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Personal protective equipment for protection against falls from a height — Flexible horizontal lifeline systems

Équipement de protection individuelle contre les chutes de hauteur — Systèmes de ligne de vie horizontale flexible

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16024 was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 4, *Personal equipment for protection against falls*.

Introduction

In cases of work where the hazard of falling from a height exists and where, for technical reasons or for work of a short duration, safe access cannot be provided, it is necessary to consider the use of personal fall protection systems. Such use should never be improvised and its adoption should be specifically provided for in the appropriate formal provisions for safety in the work place.

Flexible horizontal lifeline systems conforming to this International Standard satisfy ergonomic requirements and are only be used if the work allows means of connection to suitable anchor devices of demonstrated strength and can be implemented without compromising the safety of the user. Personnel are to be trained and instructed in the safe use of the equipment and be observant of such training and instructions. The end-user organization is to have a rescue plan and the means at hand to implement it.

This International Standard has been prepared in response to user and industry requirements for an International Standard to cover flexible horizontal lifeline systems. It is based on current knowledge and practice concerning the use of personal fall protection systems and equipment specified in the ISO 10333 series of International Standards and other ISO personal fall protection standards. While this International Standard covers flexible horizontal lifeline systems from anchor connector to anchor connector, it does not cover the anchor or anchors themselves.

This International Standard presumes that the manufacturer of the personal fall protection system, subsystem or components used in a flexible horizontal lifeline system operates a quality management system which conforms to national and regional regulations in force at the time. Guidance on the form that this quality management system may take can be found in ISO 9000.

Personal protective equipment for protection against falls from a height — Flexible horizontal lifeline systems

1 Scope

This International Standard specifies design and performance requirements, test methods, user instructions, marking and labelling as appropriate, of flexible horizontal lifeline systems for use at any one time by up to three persons, exclusively for the attachment of personal protective equipment for protection against falls from a height. It does not stipulate designs for flexible horizontal lifelines, except for design limitations that are necessary for safe and durable service.

This International Standard does not cover rigid rail systems, nor is it intended to cover flexible guardrails, hand lines and work-positioning anchor lines.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9227, *Corrosion test in artificial atmospheres — Salt spray tests*

ISO 10333-1, *Personal fall-arrest systems — Part 1: Full-body harnesses*

ISO 10333-2, *Personal fall-arrest systems — Part 2: Lanyards and energy absorbers*

ISO 10333-3, *Personal fall-arrest systems — Part 3: Self-retracting lifelines*

ISO 10333-4, *Personal fall-arrest systems — Part 4: Vertical rails and vertical lifelines incorporating a sliding-type fall arrester*

ISO 10333-5, *Personal fall-arrest systems — Part 5: Connectors with self-closing and self-locking gates*

ISO 10333-6, *Personal fall-arrest systems — Part 6: Systems performance tests*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
component
integral assembly of interconnected elements (parts) intended to perform one or more functions in the system

NOTE A mobile attachment device is an example of a component.

3.2
configuration
defined layout of a flexible horizontal lifeline system in terms of numbers, arrangements and lengths of spans together with defined requirements for flexible horizontal lifeline materials and strength of end anchors and intermediate anchors

3.4
element
integral part of a constituent, component, hybrid component, subsystem or system, which is generally not sold separately to users (e.g. webbing)

3.5
end anchor
structural member located at each end of the flexible horizontal lifeline

See Figure 1.

NOTE End anchors are outside the scope of this International Standard.

3.6
end anchor connector
component with means specifically for coupling the flexible horizontal lifeline to an end anchor

See Figure 1.

3.7
fall arrest system
assembly of components joined together so that, when connected to a suitable anchor point with sufficient clearance from the ground or other obstacles, it operates as a complete arrangement of equipment able to fulfil its function in use of arresting a fall

3.8
flexible horizontal lifeline system
flexible lifeline supported by two or more anchors such that the slope of a straight line joining any two adjacent anchors does not deviate from the horizontal by more than 15°

3.9
flexible lifeline
line comprising wire rope, fibre rope or webbing

3.10
free fall distance
vertical displacement of the harness fall arrest attachment point between the onset of the fall and at the point just before the system begins to react by applying force to arrest the fall

See Figure 2.

NOTE This distance excludes deceleration distance, but includes any fall arrester activation distance before fall arrest forces occur.

