
Air cargo — Restraint slings —

**Part 1:
Design and testing**

Fret aérien — Câbles d'arrimage —

Partie 1: Conception et essais

STANDARDSISO.COM : Click to view the full PDF of ISO 20291-1:2021



STANDARDSISO.COM : Click to view the full PDF of ISO 20291-1:2021



COPYRIGHT PROTECTED DOCUMENT

© ISO 2021

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	2
4 Design requirements	6
4.1 General	6
4.2 Construction	6
4.3 Tension retaining device	8
4.4 End fittings	8
4.5 Ultimate load	10
4.6 Elongation	10
4.7 Environment	10
4.8 Operator safety	11
5 Testing	11
5.1 General	11
5.2 Testing apparatus	12
5.3 Sleeves test	12
5.4 Ultimate load and elongation test	12
5.5 Cyclic load test	14
5.6 Test record	15
6 Quality control	15
7 Markings	15
8 Options	16
9 Manufacturer's instructions	17
10 Operating instructions	17
Bibliography	19

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 9, *Air cargo and ground equipment*.

A list of all parts in the ISO 20291 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The aim of this document is to standardize the design and testing requirements for air cargo restraint sling assemblies used as an alternate to restraint straps for tie-down of cargo on board civil transport aircraft.

The civil aviation requirements referred to in this document are those relating to the design of transport aircraft. They constitute the set of design requirements internationally agreed in the application of International Civil Aviation Organization (ICAO) Annex 6, *Airworthiness of aircraft*, to the Convention on International Civil Aviation.

Throughout this document, the minimum essential criteria are identified by use of the key word "shall". Recommended criteria are identified by use of the key word "should" and, while not mandatory, are considered of primary importance in providing safe air cargo restraint sling assemblies. Deviation from the recommended criteria should only occur after careful consideration and thorough service evaluation have shown that alternate methods can be used to provide an equivalent level of safety.

The requirements of this document are expressed in the applicable SI units, with approximate inch-pound units conversion between brackets for convenience in countries using that system.

Sling or cable assemblies made of steel wire rope are intended to be used in lieu of cargo restraint straps meeting the requirements of ISO 16049-1, where straps inherent elongation under tension appears inadvisable for a given tie-down arrangement. Typical examples of loads where substitution of cables for straps throughout a given tie-down arrangement can be advisable are those for which even limited movement during flight can be hazardous, such as heavy vehicles, aircraft engine stands, helicopters, machinery.

On the date of publication of this document, no airworthiness approval procedure by Civil Aviation Authorities is applicable to restraint slings. Their use for cargo restraint, however, remains subject to the requirements of the approved aircraft type or sub-type Weight and Balance Manual (see ISO 20291-2).

[STANDARDSISO.COM](https://standardsiso.com) : Click to view the full PDF of ISO 20291-1:2021

Air cargo — Restraint slings —

Part 1: Design and testing

1 Scope

This document specifies the design criteria and testing methods adequate to guarantee the ultimate strength and operational dependability of cargo restraint sling assemblies made of steel wire rope, with a 22,25 kN (5 000 lbf) rated ultimate load capability, as can be used by the airline industry in order to restrain on board civil transport aircraft during flight, including the following:

- cargo loaded and tied down onto airworthiness approved air cargo pallets, themselves restrained into aircraft lower deck, main deck or upper deck cargo systems and meeting the requirements of ISO 8097 (NAS 3610) or ISO 21100, or
- non-unitized individual pieces of cargo, or pieces of cargo placed onto an unrestrained ("floating") pallet into either lower deck, main deck or upper deck containerized cargo compartments of an aircraft, to be restrained onto aircraft structure attachment (tie-down) points.

Two types of wire rope restraint slings are defined:

- a) type A: adjustable length restraint sling assemblies, including a tension retaining device and termination fittings attached to the wire rope end eyes;
- b) type B: fixed length restraint sling extensions, to be used in conjunction with a type A cable; extensions are usually terminated at both ends by eyes, without additional fittings, and can be attached through hooks or shackles.

The cables specified in this document are intended exclusively for restraint purposes on board aircraft, and not for use as lifting slings.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 2408, *Steel wire ropes — Requirements*

ISO 4117, *Air and air/land cargo pallets — Specification and testing*

ISO 4171, *Air cargo equipment — Interline pallets*

ISO 4346, *Steel wire ropes for general purposes — Lubricants — Basic requirements*

ISO 7166, *Aircraft — Rail and stud configuration for passenger equipment and cargo restraint*

ISO 7531, *Wire rope slings for general purposes — Characteristics and specifications*

ISO 7597, *Forged steel lifting hooks with latch, grade 8*

ISO 8097, *Aircraft — Minimum airworthiness requirements and test conditions for certified air cargo unit load devices*

ISO 8793, *Steel wire ropes — Ferrule-secured eye terminations*

ISO 8794, *Steel wire ropes — Spliced eye terminations for slings*

ISO 9788, *Air cargo — Double stud tie-down fittings — Design and testing requirements*

ISO 10254, *Air cargo and ground equipment — Vocabulary*

ISO 17893, *Steel wire ropes — Vocabulary, designation and classification*

ISO 21100, *Air cargo unit load devices — Performance requirements and test parameters*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10254, ISO 17893 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

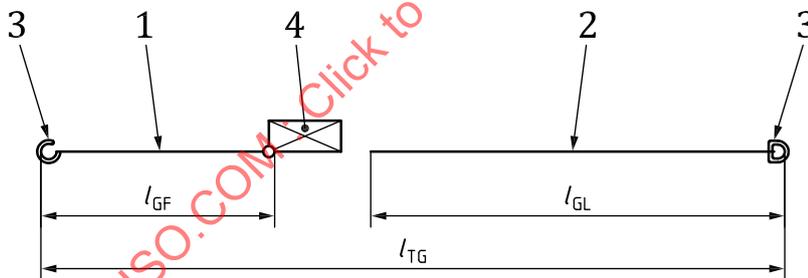
- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 restraint sling assembly type A

elementary *tie-down* (3.3) unit made of steel wire rope cable with *end fittings* (3.6) and *tension retaining device* (3.5), used for restraint of cargo on board civil transport aircraft

Note 1 to entry: It consists of 1 (one) *fixed length* (3.8.1) end and one adjustable end and can be used in conjunction with one or two extensions(s).

