 4.4.1 or 4.4.2. The test weight shall be released from a point no more than 12 inches (305 mm) horizontally from the point of connection to the load cell. Release the test weight using the quick release mechanism. Compare the test results set forth in the requirements of 3.2.10.3. See Figures 13b and 14b.

E4.10 *Common practice when using Y-lanyards is to store the unused leg to a hip D-Ring or other location on the harness. This may lead to side loading on the body in the event of a fall if the unused leg of the Y-lanyard becomes taut. Education of the authorized person, warning labels and manufacturer instruction are required if the energy absorbing lanyard design has the potential to side load the harness.*

4.11 Static Strength Testing of Wrap-Around Energy Absorbing Lanyards. Using a previously tested energy absorbing lanyard from 4.5, connect the energy absorbing lanyard test specimen between the connectors of the tensile test equipment specified in 4.1 by means of the connector at the end of the energy absorbing lanyard designed to attach to the harness. The anchoring end of the energy absorbing lanyard shall be wrapped around and tied back onto itself to simulate as exactly as

E4.11 *Manufacturers are encouraged to test the energy absorbing lanyard in its most extreme arrangement on the worst anticipated material. For example, if the wrap-around energy absorbing lanyard is designed to connect around I-beams, the energy absorbing lanyard should be arranged around the I-beam in its worst possible arrangement.*

possible the intended means of assembling it into the anchorage. Subject the energy absorbing lanyard to a force no less than 5,000 pounds (22.2 kN) for a period no less than 1 minute. The time to reach this force shall be no less than 3 minutes to avoid dynamic effects. Compare the test results to the requirements set forth in 3.2.7. See Figure 15.

4.12 Abrasion Resistance Testing of Wrap-Around Energy Absorbing Lanyards. Using a previously tested wrap-around energy absorbing lanyard from 4.5, expose the anchor end of the wrap-around energy absorbing lanyard to 2,500 cycles on the abrasion tester. Using the abraded specimen, conduct a static strength test according to 4.11 to a force not less than 3,600 pounds (18 kN) for no less than 1 minute. The abraded area of the lanyard shall be placed on the edge of the wrap-around test beam with the highest load concentration. Compare the results of the test with requirements set forth in 3.2.7. See Figure 7.

E4.12 *The abrasion test should be conducted on the area of the lanyard that is intended to contact the anchorage.*

4.13 Conditioning of Test Samples. New samples shall be used for each conditioning requirement. Each sample shall be tested within 5 minutes of conditioning.

4.13.1 Ambient Wet. 6 ft FF and 12 ft FF samples shall be immersed in water at 68 +/- 4°F (20 +/- 2°C) for a minimum of 8 hours.

4.13.2 Cold Dry. 6 ft FF and 12 ft FF samples shall be conditioned at –31 +/- 4°F (–35 +/- 2°C) for a minimum of 8 hours.

4.13.3 Hot Dry. 6 ft FF and 12 ft FF samples shall be conditioned at 113 +/- 4°F (45 +/- 2°C) for a minimum of 8 hours.

5. MARKING AND REFERENCE LITERATURE

5.1 General Marking Requirements.

5.1.1 Markings shall be in English.

5.1.2 The legibility and attachment of required markings shall endure for the life of the component, subsystem or system being marked. When pressure sensitive labels are used, they shall comply

with the applicable provision of UL 969-89, *Marking and Labeling Systems.*

5.1.3 Equipment shall be marked with the following:

- Part number and model designation;
- Year of manufacture;
- Manufacturer's name or logo;
- Capacity rating;
- Serial number;
- Standard number;
- Warning to follow the manufacturer's instructions included with the equipment at time of shipment from the manufacturer.

5.2 Specific Marking Requirements.

5.2.1 Personal Energy Absorbers and Energy Absorbing Lanyards. Personal energy absorbers and energy absorbing lanyards shall be marked to identify:

- The fiber used in the material of construction;
- The length;
- The need to avoid contact with sharp edges and abrasive surfaces;
- The need to make only compatible connections;
- The maximum elongation;
- Restriction, if any, on the types of components, subsystems or systems with which the personal energy absorber is designed to be used;
- The average arrest force, maximum free fall distance and capacity of the personal energy absorber on a separate label identical in size, color and content as Figure 16a and 16b;
- 6 ft FF personal energy absorbers shall be in black print on a contrasting white background. See Figure 16a;
- 12 ft FF personal energy absorbers shall be in white print on a contrasting black background. See Figure 16b.

5.2.2 Y-Lanyard. In addition to 5.2.1, Y-lanyards that fail the Dynamic Hip Test detailed in 3.2.10, must include a warning label on both connecting ends of the lanyard specifically directing users how to safely store the unused leg of the lanyard.

5.3 General Instruction Requirements.

5.3.1 Instructions shall be provided to the user, printed in English, and affixed to the equipment at the time of shipment from the manufacturer.

5.3.2 Instructions shall contain the following information:

- A statement that the manufacturer's instructions shall be provided to the users;
- Manufacturer's name, address and telephone number;
- Manufacturer's part number and model designation for the equipment;
- Intended use and purpose of the equipment;
- Proper method of use and limitations on use of the equipment;
- Illustrations showing locations of markings on the equipment;
- Reproduction of printed information on all markings;
- Inspection procedures required to assure the equipment is in serviceable condition and operating correctly;
- Anchorage requirements;
- An illustration of how to calculate free fall distances;
- Criteria for discarding equipment which fails inspection;
- Procedures for cleaning, maintenance and storage;
- Reference to the ANSI/ASSE Z359.13, *Personal Energy Absorbers and Energy Absorbing Lanyards*, standard and applicable regulations governing occupational safety.

5.3.3 Instructions shall require that only the equipment manufacturer, or persons or entities authorized in writing by the manufacturer, shall make repairs to the equipment.

5.3.4 Instructions shall require the user to remove equipment from field service if it has been subjected to the forces of arresting a fall.

5.4 Specific Instruction Requirements.

5.4.1 Personal Energy Absorbers. In addition to

E5.4.1 *For shock or impulsive loadings, the dynam-*

general instruction requirements, written instructions for personal energy absorbers shall include:

- The material used in personal energy absorber construction;
- The need to make only compatible connections and limitations of compatibility;
- Proper method of coupling the personal energy absorber to adjacent components of the system;
- The maximum arrest force of the personal energy absorber when dynamically tested in accordance with the requirements of this standard;
- The maximum elongation of the personal energy absorber when dynamically tested in accordance with the requirements of this standard;
- A reference chart that indicates the deployment distance of the personal energy absorber according to the user weight and free fall distance;
- A statement that indicates information necessary in designing fall protection systems shall be made available from the manufacturer. Manufacturers may provide designers of fall protection systems a representative graph(s) of the time history plot of the loading from a drop test.

6. USER INSPECTION, MAINTENANCE AND STORAGE OF EQUIPMENT

Users of PFAS shall, at a minimum, comply with all manufacturer instructions regarding the inspection, maintenance and storage of the equipment. The user's organization shall retain the manufacturer's instructions and make them readily available to all users.

6.1 Inspection.

6.1.1 Equipment shall be inspected by the user before each use and, additionally, by a competent person other than the user at intervals of no more than one year.

6.1.2 Inspection criteria for the equipment shall be set by the users' organization. Such criteria for the equipment shall equal or exceed the greater of the criteria established by this standard or the manufacturer's instructions.

6.1.3 When inspection reveals defects in, damage

ic load factor, which is defined as the ratio of the dynamic displacement to static displacement under the load, can be as large as 2.0 for an instantaneously applied load. The magnitude of this value is affected by the rate in which the load being applied to the anchorage. As the rate at which the load is applied decreases, i.e., becomes less steep, the dynamic load factor tends to a value of 1.0. Values for the peak and average forces observed should be provided in this documentation. This will allow the designer of the system to determine an equivalent static force to be used in their calculations.

The maximum arrest forces realized in the conditioning tests should be available to qualified, competent and authorized persons through the manufacturer's instructions.

to or inadequate maintenance of equipment, the equipment shall be permanently removed from service or undergo adequate corrective maintenance before return to service.

6.1.4 In addition to the inspection requirements set forth in the manufacturer's instructions, the equipment shall be inspected at both inspection levels described in 6.1.1 for:

- Absence or illegibility of markings;
- Absence of any elements affecting the equipment form, fit or function;
- Evidence of activation or fall arrest service such as a warning flag or label on the personal energy absorber or energy absorbing lanyard;
- Evidence of defects in or damage to hardware elements including cracks, sharp edges, deformation, corrosion, chemical attack, excessive heating, alteration and excessive wear;
- Evidence of defects in or damage to straps or ropes including fraying, unsplicing, unlaying, kinking, knotting, roping, broken or pulled stitches, excessive elongation, chemical attack, excessive soiling, abrasion, alteration, needed or excessive lubrication, excessive aging and excessive wear.

6.2 Maintenance and Storage.

6.2.1 Maintenance and storage of equipment shall be conducted by the user's organization in accordance with the manufacturer's instructions. Unique issues, which may arise due to conditions of use, shall be addressed with the manufacturer.

6.2.2 Equipment which is in need of or scheduled for maintenance shall be tagged as "unusable" and removed from service.

6.2.3 Equipment shall be stored in a manner as to preclude damage from environmental factors such as heat, light, excessive moisture, oil, chemicals and their vapors or other degrading elements.

7. REFERENCES

When referred to herein, the specific references cited below (inclusive of the revision designated) shall be applied. If any of the listed references is revised

or is obsolete by its issuer, the specific reference cited below shall continue to apply to this standard unless this standard is officially amended.