3.11
in-line fittings
fittings incorporated in the line between the flexible horizontal lifeline terminations and anchor connectors

3.12
intermediate anchor
structural member supporting a flexible horizontal lifeline at location(s) other than at its ends

See Figure 1.

3.13
intermediate anchor connector
component with means specifically for coupling the flexible horizontal lifeline to an intermediate anchor

NOTE An intermediate anchor connector guides and supports the flexible horizontal lifeline and does not restrict the longitudinal movement of the line.

3.14
lifeline energy absorber
device connected to a flexible horizontal lifeline to dissipate energy and reduce the forces in the line resulting from a fall arrest

3.15
lifeline termination
fixture at the end of a flexible horizontal lifeline that allows connection to the end anchor or anchor connector

EXAMPLE Splice, ferrule, or swage.

3.16
maximum arrest force
peak force and measured at the full body harness attachment point during a dynamic test

3.17
maximum arrest load
peak force and measured at the end anchor of a flexible horizontal lifeline during a dynamic test

3.18
minimum clearance
minimum distance from the anchor point required to ensure that a user would not strike the ground or obstacle in the event of a fall

See Figure 2.

NOTE This would include total fall distance, the height of the worker and a safety margin.

3.19
mobile attachment device
device, either designed and built or adapted for the purpose, for the connection of personal fall arrest equipment to a flexible horizontal lifeline, and which can slide along the lifeline

NOTE Mobile attachment devices are not generally interchangeable between systems from different manufacturers, or between different models of system from the same manufacturer.

3.20
multi-span flexible horizontal lifeline system
flexible horizontal lifeline system that is supported at points along its length by intermediate anchors and intermediate anchor connectors

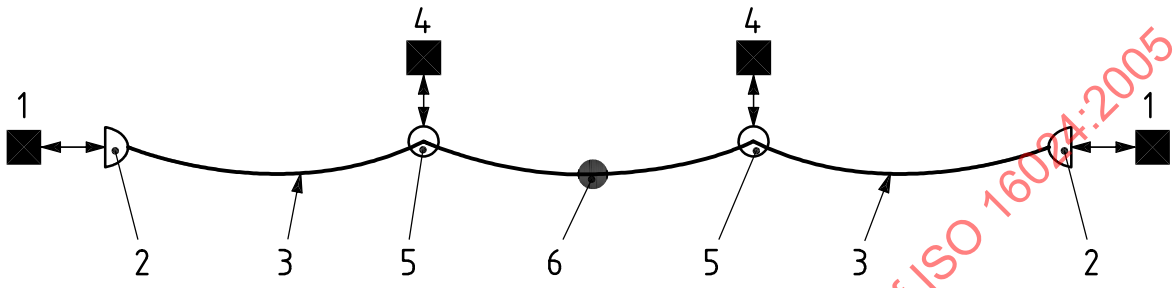
See Figure 1.

3.21
single span flexible horizontal lifeline system
flexible horizontal lifeline system without intermediate anchors

NOTE The system is only supported by the two end anchors.