Note 2 to entry: See [Figure 1](#).



Key

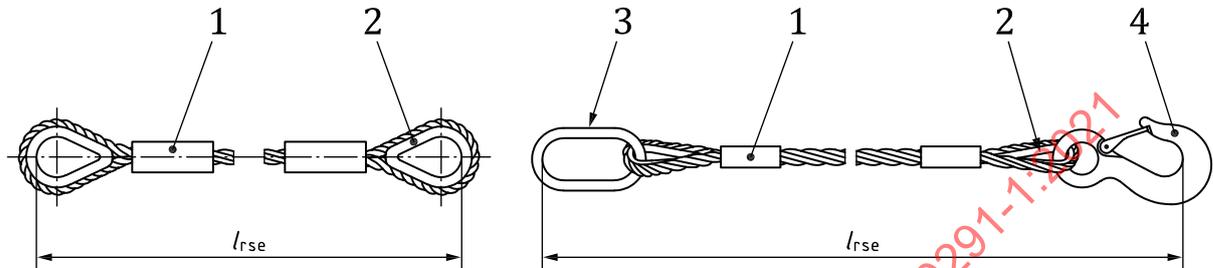
- 1 fixed end
- 2 adjustable end
- 3 end fitting
- 4 tension retaining device
- l_{GF} fixed length
- l_{GL} adjustable length (3.8.2)
- l_{TG} total length (3.8.3)

Figure 1 — Adjustable (type A) restraint sling assembly

3.2 restraint sling extension type B

fixed length (3.8.1) steel wire rope (cable) with end eyes but no *tension retaining device* (3.5), with or without *end fittings* (3.6), used in conjunction with a *restraint sling assembly* (3.1) to extend usable length between attachment points

Note 1 to entry: See [Figure 2](#).



Key

- 1 ferrule
- 2 thimble
- 3 end fitting (ring)
- 4 end fitting (hook)

l_{rse} length of restraint sling extension (3.9)

Figure 2 — Fixed length (type B) restraint sling extensions

3.3 tie-down

fact of restraining cargo movements in relation to an aircraft's structure, throughout the range of relative accelerations resulting from the allowable flight envelope, by means of an appropriate use of a number of elementary devices against each direction of restraint

3.4 tensioning device

mechanical device inducing and maintaining a tensile force in the load restraint assembly

EXAMPLE Lever, ratchet, winch, cam, over-centre device, or equivalent.

3.5 tension retaining device

part connecting to the wire rope and retaining any force induced between the ends of the assembly

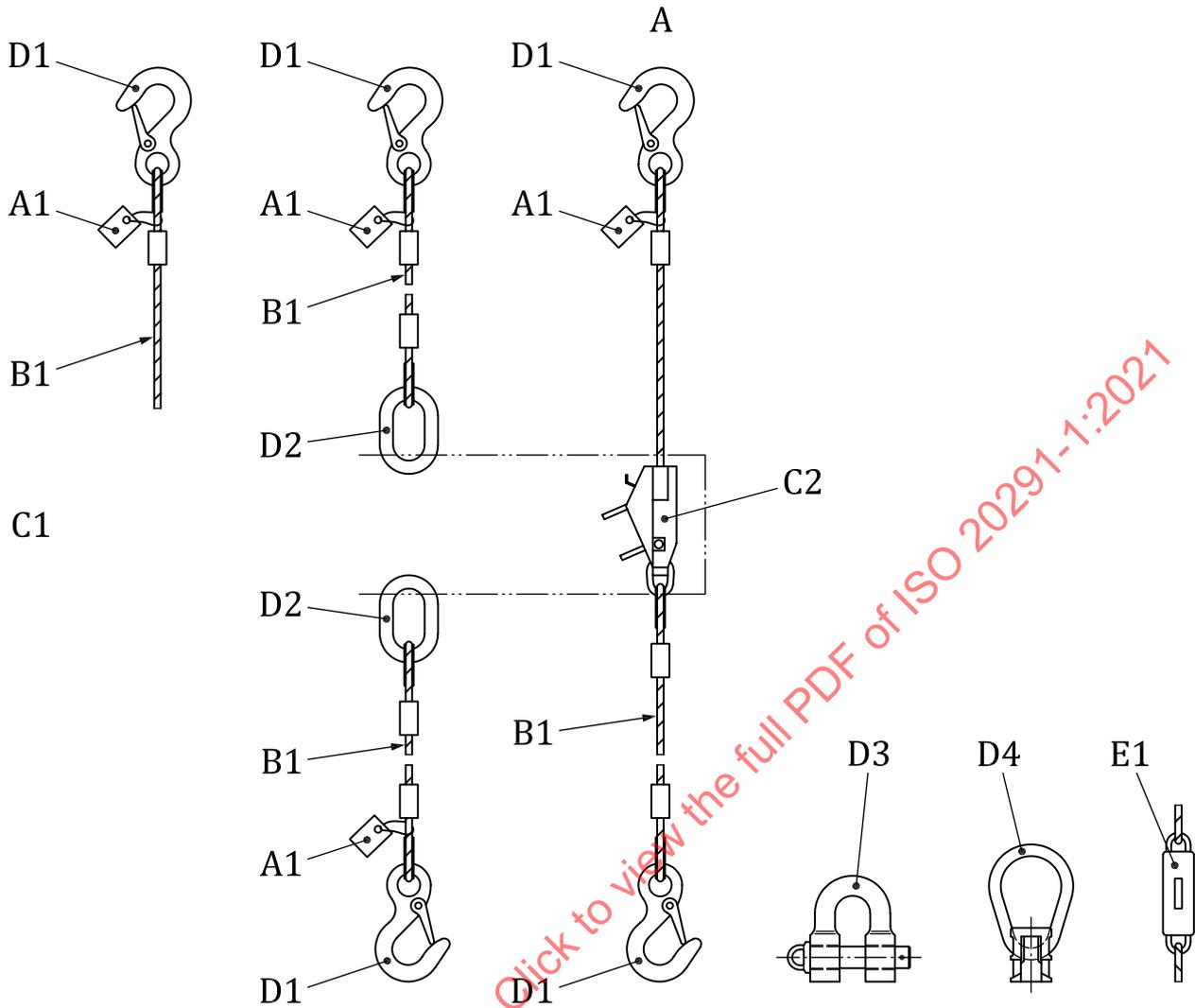
3.6 end fitting connecting component

metallic device connecting a wire rope end to the attachment point on the aircraft structure, the pallet edge track, another restraint element, or the load to be restrained