7.1 Superintendent of Documents, U.S. Government Printing Office Washington, DC

7.1.1 *Standard Industrial Classification Manual*

7.2 U.S. Department of Defense, National Publication Form Center 5801 Tabor Avenue Philadelphia, PA 19120-5099

7.2.1 MIL-W-83420D, *Military Specification, Wire Rope, Flexible, for Aircraft Control*

7.3 General Services Administration Specification Branch 7th & D Street, S.W. Washington, DC 20407

7.3.1 Federal Standard 191A, Test Method 4108. *Strength and Elongation, Breaking; Textile Webbing, Tape and Braided Items*

7.3.2 Federal Standard 191A, Test Method 6015. *Strength and Elongation, Breaking of Cordage; Spliced Specimen Method*

7.3.3 Federal Standard 751 A, *Stitches, Seams, and Stitching*

7.3.4 Federal Standard 191A, Method 5309, *Abrasion Resistance of Textile Webbing.*

7.4 ASTM 1916 Race St. Philadelphia, PA 19103

7.4.1 E8/8M-11, *Test Methods of Tension Testing of Metallic Materials*

7.5 Underwriters Laboratories, Inc. Northbrook, Illinois

7.5.1 UL 969-89, *Marking and Labeling Systems*

7.6 American Society of Safety Engineers, 1800 East Oakton Street, Des Plaines, Illinois, 60018-2187

7.6.1 ANSI/ASSE Z359.1, *Safety Requirements of Personal Fall Arrest Systems, Subsystems and Components*

7.6.2 ANSI/ASSE Z359.12, *Safety Requirements for Connecting Components for Personal Fall Arrest Systems (PFAS) Connectors*