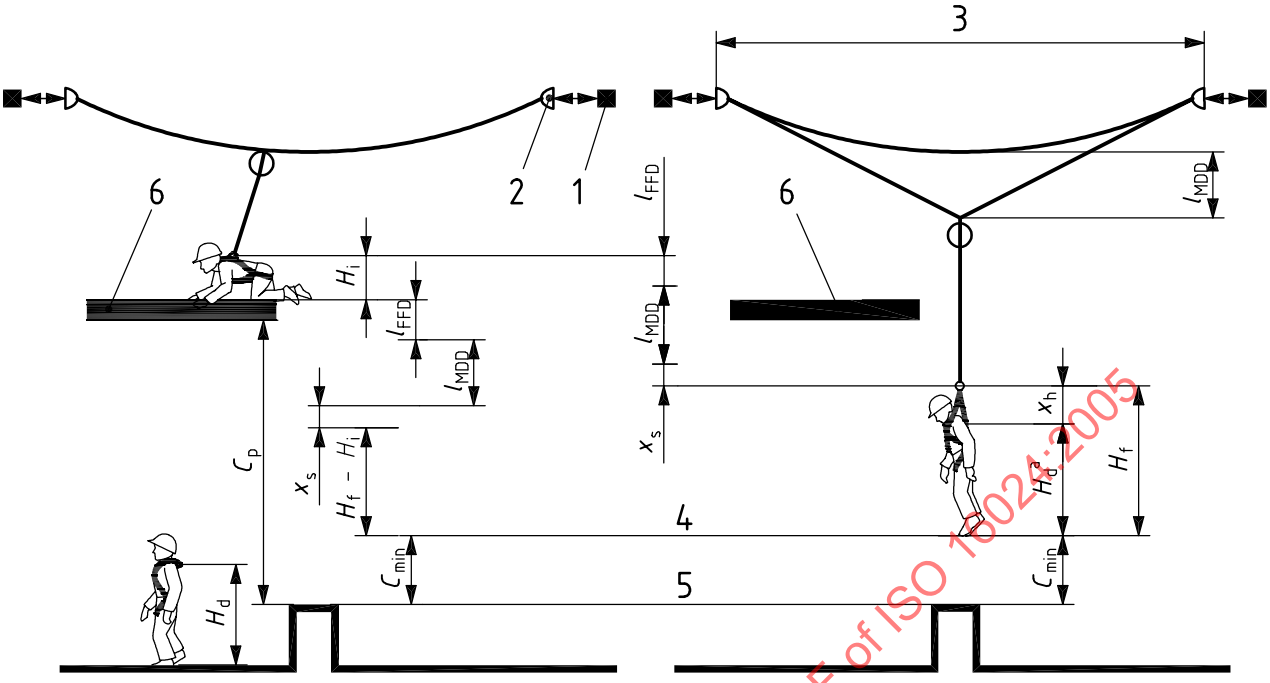
3.22
total fall distance
maximum vertical distance between the person's fall arrest attachment to the flexible horizontal lifeline at the onset of a free fall and after the fall is arrested, including dynamic deflection of the flexible horizontal lifeline, free fall distance and component/s extension, e.g. energy absorber/harness stretch

See Figure 2.



Key
1 end anchor
2 end anchor connector
3 horizontal lifeline
4 intermediate anchor
5 intermediate anchor connector
6 mobile attachment device

Figure 1 — Horizontal lifeline components



a) Before fall **b) After fall**

Key

1	end anchor
2	end anchor connection
3	total span
4	lowest point of fall
5	highest obstacle
6	platform
C_p	required minimum clearance below the platform
C_{min}	minimum post-fall clearance of at least 1 m
l_{FFD}	free-fall distance
H_d	height of D-ring above the platform when the worker is standing
H_f	height of D-ring above the worker's toes at fall arrest
H_i	height of D-ring above the worker's toes at start of fall ($H_i = H_d$ when the worker is standing)
l_{MDD}	maximum deflection distance
x_h	harness stretch
x_s	extension of energy absorber (and/or lanyard stretch)
a	The value of H_d = 1,5 m may be assumed for a user 1,8 m tall.

Figure 2 — Fall and safety distances from platform

4 Design requirements

4.1 General

4.1.1 This International Standard sets criteria for the acceptance of flexible horizontal lifeline systems, whose design, layout and performance is traceable to test results and has been verified by tests over the intended range of installed configurations. If performance calculations are used, those calculations shall be backed up with test data from a similar configuration. All performance of systems shall be verified by traceable test documentation.

When national regulations require different fall arrest forces or loads, such values shall be used for design, testing, instructions and marking. Examples include 8 kN in place of 6 kN, 16 kN in place of 12 kN and 22,2 kN in place of 20 kN.

4.1.2 All personal fall protection equipment used in conjunction with flexible horizontal lifelines shall meet the requirements specified in relevant standards including national and International Standards including ISO 10333 (all parts).

NOTE Some equipment might not function correctly with flexible horizontal lifelines, e.g. some self-retracting lifelines.

4.1.3 All flexible horizontal lifelines shall be capable of functioning at environmental conditions, likely to be encountered at the site of the installations.

NOTE Some components can be subject to low temperature brittle failure. This is especially important for energy absorbers that plastically deformed to dissipate energy.

4.1.4 The system shall limit the maximum arrest force transmitted to the harness attachment point of the user's full body harness to 6 kN (see 4.1.1).

4.1.5 The system shall ensure a minimum post-fall clearance of one metre (1,0 m) between the user and the ground and/or obstacle/structure. See Figure 2.

4.1.6 All predictions of forces and deformations for flexible horizontal lifelines containing energy absorbers shall take into account the additional extension that results from the deployment of that energy absorber. This deployment will affect the minimum clearance.

4.2 Flexible horizontal lifelines

4.2.1 Wire rope lines

The minimum static strength of the finished wire assembly, including terminations, shall be known to be at least twice the maximum arrest load in the line developed from traceable test results for the particular configuration in which it is to be used.