Note 1 to entry: See examples in [Figure 3](#), D1 to D3.

Note 2 to entry: The end fittings most commonly used on air cargo restraint slings include:

- a) retainer or latch equipped hook (see example in [Figure 3](#), D1),
- b) air cargo *tie-down* (3.3) double stud (male) fitting (see example in [Figure 3](#), D4) conforming to ISO 9788, connected to the cable directly or through an intermediate ring,
- c) ring (see example in [Figure 3](#), D2) or wire rope end loop (eye) compatible with hooks.



Key

- | | |
|----------------------------------------------|-----------------------------------------|
| A restraint sling assembly (complete) | D connecting elements |
| A1 marking (label) | D1 hook with retainer or latch |
| B tension holding element | D2 end ring |
| B1 steel wire rope | D3 shackle with steel pin |
| C tensioning device (3.4) (optional) | D4 double stud tie-down fitting |
| C1 possible tension arrangement | E1 tension force indicator (3.7) |
| C2 example of rope tensioner | D connecting elements |

Figure 3 — Examples of restraint sling equipment

3.7 tension force indicator

device that indicates the tensile force applied to the *restraint sling assembly* (3.1)

Note 1 to entry: See example in [Figure 3](#), C.

3.8 length of restraint sling assembly

3.8.1 fixed length

l_{GF}

length of a fixed end, measured from the force bearing point of the *end fitting* (3.6) to the outer turning radius of the connection of the wire rope to the *tension retaining device* (3.5)

Note 1 to entry: See [Figure 1](#).

Note 2 to entry: This length can be zero, i.e., the end fitting directly attached to the *tensioning device* (3.4).

3.8.2 adjustable length

l_{GL}

maximum length of an adjustable end, measured from the tension device to the force bearing point of the *end fitting* (3.6)

Note 1 to entry: See [Figure 1](#).

3.8.3 total length

l_{TG}

sum of *fixed length* (3.8.1), *adjustable length* (3.8.2) and length of the *tension retaining device* (3.5)

3.9 length of restraint sling extension

l_{rse}

length measured between the force bearing points of each terminal, whether thimbles, hooks or rings

Note 1 to entry: See [Figure 2](#).

3.10 breaking force

BF

maximum force that the *restraint sling assembly* (3.1) withstands when tested in a complete form, i.e. with *tension retaining device* (3.5) and *end fittings* (3.6)

3.11 hand force

HF

force applied to adjust latch, or unlatch the *restraint sling assembly* (3.1)

3.12 limit load

LL

maximum load to be expected in service

Note 1 to entry: See CAAC CCAR-25, CS-25, JAS Part 3 or 14 CFR Part 25, § 25,301 (a).

Note 2 to entry: It is two thirds of *ultimate load* (3.13), i.e. 14,8 kN (3 333 lbf) for a rated ultimate load of 22,2 kN (5 000 lbf).

3.13 ultimate load

UL

limit load (3.12) multiplied by a safety factor of 1,5

Note 1 to entry: See CAAC CCAR-25, CS-25, JAS Part 3 or 14 CFR Part 25, § 25,303.

Note 2 to entry: It is used for computation of cargo *tie-down* (3.3) arrangements, based on the ultimate load factors defined in the aircraft Weight and Balance Manual in each direction of restraint, throughout the certified flight envelope of the aircraft type. The *restraint sling assembly's* (3.1) rated ultimate load must not exceed the measured *breaking force* (BF) (3.10).

3.14

residual tension

tension force which can be measured in the rope of a cable assembly attached between two fixed points, after its length was adjusted and it was operated and latched with the reference *hand force (HF)* (3.11), prior to application of any external load

3.15

competent person

designated person, suitably trained, qualified by knowledge and practical experience and with the necessary instructions to enable the required tests and examinations to be carried out

Note 1 to entry: A competent person can be suitably trained in accordance with ISO 9001:2015, 7.2.

4 Design requirements

4.1 General

4.1.1 Unless otherwise specified, the design requirements hereafter equally apply to type A and type B restraint slings as defined in [Clause 1](#).

4.1.2 This document specifies the design criteria for individual restraint sling assemblies but does not intend to specify the way they are to be used aboard aircraft to ensure proper restraint throughout the certified flight envelope. It is presupposed that tie-down arrangements meet all the applicable requirements of the Weight and Balance Manual for the aircraft type or sub-type concerned, particularly as regards, but not necessarily limited to, ultimate load factors to be taken into account to determine the number of cables to be used in each direction of restraint, maximum angles to be observed with the direction of restraint, minimum spacing and ultimate load capacity of attachment points, etc.

4.1.3 When restraint sling assemblies are attached to the edge rails of a certified air cargo pallet meeting the requirements of ISO 8097 (NAS 3610) or ISO 21100 (AS 36100), operating instructions should duly take into account the restraint net attachment point locations on the pallet edge rail and other requirements defined by the appropriate ISO 8097 (NAS 3610) or ISO 21100 (AS 36100) configuration drawing(s).