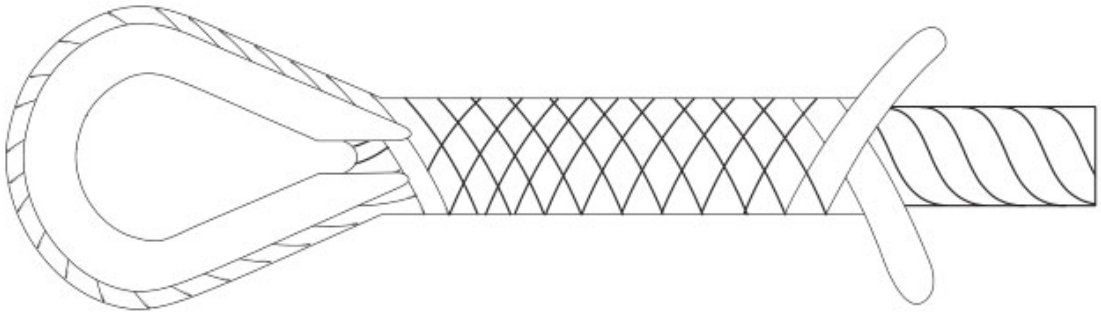


Figure 1: Spliced Connection

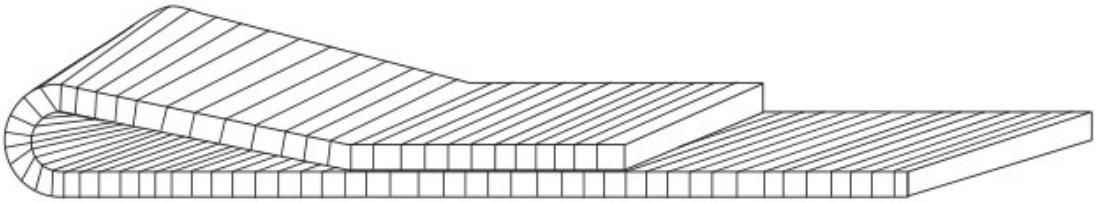


Figure 2: Stitched Connection

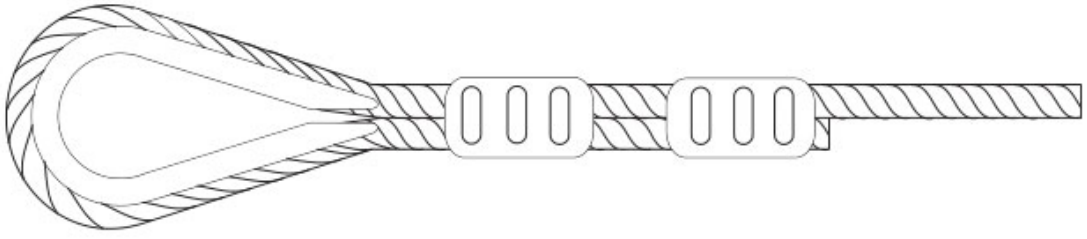


Figure 3: Swaged Connection

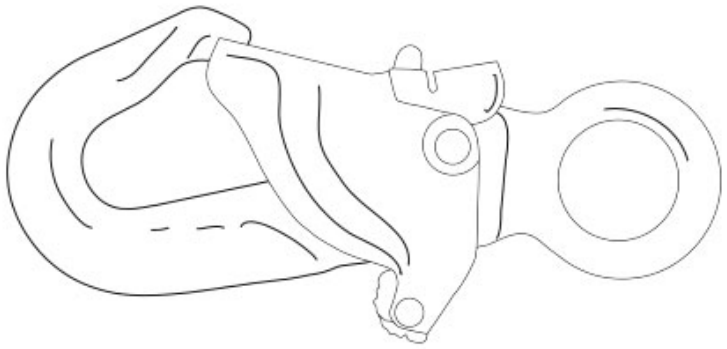


Figure 4a: Locking Snaphook

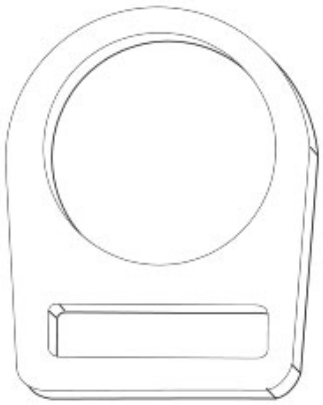


Figure 4b: D-Ring

Figure 4c: Locking Carabiner

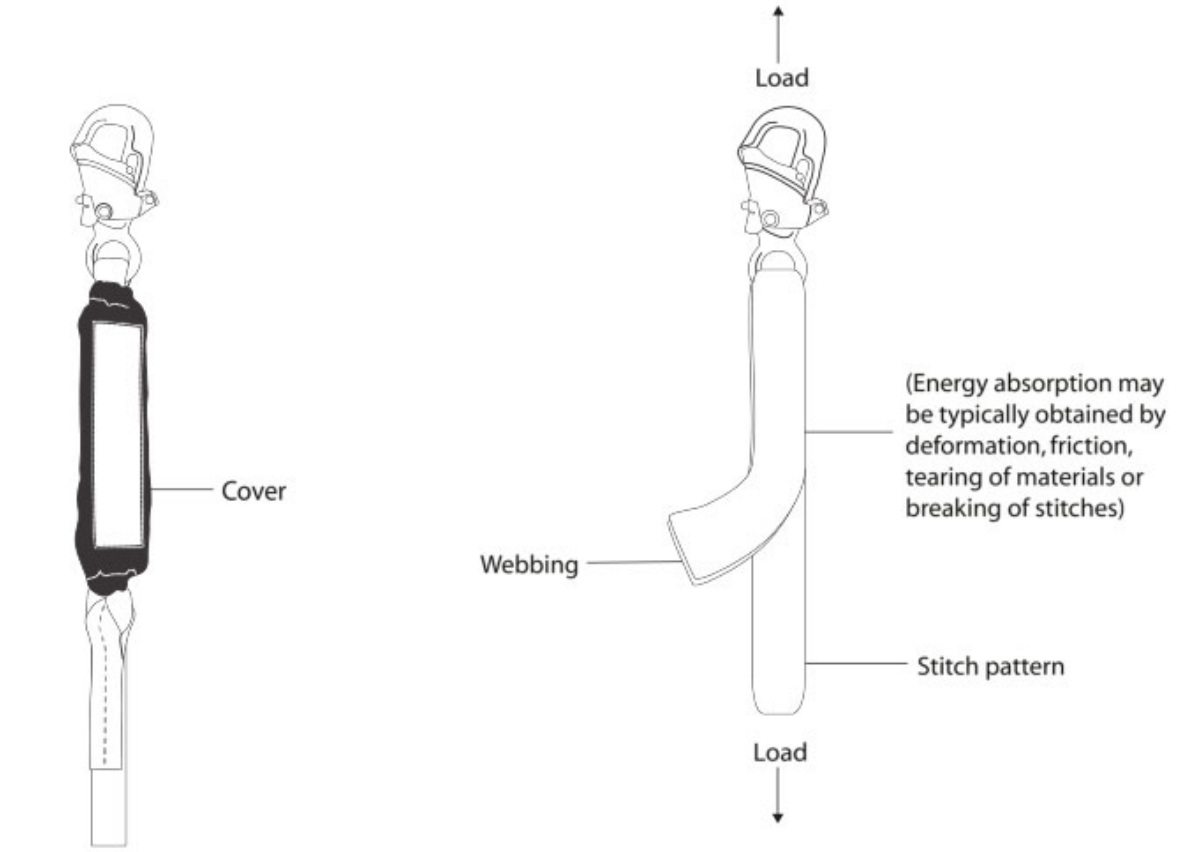


Figure 5a: Typical Personal Energy Absorber

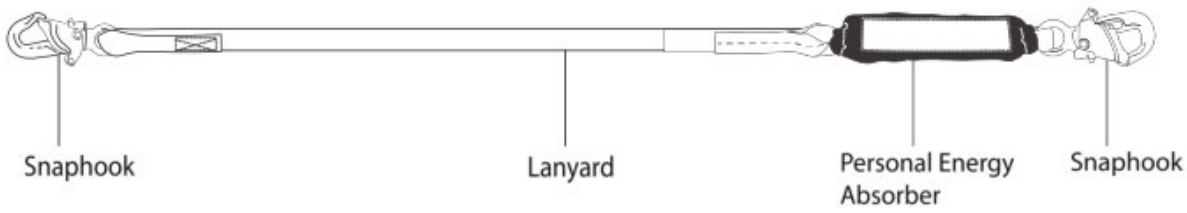


Figure 5b: Typical Energy Absorbing Lanyard

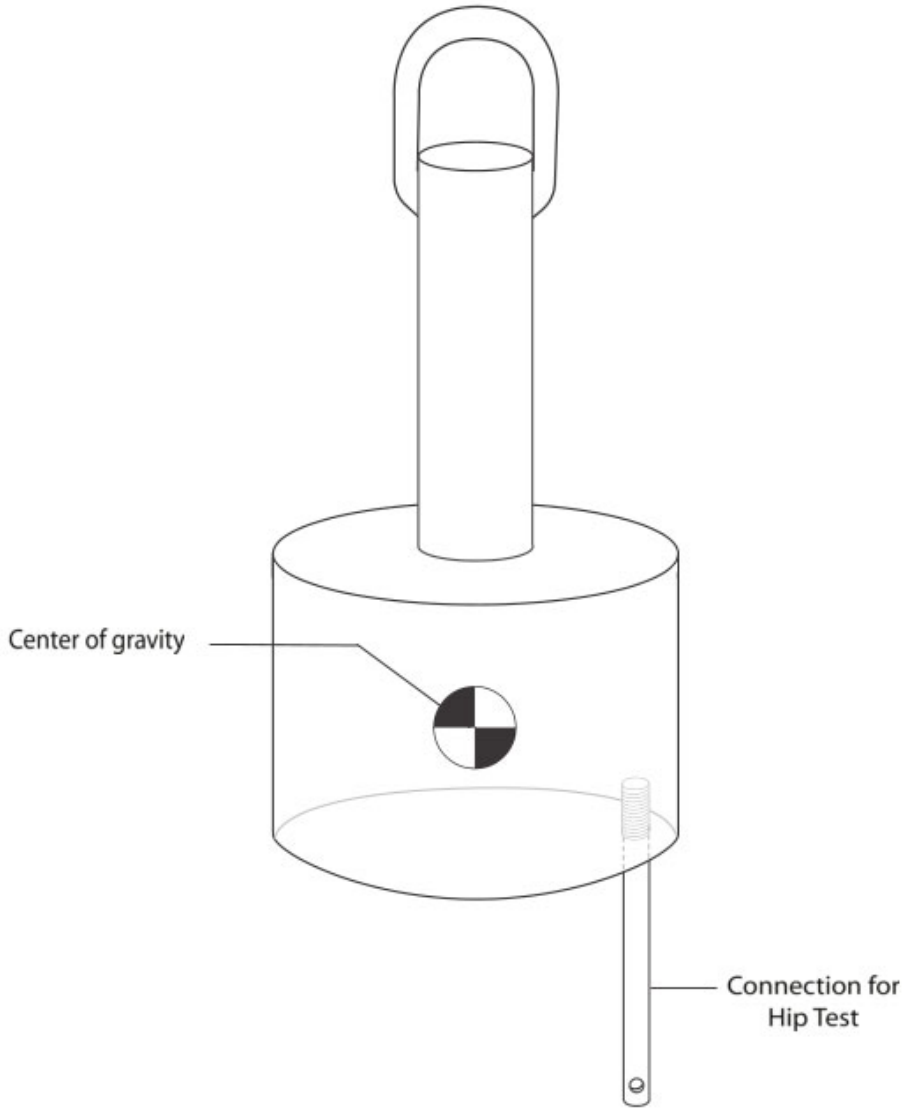
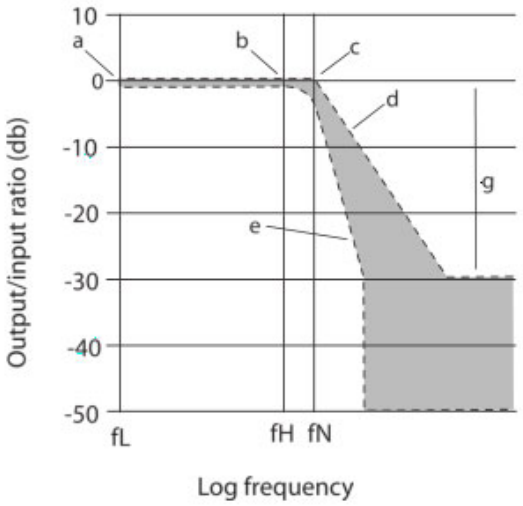


Figure 6: Example Test Weight

Legend:
a = +/- 1/4 dB
b = + 1/2 dB, -1 dB
c = + 1/2 dB, -3 dB
d = -9 dB/octave
e = -24 dB/octave
fH = 60 Hz
fL = 0.1 Hz
fN = 100 Hz
g = -30 dB



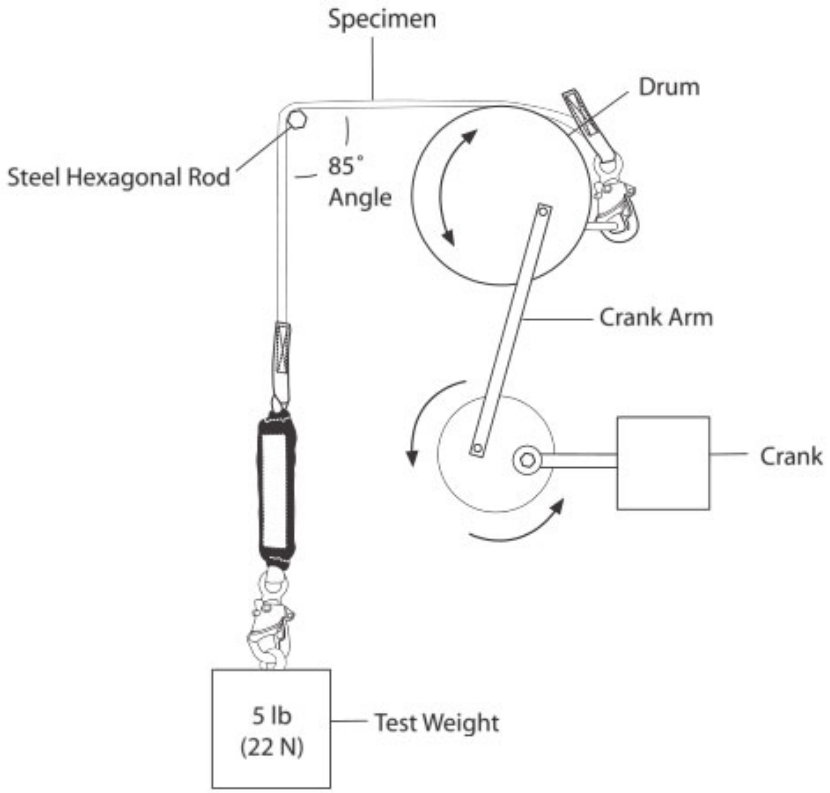


Figure 7: Abrasion Test

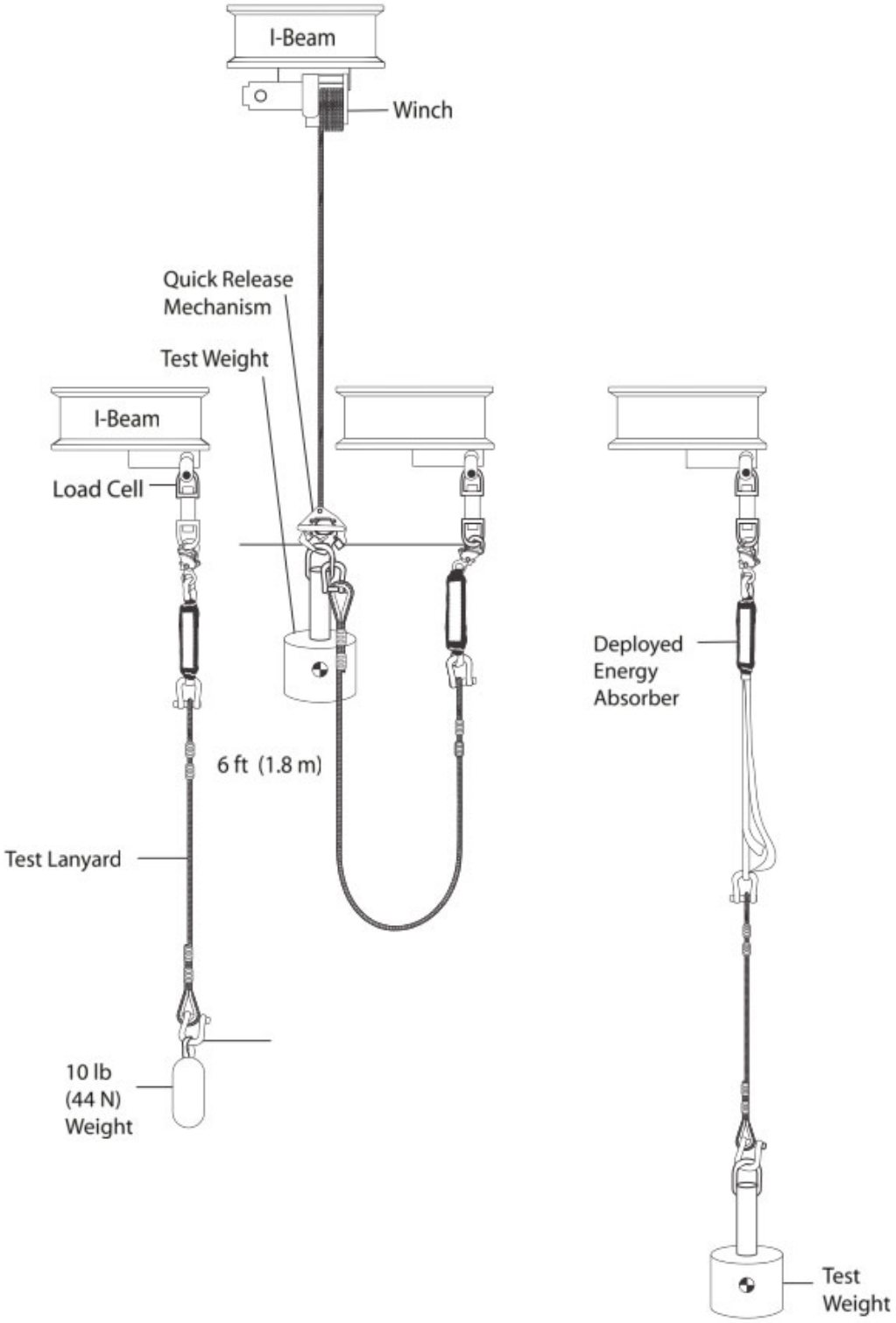


Figure 8: Dynamic Performance Testing of Personal Energy Absorbers (6 ft FF)