4.2.2 Webbing lines

The minimum static strength of the finished webbing assembly, including terminations, shall be known to be at least three times the maximum arrest load in the line developed from traceable test results for the particular configuration in which it is to be used.

4.2.3 Fibre rope lines

The static strength of the finished fibre rope assembly, including terminations, shall be known to be at least three times the maximum arrest load in the line developed from traceable test results for the particular configuration in which it is to be used. Synthetic rope used as a flexible, horizontal lifeline constituent shall be made of virgin synthetic filament or multifilament synthetic fibres suitable for their intended use. Polypropylene shall not be used.

4.3 Anchor connectors

4.3.1 End anchor connectors

End anchor connectors shall be designed to resist, and to transfer to the end anchor, a minimum force as follows:

a) a force in line with the flexible horizontal lifeline of at least two times the maximum arrest load in the line;

b) a downward force of 12 kN at right angles to the axis of the line and in the direction of the fall arrest.

NOTE 1 This is based on two times the required 6 kN maximum force at the person.

NOTE 2 See 4.1.1.

The forces specified in a) and b) shall be considered as acting independently from one another.

4.3.2 Intermediate anchor connectors

Intermediate anchor connectors and intermediate anchor hardware, e.g. structural anchors or brackets, shall allow the flexible horizontal lifeline to run freely through the aperture and to prevent damage to the flexible horizontal lifeline.

Intermediate anchor connectors shall be designed to resist, and to transfer to the intermediate anchor, a minimum force as follows:

a) a downward force of 12 kN at right angles to the axis of the flexible horizontal lifeline and in the direction of the fall and its arrest;

b) if the flexible horizontal lifeline is diverted through the intermediate anchor connectors at an angle greater than 10°, a force of at least two times the resultant loads produced by the maximum arrest load in the flexible horizontal lifeline.

The forces specified in a) and b) shall be considered as acting independently from one another.

4.4 Mobile attachment devices

Mobile attachment devices shall either be impossible for users to remove from the lifeline or shall be removable only by at least two consecutive deliberate manual actions.

Mobile attachment devices shall be capable of resisting a static force of 20 kN in the direction of intended loading without breaking and without deforming in a manner which permits inadvertent detachment from the lifeline.

NOTE 1 See 4.1.1.

NOTE 2 To resist wear from frequent travelling along the flexible horizontal lifeline, pulleys, snap hooks and karabiners should be selected for both the suitability of the material from which they are made and the thickness of that material. The finish on theses devices should not damage the flexible horizontal lifeline or fittings.

4.5 Lifeline energy absorber

Energy absorbers for flexible horizontal lifelines shall be capable of resisting a static force of at least two times the maximum arrest load, and three times this load if the lifeline energy absorber is non-metallic, developed from traceable test results for the particular configuration, and no less than 12 kN in the direction of intended loading.

5 Performance requirements

5.1 Acceptance criteria

A system is accepted if it meets the following criteria:

a) evidence that the production samples have met the design requirements (Clause 4) as well as the test requirements for both the dynamic performance (5.2) and static residual strength (5.3) tests;

b) tests shall show an adequate schedule of tests to cover manufacturers' recommended set-up configurations;

c) any configuration of the system not tested, lies between two previously tested configurations.

When the material specifications or components of a system are altered in such a way that the change is likely to result in a change in the dynamic performance of the flexible horizontal lifeline system, then the flexible horizontal lifeline system shall be retested.

5.2 Dynamic performance

The horizontal lifeline system shall be tested in accordance with 6.2.2. The results of testing shall agree with the maximum arrest load and total fall distance predicted by the manufacturer's calculations within plus or minus 10 %.

5.3 Static residual strength

After determining which span in accordance with 6.2.2 will develop the greatest peak force at the end anchors (i.e. the maximum arrest load), that span shall be tested in accordance with 6.2.3. The system may deform or yield but shall not release the load.

5.4 Lifeline fittings static strength

All flexible horizontal lifeline fittings shall be tested in accordance with 6.3 (e.g. line terminations, end anchor connectors, in-line fittings, energy absorbers, turnbuckles). The line fittings may deform or yield but shall not release the load. Any deformation of components shall not cause or be capable of causing damage to the flexible horizontal lifeline.

5.5 Intermediate anchor connector strength

When tested in accordance with 6.4, the intermediate anchor connector may deform or yield but shall not release the load.