4.1.4 Subject to proper operating instructions per [4.1.2](#) and [4.1.3](#) being defined and complied with, using restraint sling assemblies manufactured to an adequate design and a tested ultimate load capability is nevertheless deemed necessary in order to ensure flight safety. General utilization guidelines and calculation methods adequate to guarantee the effectiveness and ultimate load strength of the tie-down arrangements performed with cables to restrain cargo on board civil transport aircraft can be found in ISO 20291-2.

4.1.5 The restraint sling assembly shall be designed to be used on and compatible with:

- a) the edge rails of air cargo pallets meeting the requirements of ISO 4117 or ISO 4171, airworthiness approved according to ISO 8097 (NAS 3610, TSO C90c) or ISO 21100 (AS36100, TSO C90d), or
 - b) aircraft floor tracks or structural attachment points meeting the requirements of ISO 7166,
- either directly or using ISO 9788 double stud tie-down fittings as intermediate attachment hardware.

4.2 Construction

4.2.1 Wire rope shall meet the requirements of ISO 2408, should be of ISO 2408:2017, Annex C class 6x7-FC or 6x7-IWRC, grade 1 960 N/mm², 6 mm (0.25 in) diameter, of minimum breaking force 23,4 kN or 25,3 kN, and should be galvanized (zinc-coated) or stainless steel, of a construction appropriate to guarantee the required breaking force while keeping maximum flexibility.

NOTE Using steel grade 1 770 N/mm² usually results in a lower breaking force.

4.2.2 In exception from ISO 7531, justified by airworthiness standards (e.g. CAAC CCAR-25, CS-25, JAS Part 3 or 14 CFR Part 25, § 25,303) applicable aboard aircraft, the minimum breaking force of the new unfinished wire rope shall be the rated ultimate load (UL) of the complete restraint sling assembly (see 4.5).

4.2.3 All wire rope end eyes shall be secured with stainless steel crimped ferrules or swaging sleeves in accordance with ISO 8793 (see Figure 2). Cable grips, clips or clamps, or splicing per ISO 8794 shall not be used. The minimum length of plain rope between the inside ends of ferrules terminating a same wire rope shall be 20 times the nominal rope diameter.

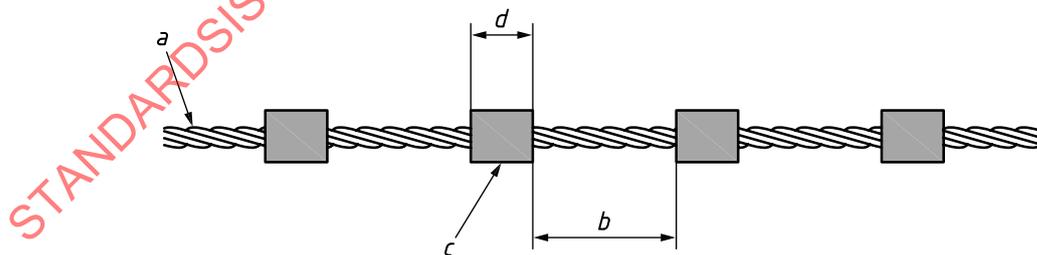
4.2.4 All wire rope end eyes shall be protected against direct contact of attached fittings with rope by a thimble appropriate to the wire rope's diameter, preferably made of galvanized or stainless steel or aluminium alloy, or otherwise protected against corrosion. Soft or spliced loops are not allowed.

4.2.5 Where a wire rope end has no eye loop, e.g. at a free end of the adjustable end of a type A cable, it shall be fitted with a stainless steel crimped ferrule stop in order to avoid its disengagement and strands unwinding.

4.2.6 Optionally, all (for type B fixed length extensions) or part (the fixed end of type A adjustable length cables) of the wire rope may be enclosed in protective semi-soft, e.g. polyamide, PVC or similar, non-load bearing tubing in order to protect it, the hands of the operators, and any piece of cargo an extension can be passed around. If provided, such tubing shall be:

- transparent in order to allow visual cable inspection and verification that it is not broken nor unduly bent, and
- rigid enough to ensure that the minimum bending radius the wire cable can withstand (see wire rope manufacturer's information) is exceeded around a piece of cargo up to at least the cable's breaking force.

4.2.7 In order to allow length adjustment, the wire rope of the adjustable end (l_{GL}) of type A cables shall be fitted with stainless steel ferrules (sleeves) at regular intervals to allow catching by the load retaining device, capable of withstanding the tension loads sustained during flight. See Figure 4 for the dimensions required.



Key

- a* \varnothing 6 mm (0.25 in)
- b* spacing 25 mm to 38 mm (1 in to 1.5 in)
- c* $\geq \varnothing$ 12,7 mm (0.5 in)
- d* $\geq \varnothing$ 8 mm (0.3 125 in)

Figure 4 — Type A restraint sling adjustable end sleeves

4.2.8 The load bearing ferrules (sleeves) shall meet the applicable requirements of ISO 8397. In addition, each sleeve should be attached to the wire rope in such a manner as to be capable of

withstanding in either direction at least 1,25 times the nominal ultimate load of the cable assembly. See [5.3](#) for verification testing.

4.3 Tension retaining device

4.3.1 Type A adjustable restraint sling assemblies shall include a tension retaining device at the free end, opposite to the end fitting, of the fixed length (l_{GF}) not bearing sleeves.

They do not require a tensioning device capable of inducing a wire rope pre-tension. This may nevertheless be provided as an option (see 8.6), subject to meeting the device elongation requirements (see [4.6](#)).

The type of tension retaining and, if provided, tensioning devices of type A adjustable length restraint sling assemblies is to be selected on agreement between the manufacturer and the purchaser.

4.3.2 The tension retaining device shall be equipped with means to catch a cable sleeve (see [Figure 4](#)) in such a way that the sleeve and adjacent wire rope are fully enclosed. In addition, a positive, self-engaging, locking system in the closed position shall be provided in order to prevent any risk of self or inadvertent release whether or not the wire rope is under tension. The design shall provide an immediate visual indication whether this lock is in the open or closed position. Consideration should be given to the geometry of catching or locking parts filling any remaining gap in the spacing between 2 adjacent sleeves whether this lock is in the open or closed position.