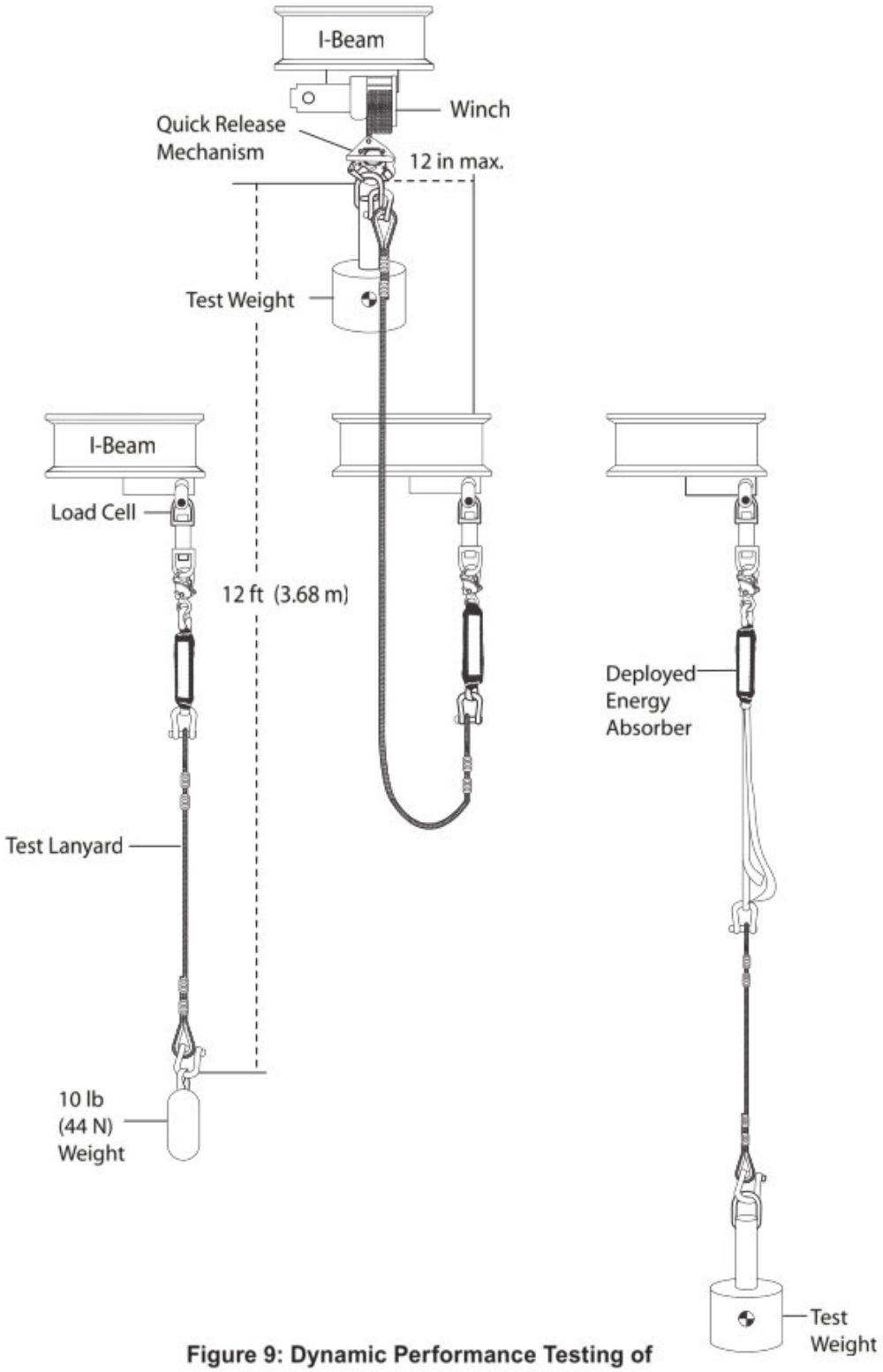


Figure 9: Dynamic Performance Testing of Personal Energy Absorbers (12 ft FF)

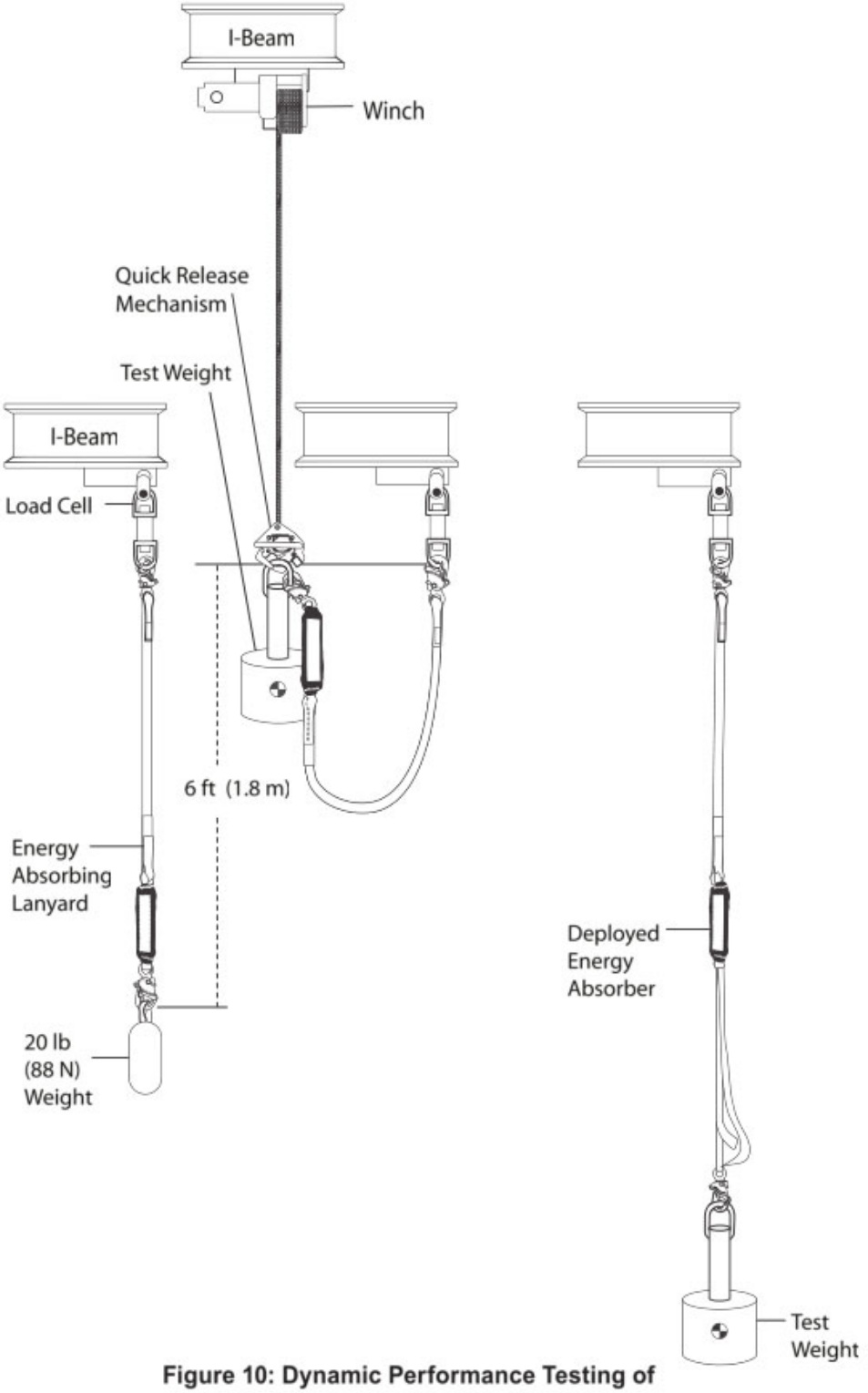


Figure 10: Dynamic Performance Testing of Energy Absorbing Lanyard (6 ft FF)