5.6 Corrosion resistance

When tested in accordance with 6.5, all metallic components shall show no evidence of corrosion of the base metal. Post-test presence of white scale is acceptable.

6 Testing

6.1 Test equipment

6.1.1 Test mass

The test mass shall have a mass of (100 ± 1) kg. For flexible horizontal lifeline systems rated by the manufacturer for more than one user, the test mass shall have a mass of (200 ± 2) kg for 2 users and (300 ± 3) kg for 3 users. All test masses shall be rigidly constructed.

For the static strength test, a method of applying a $(12 \pm 0{,}5)$ kN force is required. Use of an appropriate dead weight is acceptable.

NOTE See 4.1.1.

6.1.2 Quick release mechanism

The test mass or masses shall be released by a quick release mechanism that shall release the test mass or masses without imparting motion to it or them.

6.1.3 Force measurement system

The force measuring system shall be capable of measuring at least twice the expected force with an accuracy of ± 2 % and of withstanding a force of 50 kN without damage, and arranged so that measurements are carried out with a continuously active band up to 100 Hz but with a minimum sampling rate of 1 000 Hz.

6.1.4 Test venue

The test site shall be fitted out to enable each selected test configuration to be set up with adequate support for the expected loads on each end and intermediate anchor and adequate clearance for the falling test masses. The maximum elastic deformation of the test structure at the point of anchor of the tested horizontal lifeline system shall be 1,0 mm for a 20 kN load.

NOTE See 4.1.1.

6.1.5 Sampling

The test program employed to verify that the system meets the requirements of this specification shall include a sufficient number of configuration samples to ensure that the system will perform adequately over the range of span lengths, free fall distances, lanyard lengths, number of spans, directional changes (e.g. corners) and other parametric variations for which the system is recommended by the manufacturer.

NOTE See Annex A for a typical sample test procedure.

6.2 Verification tests

6.2.1 General

Testing shall be performed by an independent test authority to verify the claims made by the manufacturer, such as line loads, fall distance and design factors. A representative series of tests shall be performed within the parameters given by the manufacturer.

6.2.2 Dynamic performance

These tests shall be carried out for each system configuration required in 6.1.5.

Set up the equipment for testing in the manner specified by the manufacturer. Use a number of test masses for each test equal to the maximum number of users permitted for the flexible horizontal lifeline system, up to a maximum of three.

NOTE 1 All flexible horizontal lifeline systems can be tested to this International Standard, up to a maximum of three users. Additional users (i.e. more than three) are not covered by this International Standard.

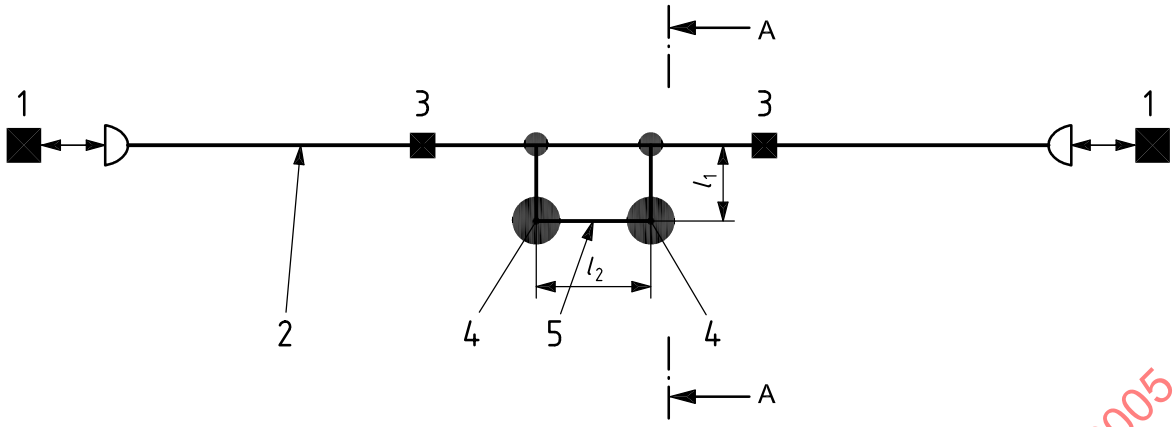
Connect the test mass(es) to the system using the connecting subsystem (e.g. energy-absorbing lanyard) permitted for use with the flexible horizontal lifeline. Each type of connecting subsystem authorized for use with the system shall be evaluated with separate tests. When multiple test masses are to be dropped simultaneously, attach the masses to the flexible horizontal lifeline (see Figure 3) using the same type of connecting subsystem.