4.3.3 It shall be possible to latch and unlatch the tension retaining device with a hand force (HF) not exceeding 100 N (22 lbf), regardless of any tension remaining in the cable.

Disengagement of the locking system shall be possible only by a deliberate hand action, without the use of tool(s), regardless of the cable's residual tension.

4.3.4 The thickness of the tension retaining device when in its latched position, including the handle in its stored position, shall be kept to a minimum consistent with its design principle, and should preferably not exceed 38 mm (1.5 in).

4.3.5 Tension retaining devices shall present no sharp edges which may come into contact with the steel wire ropes or the operator's hands.

4.3.6 The recoil travel of the end of the handle of the tension retaining device under residual tension shall not exceed 150 mm (6.0 in) when opening the device. The design should aim at minimizing the spring effect creating a hazard to the operator (see [4.8.2](#)).

4.3.7 Positive means shall be provided to prevent the adjustable wire rope length from getting free from the tension retaining device at maximum length (see [4.2.5](#)).

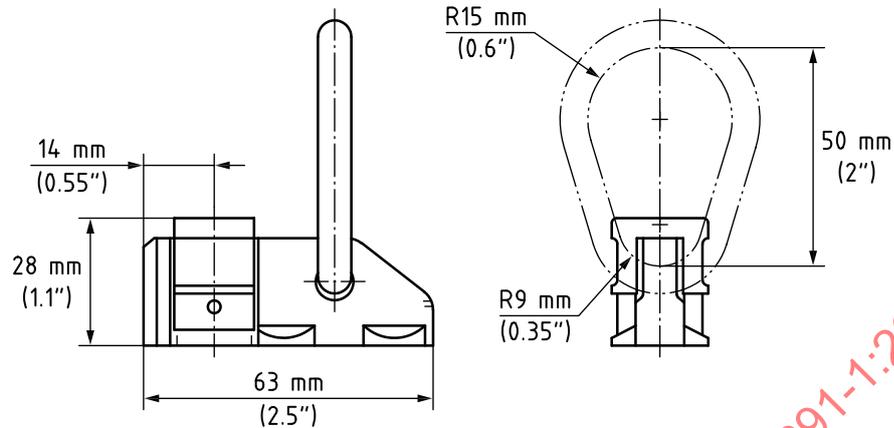
4.3.8 All devices shall be designed so that there are no crushing or shearing points which might lead to the hands of the operator being injured during intended use.

4.3.9 No lubricant should be necessary for proper operation of type A restraint slings length adjustment. If a lubricant is nevertheless deemed necessary for the tension retaining device, it shall be permanent and meet the requirements of ISO 4346.

4.4 End fittings

4.4.1 Type A adjustable length restraint sling assemblies shall be equipped at each end with a fitting (connecting component), which may be, for example, a hook with retainer or latch (see example in

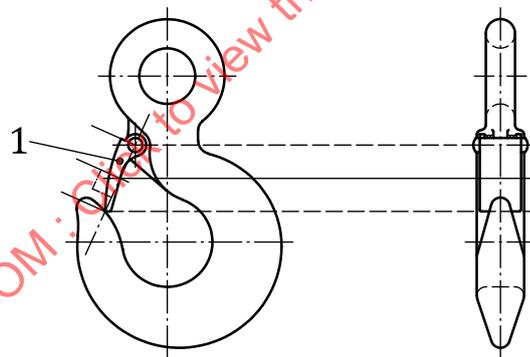
Figure 3, D1 and Figure 6), a shackle or clevis (see example in Figure 3, D3), or a double stud aircraft tie-down fitting (see example in Figure 5), with or without a ring.



NOTE Dimensions for indication only. See ISO 9788 for track interface geometry.

Figure 5 — Example of ISO 9788 double stud tie-down fitting with ring

4.4.2 Hooks shall meet the requirements of ISO 7597 forged grade 8, form E (eye type), size code 4 or 5 such as to meet or exceed the rated ultimate tensile load (UL) per 4.5. See Figure 6, 4.4.6 and 4.4.7. Wire or cast or stamped flat hooks are acceptable alternatives, providing they meet the same performance requirements and are equipped with a retainer (latch).



Key

1 retainer (latch)

Figure 6 — Example of ISO 7597 cable hook

4.4.3 Double stud tie-down fittings shall meet the requirements of ISO 9788.

4.4.4 Type B fixed length restraint sling extensions to be used in conjunction with type A can have end rings (see example in Figure 3, D2) or hooks (see example in Figure 3, D1), or, alternately, they can have no end fittings permanently attached to their end eyes, providing the size of the eyes is sufficient to accommodate type A cables hooks or shackle interface (see Figure 3, D3).

4.4.5 Separate rings (see example in Figure 3, D2) may also be used to connect two cables terminated with hooks, under the requirement that such rings were tested and accordingly identified by a markings data plate (see Clause 7 and Figure 3, A1).

4.4.6 The thickness of end fittings shall be kept to a minimum consistent with their type, in order to minimize the risk of interference with aircraft cargo systems or an adjacent pallet during handling. A maximum thickness of 19 mm (0.75 in) should be considered, based on consistency with intermediate double stud tie-down fittings.

4.4.7 All hooks, regardless of their type, shall be equipped with a retainer or latch (see 1 in [Figure 6](#)) preventing any risk of self or inadvertent disengagement whether or not under tension. Disengagement of the retainer or latch shall be possible only by a deliberate hand action, without the use of tool(s). It shall be possible to disengage the retainer or latch only after full tension release on the restraint sling assembly.

4.4.8 Wire hooks, rings, or equivalent shall be welded in order to prevent any risk of self-opening under load. No open junctions are allowed.

4.4.9 Two different end fittings may, at the purchaser's option, be provided on one same end of the assembly, in order to increase attachment flexibility. In this case, testing per [5.4](#) shall be performed twice, using each of the fittings as the attachment point.