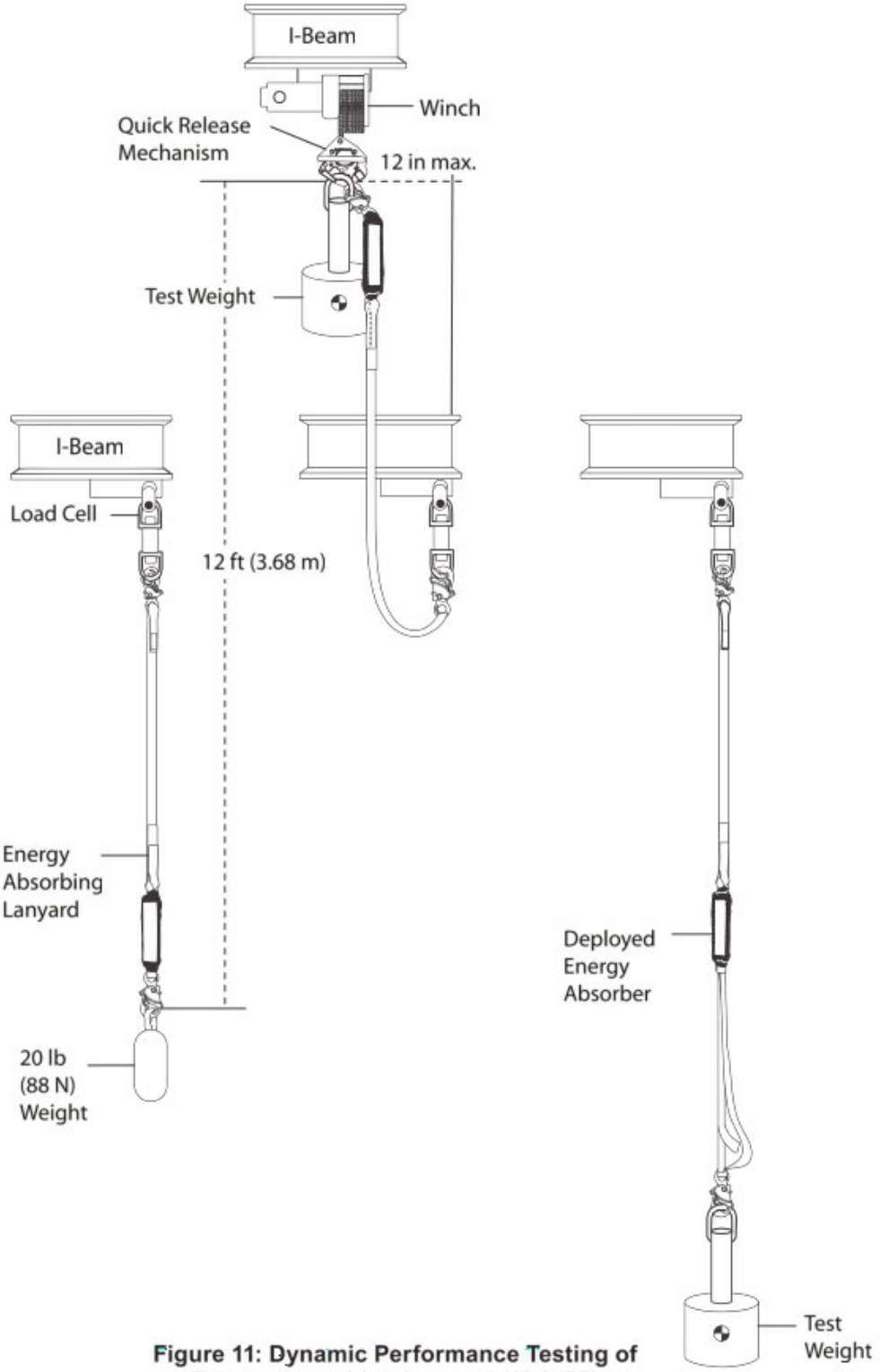


Figure 11: Dynamic Performance Testing of Energy Absorbing Lanyard (12 ft FF)

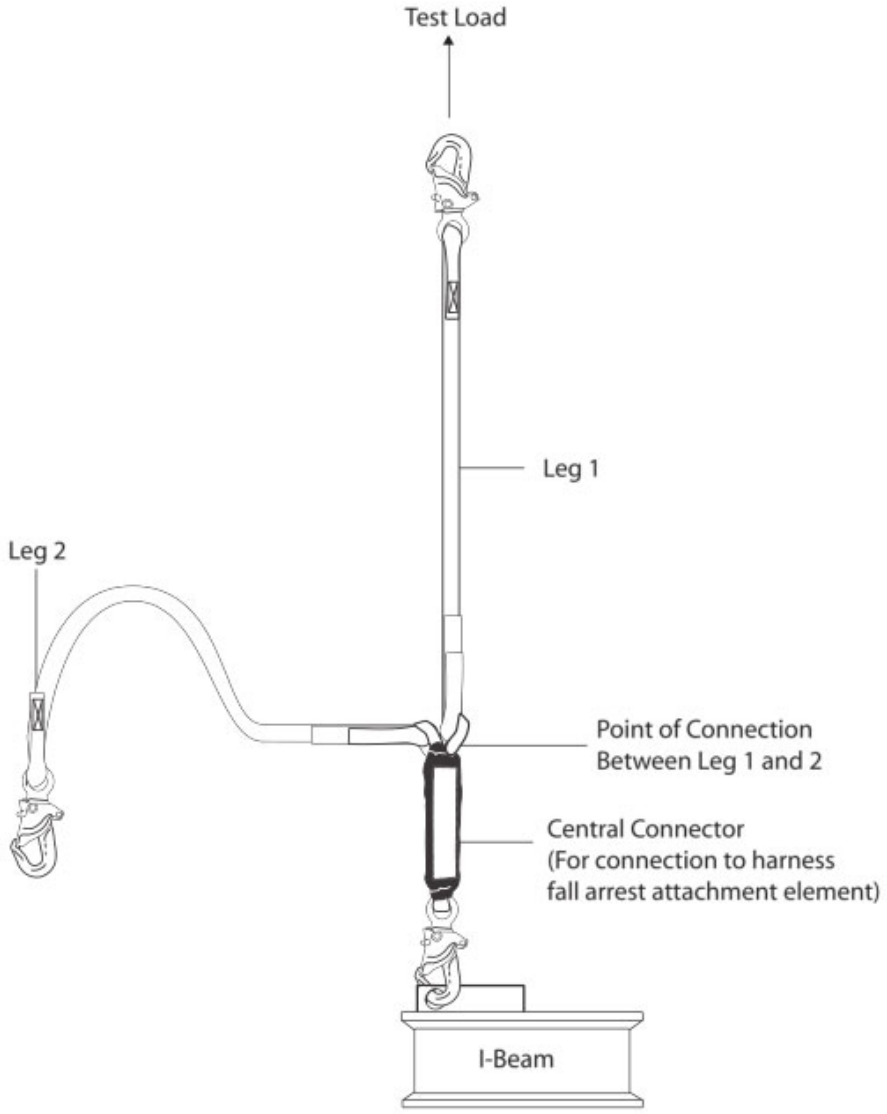


Figure 12a: Static Strength Test of Y-Lanyard

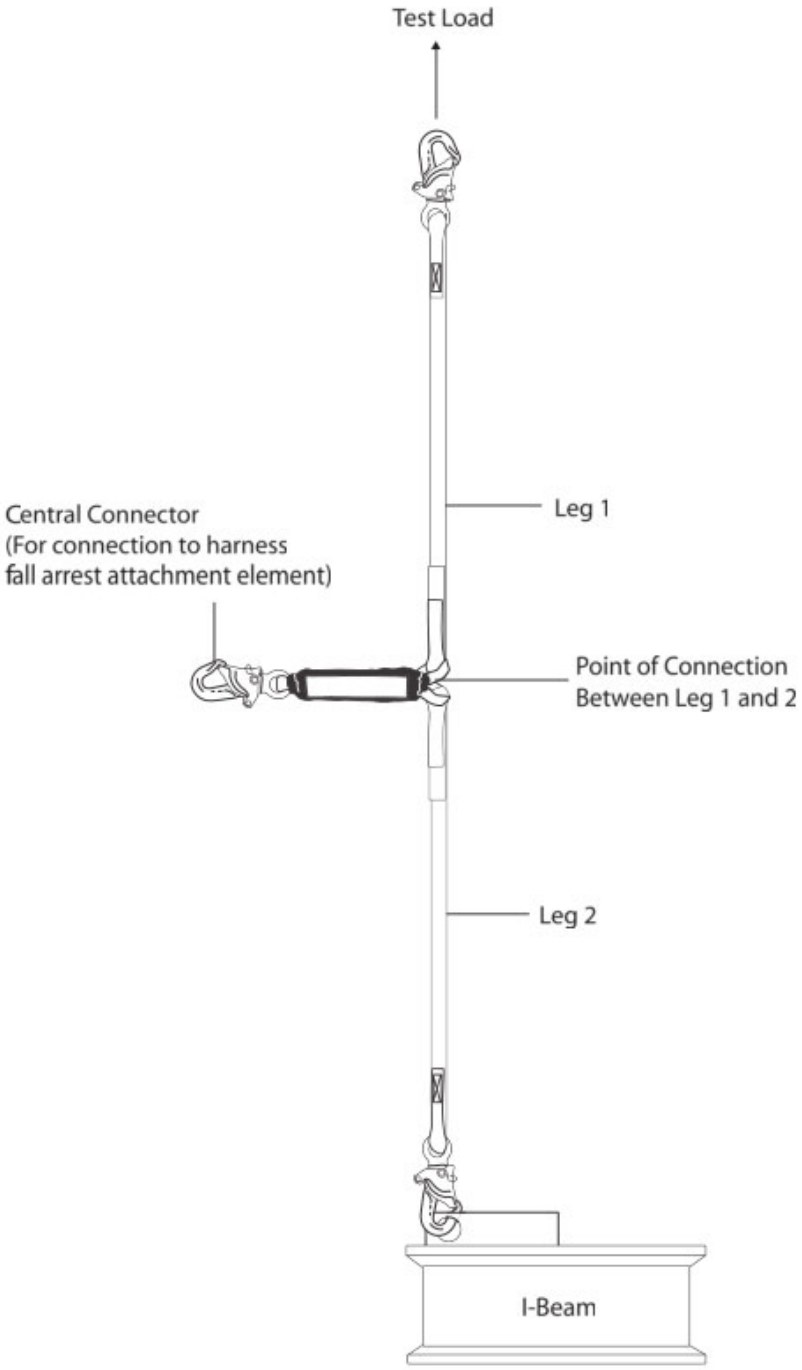


Figure 12b: Static Strength Test of Y-Lanyard (misuse)