NOTE Additional information can be obtained by placing load cells in the connecting subsystem, e.g. energy-absorbing lanyard.

Attachment points to the flexible horizontal lifeline of adjacent connecting subsystem shall have a maximum spacing of 0,5 m. Offset test masses by a maximum horizontal distance of 0,3 m of their corresponding connecting subsystem attachment point to the flexible horizontal lifeline.

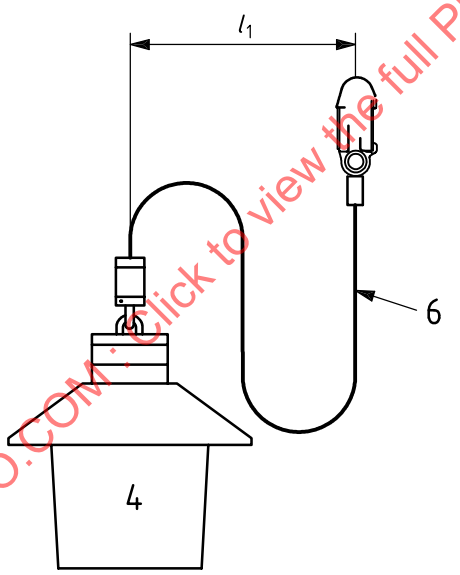
To obtain the maximum arrest load, measure the forces at both end anchors for multi-span tests, and at one anchor for single span tests (if a lifeline energy absorber is used, the single load cell shall be positioned at the end anchor opposite of the energy absorber) and at one test mass.

Measure and record the horizontal lifeline system and test mass positions prior to and during the dynamic performance test, to determine deflection and clearance requirements.



l_1	l_2
⩽ 0,3 m	⩽ 0,5 m

a) Plan view



b) Offset view A-A

Key

1 end anchor
2 horizontal lifeline
3 intermediate anchor
4 test mass (may consist of 100 kg masses rigidly connected)
5 rigid connection
6 connecting subsystem

A minimum mass of 100 kg shall be used. More may be used where needed, see 6.1.1.

NOTE Plan view and offset view A-A are not shown to the same scale.

Figure 3 — Spacing and arrangement of test mass

6.2.3 Static residual strength test

After the dynamic performance test has been carried out, apply a force of (12 ± 0,5) kN vertically downward at the centre of the span ± 0,3 m, adjacent to the end anchor connector for ($2\ ^{+0,5}_{0}$) min.

NOTE This requirement is intended to provide system capacity after a fall event to permit and facilitate rescue operations.

6.3 In-line fitting static strength

Mount the in-line fittings in a test machine. Apply a minimum of two times the maximum arrest load in the same direction as will be applied in service. Hold this force for ($2\ ^{+0,5}_{0}$) min. Repeat the test to include all possible combination of line fittings.

6.4 Intermediate anchor connector strength

Apply a force of (12 ± 0,5) kN:

a) at right angles to the axis of the line;

b) in the direction of intended loading.

Hold each load for ($2\ ^{+0,5}_{0}$) min.

NOTE See 4.1.1.

It is permissible to change components between tests.

6.5 Corrosion

Salt-spray test the metallic components in accordance with ISO 9227, with an initial exposure of ($24\ ^{+0,5}_{0}$) h, followed by ($1\ ^{+0,2}_{0}$) h drying, followed by a second exposure of ($24\ ^{+0,5}_{0}$) h, followed by ($1\ ^{+0,2}_{0}$) h drying.

7 Labelling and instructions

7.1 User's instructions

Clear instructions, in the language of the country where the system is intended for use, for the assembly, installation, use, inspection and maintenance of the system, system components and associated hardware shall be supplied for all the equipment. The following shall be included in the instructions:

a) a method of determining the various configurations in which the flexible horizontal lifeline system may be used (including a means to set and adjust the specified line tension);

b) the required strength of the end anchors and intermediate anchors;

c) any guidelines for the user to select the appropriate personal fall protection equipment for connecting to the system and advice on equipment configurations that are acceptable, as well as those that are not intended to be used together;

d) the maximum number of users of the system and where they have to be positioned on the system (especially important in cases where number of persons on any span varies from the total number of recommended users);

e) a method of determining the fall arrest clearances required under each span (see Figure 2);