4.5 Ultimate load

4.5.1 The breaking force (BF) of the restraint sling assembly, when tested in accordance with [5.3](#) and [5.4](#), shall guarantee a rated ultimate tensile load (UL) to be specified at purchasing as well as through operating instructions.

4.5.2 The rated ultimate load (UL) of the restraint sling assembly shall be 22 250 N (5 000 lbf). This is compatible with the best omni-directional performance obtainable from civil transport aircraft structural attachment points, air cargo pallets track, and appropriate intermediary hardware.

4.5.3 In accordance with CAAC CCAR-25, CS-25, JAS Part 3 and 14 CFR Part 25 § 25,303, the ultimate load (UL) is 1,5 times the limit load (LL), which is the maximum load to be expected in service during flight.

4.6 Elongation

4.6.1 The total elongation of the type A or type B restraint sling under load, i.e. the sum of wire rope elongation, wire rope twist, and any longitudinal deformation of the hardware (tensioning, if provided, or tension retaining device or end fitting), shall be at least 1,5 % when submitted to the rated ultimate load (UL) and 1 % when submitted to the rated limit load (LL), and should not exceed, respectively, 3 % and 2 % under the same tension loads.

4.6.2 Elongation is to be measured between the force bearing points of the end fittings, starting at the zero-tension load condition with the tension retaining device closed and latched, but before actuation of an optional tensioning device if provided.

4.6.3 Since device elasticity/elongation can be a factor of tie-down calculations and acceptability on a given aircraft structural attachment point, elongation shall be measured by testing (see [5.3](#)), and a report of the data obtained be handed over to the purchaser as part of manufacturer's information (see [9.2](#)).

4.7 Environment

4.7.1 All components of restraint sling assemblies, including wire rope, shall be protected against corrosion by material selection or, where not feasible, appropriate and durable coating, e.g. galvanization or equivalent coating.

4.7.2 For environmental assessment, it should be assumed that the restraint sling assemblies will be operated throughout temperature ranges of -40 °C (-40 °F) to 60 °C (140 °F) with relative humidity between 20 % and 85 %, including ice, snow, and occasional soaking in water.

4.8 Operator safety

4.8.1 The tension retaining device, tensioning device if provided, and the end fittings shall be designed to be handled by a gloved hand.

4.8.2 The tension retaining device, tensioning device if provided, and the end fittings shall be designed so as to prevent any risk of pinching, crushing or shearing which might result in the operator's hands being injured.

4.8.3 Particular attention should be paid to preventing the risk of a spring effect when releasing the tension retaining device handle to the open position under load.

5 Testing

5.1 General

5.1.1 The following tests shall be conducted by a competent person in order to ensure the integrity and function of the restraint sling assembly are maintained throughout the rated load range during flight. Equivalent alternative methods (see ISO 3108, or EN 12195-4) may be used, providing that the details of the method provide equivalent in-flight guarantees and be duly recorded together with the test results.

5.1.2 The objective of the tests is to measure the performance of the complete restraint sling assembly under load. The rated ultimate load (UL) shall not exceed the lowest breaking force (BF) recorded at testing.

5.1.3 Additional tests for measuring the performance of the isolated wire rope are optional, if the rope was procured with a breaking strength certificate delivered by its manufacturer under a third-party certified ISO 9001:2015 or equivalent quality control program. The new unfinished wire rope's breaking strength shall be higher than the rated ultimate load (UL) of the complete restraint sling assembly (see [4.2.1](#)).

5.1.4 For restraint sling type testing, at least two test specimens randomly selected from the same production batch shall be tested in accordance with [5.3](#) (sleeves test), two others in accordance with [5.4](#) (load and elongation test cyclic test), and two others in accordance with [5.5](#) (load and elongation test), and the test results recorded for each specimen. A third specimen shall be tested in each case in the event of the results showing significant discrepancies between both tested specimens.

5.1.5 In addition, for production testing of restraint slings the type of which was already approved, at least one specimen shall be tested out of every 1 000 pieces. If the manufacturer operates under a third-party certified quality system according to ISO 9001:2015 or equivalent, this test frequency may be increased to at most one every 3 000 pieces.

5.1.6 The tested specimen shall include all of its connecting components (fittings), either permanently attached to it or, if applicable, separate (e.g., when separate connection rings are intended to be used in conjunction with the restraint sling). Any variant using different connecting components (fittings) shall be separately tested.

5.2 Testing apparatus

5.2.1 Install the complete wire rope restraint sling assembly with its connecting components and tension retaining device in a certified and calibrated tensile testing machine with a load measuring accuracy of 1 % or better, and a load capacity at least 25 % higher than the restraint sling assembly's rated ultimate load. The testing machine shall be equipped with corresponding clamping devices (see [5.2.4](#)).

5.2.2 The test apparatus shall be selected in order to test a complete restraint sling assembly, including end fittings and all appurtenances, with a minimum length of l_{GF} plus length of the tension retaining device plus l_{GL} of 0,5 m (20 in). Where two end fittings exist at a same end of the assembly, separate tests shall be conducted with each fitting.

5.2.3 Ensure that the machine is equipped with a load measurement and recording system (calibrated chart, dial, scale), such that the load exerted at rupture of the specimen (BF) shall remain indicated after the rupture.

5.2.4 Ensure that the machine is equipped prior to the test with pulling attachments (clamps) compatible with the tested restraint sling assembly's end fitting (connecting component) types:

- a) for hook type end fittings, use 8 mm (0.3125 in) maximum diameter steel wire (based on typical rings of air cargo tie-down fittings);
- b) for double stud (male) fitting type, use a segment of steel track conforming to ISO 7166. The arrangement shall be such that the track can be oriented 90°, then 45°, then 0° to the direction of pulling (see [5.4.10](#)).

5.3 Sleeves test

5.3.1 In order to substantiate that each sleeve used on type A restraint slings will not fail before cable rupture, a separate test shall be conducted on two previously untested specimens selected at random.