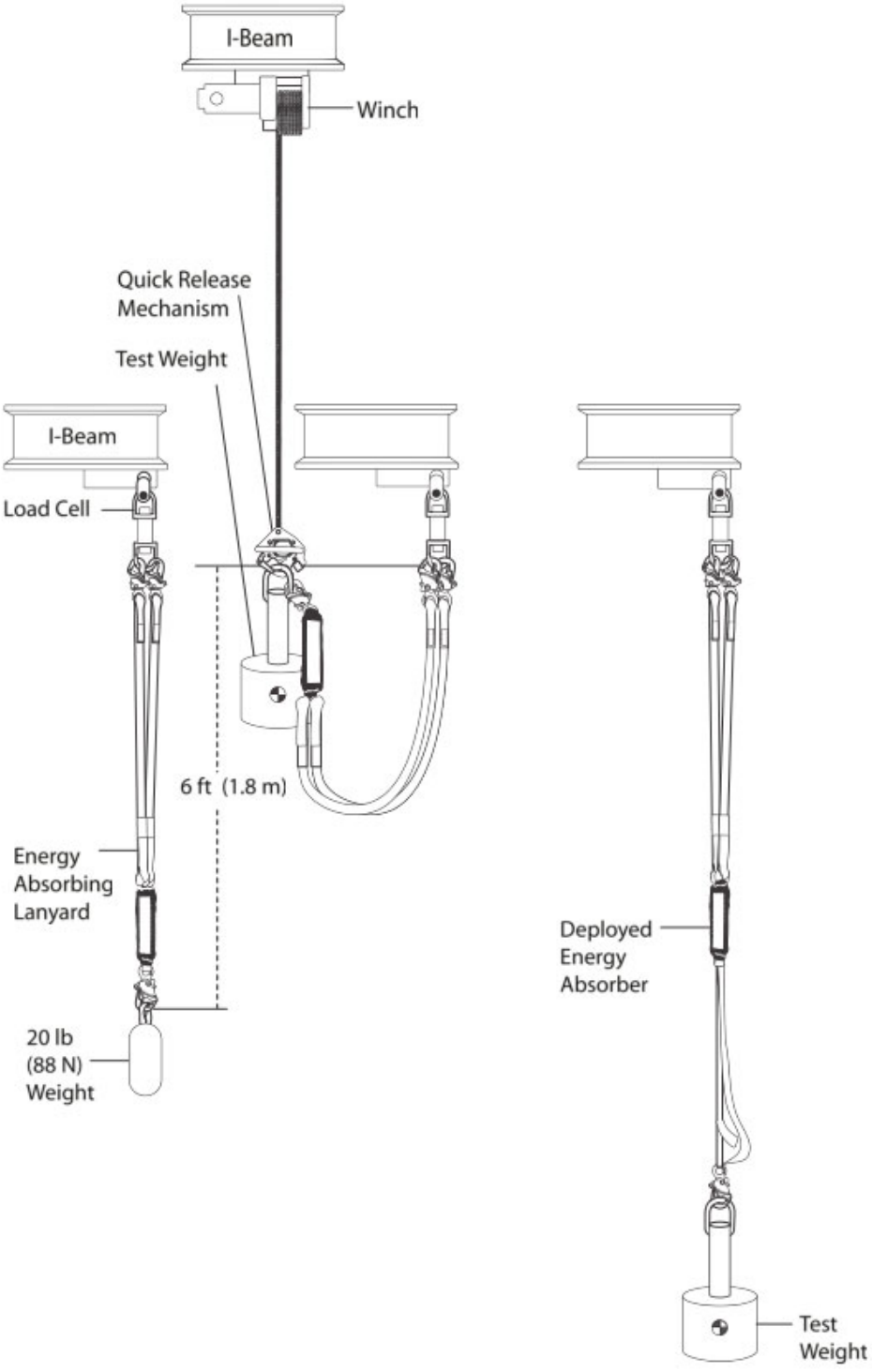


Figure 13a: Dynamic Performance Test of Y-Lanyard – Dual Connections (6 ft FF)

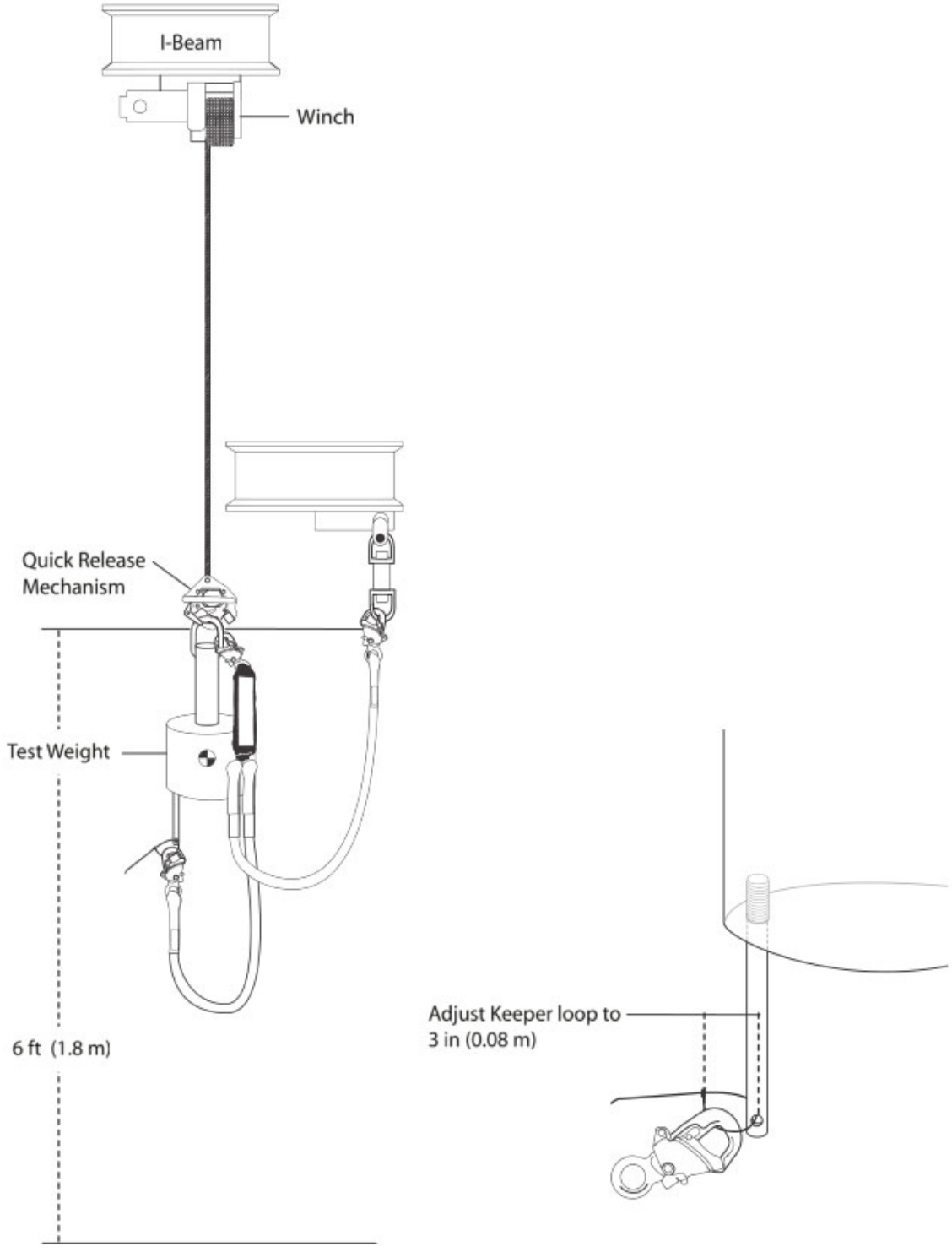


Figure 13b: Dynamic Performance of Y-Lanyard – Hip–Test (6 ft FF)

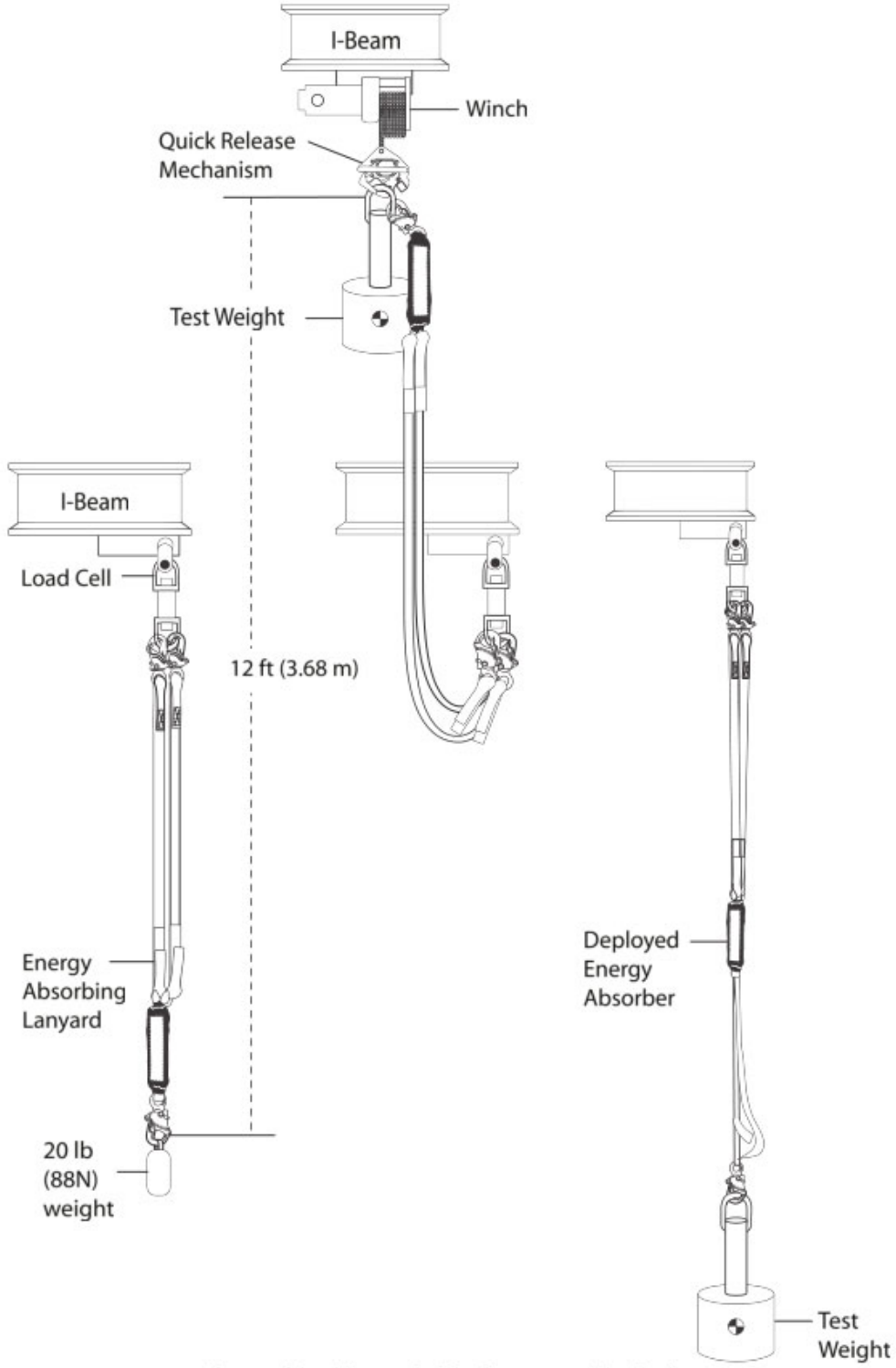


Figure 14a: Dynamic Performance Test of Y-Lanyard – Dual Connections (12 ft FF)

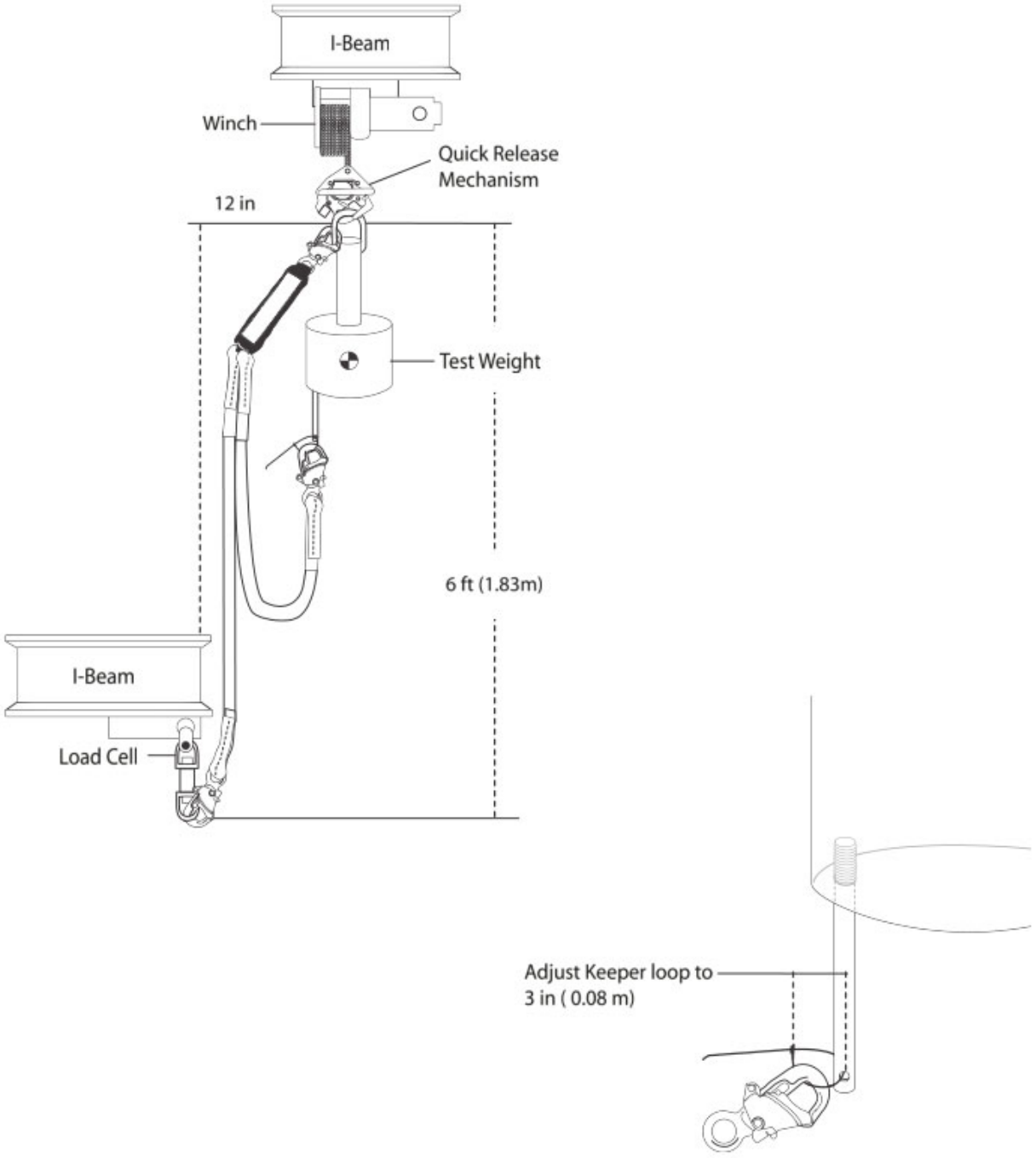


Figure 14b: Dynamic Performance of Y–Lanyard – Hip–Test (12 ft FF)