5.3.2 Install the complete type A wire rope restraint sling assembly with its connecting components and tension retaining device, adjusted to a minimum length in accordance with [5.2.2](#), in the testing machine. Start continuously applying tension at the fastest increase rate allowed by the machine, with no interruptions.

5.3.3 At device rupture, note the breaking force (BF) exerted, and identify the breaking elements: these shall be the wire rope strands. The load holding sleeve (see [4.2.7](#)) and eye ferrules (see [4.2.3](#)) shall not have slipped on the wire rope nor broken away.

5.3.4 Repeat the test for the other specimen. Record the results. Should they exhibit significant differences, proceed with testing a third specimen (see [5.1.4](#)).

5.4 Ultimate load and elongation test

5.4.1 Step 1: action the tension retaining device till no slack exists and latch it, then adjust the total length of the restraint sling assembly using the testing machine's clamps up to the last point where the testing machine measures no tension. Measure the total length at that point with an accuracy of ± 1 mm (0.04 in) to allow later elongation measurements.

5.4.2 Step 2: start applying tension and observe the cable and its tension retaining device during pull.

5.4.3 Step 3: progressively increase tension up to the intended limit load (LL). This load is to be held for at least 1 min. All load-bearing parts of the complete restraint sling assembly shall show no evidence

of failure, nor deformation that affects their function. Measure the total length at that point to determine elongation.

5.4.4 Step 4: Increase tension up to 1,25 times the intended limit load (LL). This load is to be held for 1 min. All load-bearing parts of the complete restraint sling assembly shall show no evidence of failure, nor deformation that affects their function. Measure the total length at that point to further determine elongation.

5.4.5 Step 5: For the evaluation of the product, it is recommended to subsequently unload the wire rope restraint sling assembly and to carry out functional tests. After the release of the force in [5.4.4](#), inspect the components for permanent deformation:

- a) all load bearing parts of the cable shall show no evidence of deformation that affects the function;
- b) the tension retaining device and all components with moving parts shall fully retain their function;
- c) no deformation of the thimbles shall occur;
- d) the wire rope shall not have started to slip within the eye ferrules or sleeves.

The actual breaking force may then be determined (steps 6 and 7).

5.4.6 Step 6: After the complete wire rope restraint sling assembly has been inspected, resume loading up to the intended rated ultimate load (UL), and hold for a minimum of 3 s. Observe the condition of the complete restraint sling assembly:

- a) permanent deformation of parts is allowable, unless it results in disengagement;
- b) notwithstanding partial damage, it is presupposed that the restraint sling assembly keeps the tension load fully for at least 3 s in accordance with CAAC CCAR-25, CS-25, JAS Part 3 and 14 CFR Part 25 § 25,305;
- c) no slippage shall have taken place between the wire rope and any eye ferrule or sleeve.

Measure the total length to determine ultimate load elongation.

5.4.7 Step 7: Increase tension to rupture of the restraint sling assembly. Record the measured breaking force (BF) and the part(s) of the assembly which failed.

5.4.8 Testing is deemed successful if device rupture occurred at a load (BF) higher than the intended rated ultimate load (UL), and any damage observed under the limit load then rated ultimate load did not exceed the allowances in [5.4.5](#) and [5.4.6](#).

5.4.9 Repeat the test for the other specimen. Record the results. Should they exhibit significant differences, proceed with testing a third specimen (see [5.1.4](#)). Should one of the specimens fail, i.e. exhibit a breaking force (BF) lower than the intended rated ultimate load (UL), then:

- a) either the batch of restraint sling assemblies shall be rejected, or
- b) it shall be de-rated, if acceptable to the purchaser, to an ultimate load (UL) lower than the lowest recorded breaking force.

5.4.10 If the tested restraint sling assembly includes double stud fitting type end fittings, the test procedure from [5.4.1](#) through [5.4.7](#) shall be repeated 3 times, reorienting the segment of steel track in accordance with [5.2.4](#) b):

- a) with the tension load normal (90 °) to the track surface;
- b) with the tension load 45 ° to the track surface;

c) with the tension load parallel (0 °) to the track surface.

Testing in this case will therefore require 6 specimens. Alternately, only the 90 ° load test may be performed, providing the model of double stud fitting used was separately tested at 45 ° and 0 ° angles under the same ultimate load. Test results assessment shall be as per [5.4.8](#).

5.4.11 The lowest force at which the wire rope failed (BF) shall be recorded to be used as the basis for confirming the ultimate load (UL) rating of the cable: see [4.5](#). If the sleeve used for tension retaining fails before the wire rope, the restraint sling assembly type shall be rejected and subject to appropriate redesign.

5.4.12 The length measurements in accordance with [5.4.1](#), [5.4.3](#), [5.4.4](#) and [5.4.6](#) shall be used to verify the restraint sling assembly type meets the minimum and maximum elongation objectives in [4.6.1](#) and report the elongation data obtained to the purchaser as part of manufacturer's information (see [9.2](#)).

5.5 Cyclic load test

5.5.1 A cyclic load test shall be performed to simulate the recurrent load cycles resulting from movements of the aircraft during flight (e.g. gust loads).

5.5.2 The test apparatus (see [5.2](#)) is to apply to the complete restraint sling assembly a tension load varying between zero (slack condition) and 0,4 times the limit load (LL), and release it. This constitutes one cycle.

5.5.3 The restraint sling assembly specimen shall be:

- a) installed on the testing apparatus,
- b) adjusted in length in accordance with [5.3.1](#), prior to actuation and latching of the tensioning device if provided,

and the total length at that point measured with an accuracy of ± 1 mm (0.04 in) to allow elongation measurement.

5.5.4 The assembly shall then be submitted to a minimum of 100 cycles as defined in [5.4.2](#) at a frequency of $(1,2 \pm 0,2)$ Hz, ending at the same absence of tension as measured at the beginning of the test (see [5.3.1](#)).

5.5.5 After the test, the restraint sling assembly shall be removed from the test apparatus and inspected for defects. There shall be no permanent deformation or abnormal wear on components, including the tension sleeves. There shall be no evidence of broken or otherwise weakened wire rope strand. The un-tensioned overall cable assembly's length, measured between the force bearing points of the end fittings with an accuracy to the nearest integer millimetre, shall not have increased by more than 1 % of the length submitted to the test.