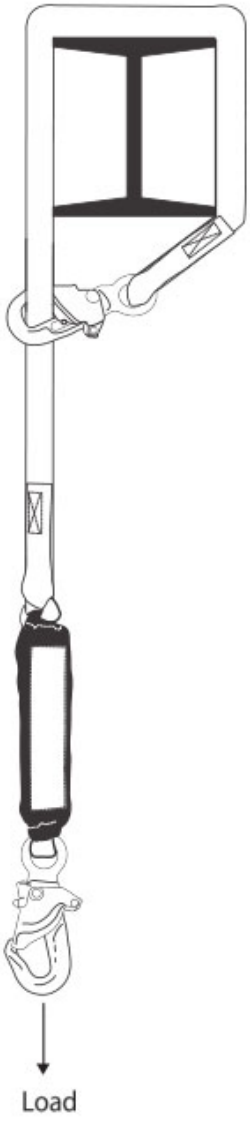


Figure 15: Static Strength Test of Wrap-Around Lanyard

Figure 16a: 6 ft FF Energy Absorber Label

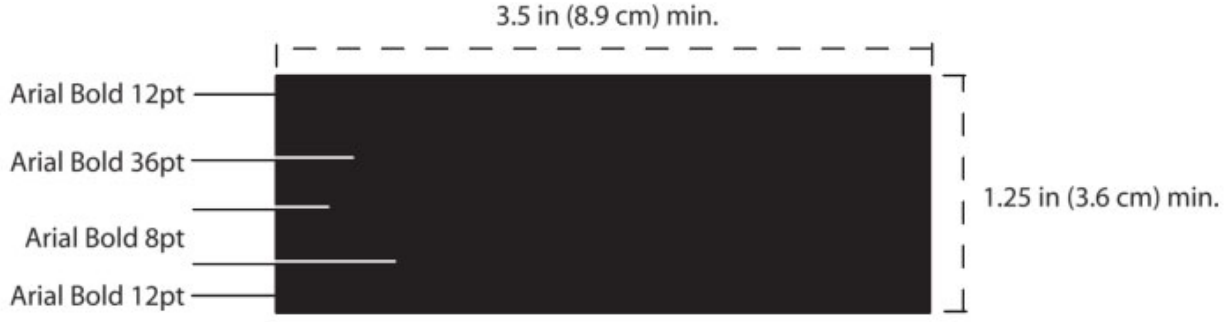


Figure 16b: 12 ft FF Energy Absorber Label

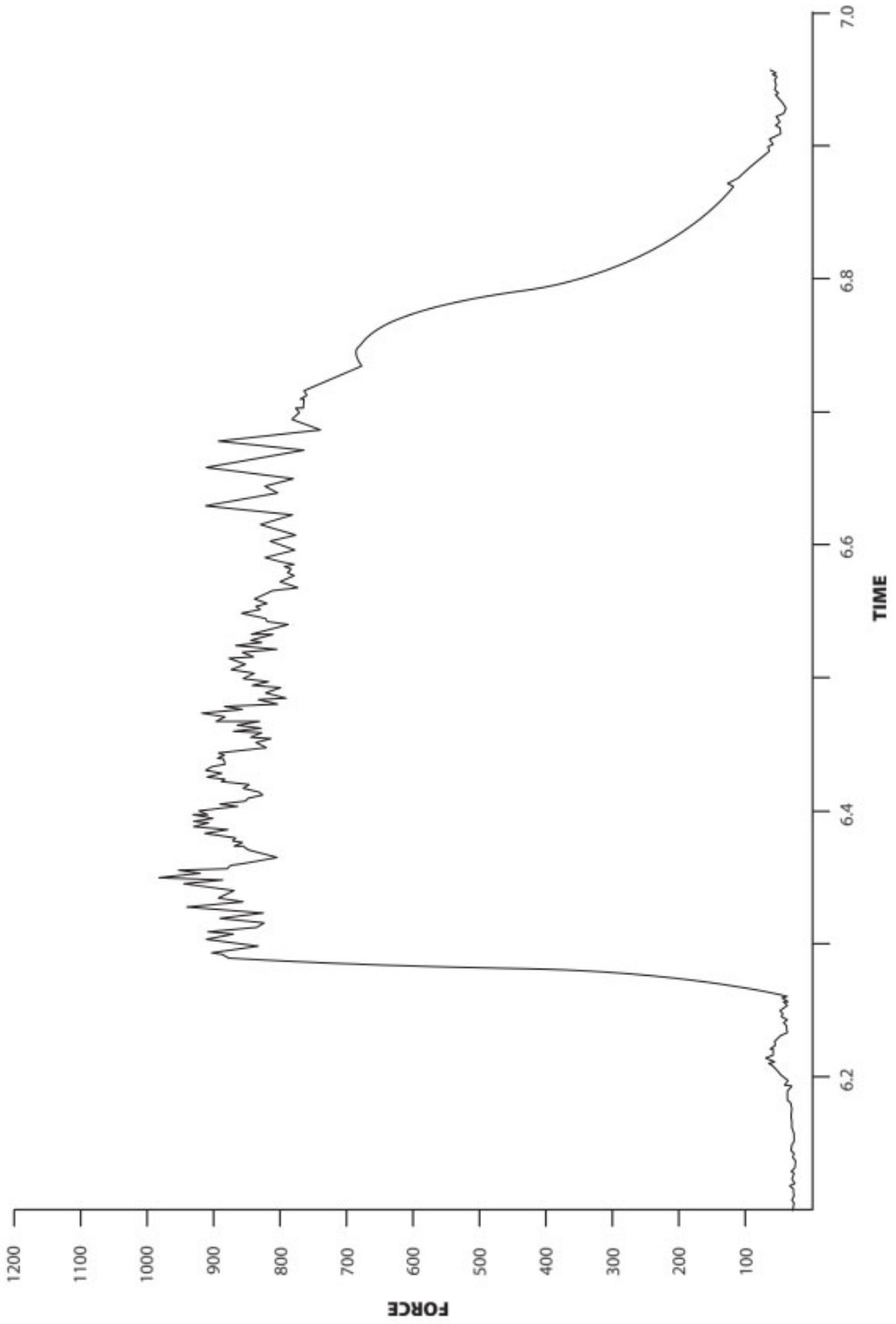


Figure 17a: Example of a Force/Time Graph for a 6 ft FF Energy Absorber

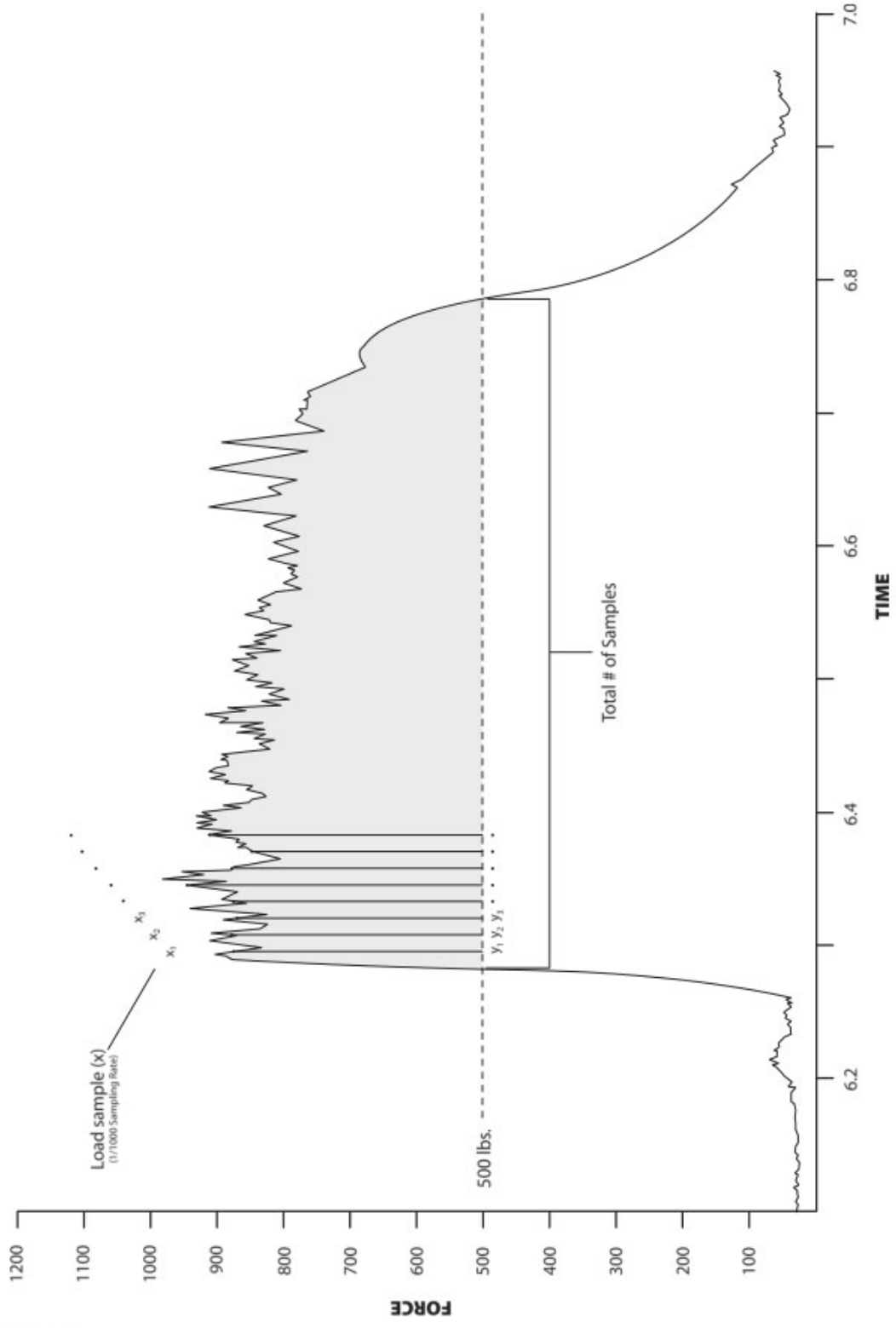


Figure 17b: Example of a Calculation Method for a 6 ft FF Energy Absorber

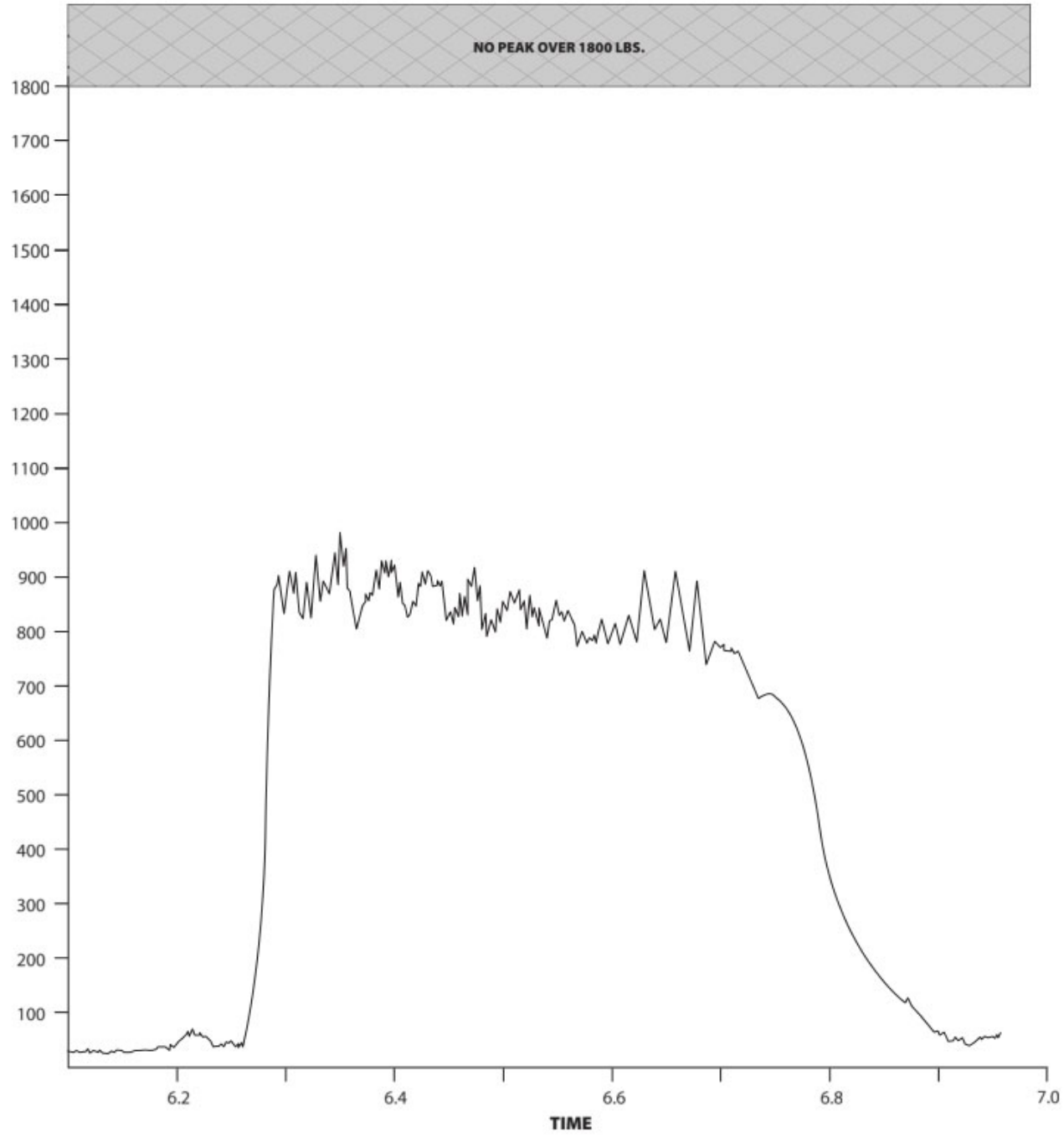


Figure 17c: Example of a 6 ft FF Energy Absorber Graph Not Exceeding 1,800 pounds.

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