5.5.6 Repeat the test for the other specimen. Record the results. Should one of the test specimens fail (see [5.4.5](#)), then the type or batch of restraint sling assemblies shall be rejected and subject to appropriate redesign.

5.5.7 The length measurements in accordance with [5.4.1](#), [5.4.3](#), [5.4.4](#) and [5.4.6](#) shall be used to verify the restraint sling assembly type keeps meeting the minimum and maximum elongation objectives in [4.6.1](#) and report the elongation data obtained to the purchaser as part of manufacturer's information (see [9.2](#)).

5.6 Test record

5.6.1 The manufacturer shall maintain and hand over to the purchaser on request a restraint sling assembly test record file mentioning the model part number, components identification and origin, production batch, as well as location, date and results of the various tests.

5.6.2 The test results to be mentioned shall include:

- a) positive results of all sleeves tests (see [5.3.2](#) and [5.3.3](#));
- b) ultimate load test steps 1 through 7 (see [5.4.1](#) through [5.4.7](#)) for at least the two specimens required (6 in the event of testing at 90 °/45 °/0 ° for double stud end fittings, see [5.4.10](#)).

In this case, if only 90 ° testing was performed, a separate test report of the isolated fitting's ultimate load test at 45 ° and 0 ° angles shall be attached).

- c) cyclic load test (see [5.5](#)) for at least the two test specimens required;
- d) elongation measurements (see [5.4.1](#), [5.4.3](#), [5.4.4](#) and [5.4.6](#)).

6 Quality control

6.1 Industry's experience demonstrates the essential character of continuous quality control in obtaining safe and dependable restraint sling assemblies: seemingly minor changes in design, materials, components or fabrication processes have been known to considerably affect final product quality and performance.

6.2 The parties (manufacturer and purchaser) shall contractually agree on a continuous (testing and production) quality assurance system acceptable to the overseeing airworthiness authority. Whenever the manufacturer operates under a third-party accredited system, the test sampling rates recommended in [6.3](#) above may vary but should provide at least the same level of confidence.

6.3 In view of the possibility of such a minor change having been overlooked, detailed visual inspection and sample tests (first article inspection) shall take place prior to delivery and entry into service of each production batch of ordered restraint sling assemblies.

6.4 When production testing is required by the purchaser subsequent to original type approval, the recommended minimum sampling rate for ultimate load and cyclic testing is one specimen every 1 000 pieces. If the manufacturer operates under a third party certified quality system according to ISO 9001:2015 or equivalent, this sampling rate may be increased to one every 3 000 pieces.

7 Markings

7.1 Each type A restraint sling assembly or type B cable extension conforming to this document shall bear at least the following markings:

- "ISO 20291-1";
- if applicable, date and reference of any authority approval;
- rated ultimate load in daN (lbf);
- manufacturer or supplier's name and address or identifiable logo;
- assembly designation (part number).

The indication "ISO 20291-1" shall be deemed to mean, under the manufacturer's or supplier's responsibility, that the unit complies with the mandatory requirements of this document for the stated rated ultimate load and meets at least in an equivalent manner its recommended criteria.

7.2 The markings shall be preferably engraved, if not stencilled or otherwise printed in an indelible manner, in characters at least 3 mm (0.125 in) high, and 5 mm (0.2 in) for the ultimate load, onto a metal tag with minimum dimensions of 38 mm × 25 mm (1.5 in × 1 in) attached to each item concerned (see positioning example in [Figure 3](#), A1, and layout example in [Figure 7](#)).

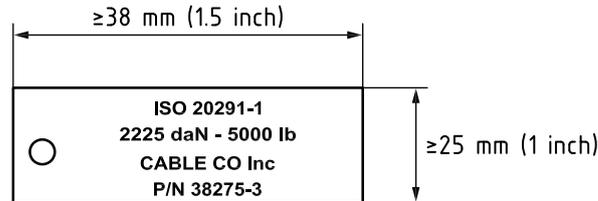


Figure 7 — Typical markings tag

7.3 Double stud tie-down fittings with an omni-directional rated load capacity of 22 250 N (5 000 lbf), if used as an integral part of the restraint sling assembly, shall be marked in accordance with ISO 9788.

8 Options

8.1 The following features are optional, to be considered for specification by the purchaser:

- types of hardware (tension retaining device and end fittings);
- length of the fixed and, for type A restraint sling assemblies, adjustable wire rope lengths;
- protective tubing (see [4.2.6](#));
- colour identification or customized marking.

8.2 Tension force indicator:

When a tension force indicator is fitted, the values shall be easily readable, paying due attention to avoiding the risk of confusion between SI and inch-pound units in the countries where the latter are used. For mechanical systems, the minimum movement of the indicator shall be 10 mm per 10 kN, with a tolerance of $\pm 15\%$, within a temperature range of $-40\text{ }^{\circ}\text{C}$ ($-40\text{ }^{\circ}\text{F}$) to $60\text{ }^{\circ}\text{C}$ ($140\text{ }^{\circ}\text{F}$). If the tension force indicator fails, the design shall ensure that the load capability of the restraint sling assembly is not affected.

8.3 Tensioning device (see [4.3.1](#)):

If an optional tensioning device is provided, it shall aim at maximizing friction coefficients in order to obtain self-blocking capability and eliminate any risk of slippage of the wire rope against the device once latched, including when the rope was soaked in water, or when submitted in flight to repeated slack (zero load)/tight cycles.

If some initial slippage is unavoidable during pretension (i.e. while the tensioning device is being actuated and latched):

- it shall not exceed 0,5 % of the maximum total length of the complete restraint sling assembly, when submitted to the residual tension force resulting from latching the device handle, lever or equivalent in the closed position (see [4.6.2](#)), and
- it shall maintain the minimum tensioning length on the rope when the device is being actuated, and