INTERNATIONAL STANDARD

ISO 16049-1

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Air cargo equipment — Restraint straps —

Part 1: Design criteria and testing methods

Équipement pour le fret aérien — Sangles d'arrimage —

Partie 1: Critères de conception et méthodes d'essai

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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 3.

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 part of ISO 16049 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 16049-1 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 9, *Air cargo and ground equipment*.

ISO 16049 consists of the following parts, under the general title *Air cargo equipment — Restraint straps*:

— *Part 1: Design criteria and testing methods*

— *Part 2: Utilization guidelines and lashing calculations*

Air cargo equipment — Restraint straps —

Part 1:
Design criteria and testing methods

1 Scope

1.1 This part of ISO 16049 specifies the design criteria and testing methods applicable to air cargo restraint straps to be used for tie-down of unitized or non-unitized cargo on board civil transport aircraft. It aims at identifying the design criteria and testing methods adequate to guarantee the ultimate load and operational dependability of cargo restraint strap assemblies with a typical 22 250 N (5 000 lbf) rated ultimate tension load capability, as used by the airline industry in order to restrain, on board civil transport aircraft during flight:

— cargo loaded and tied down on to airworthiness certified air cargo pallets, themselves restrained into aircraft lower deck or main deck cargo systems meeting the requirements of ISO 8097 (NAS 3610), or

— non-unitized individual pieces of cargo, or pieces of cargo placed on to an unrestrained (“floating”) pallet into either lower deck or main deck containerized cargo compartments of an aircraft.

1.2 The same restraint strap assemblies can also be used in other applications such as:

— non-containerized (bulk loaded) baggage and cargo compartments,

— to ensure cargo restraint inside an airworthiness certified air cargo container.

NOTE The ultimate loads permissible on the attachment points available in most aircraft bulk compartments and inside most air cargo containers are significantly lower than 22 250 N (5 000 lbf). This results in the restraint arrangements ultimate load capability being dictated by the weakest element, i.e. the attachment points. Typical 22 250 N ultimate load restraint straps will therefore be in excess of the requirements for such applications.

1.3 This part of ISO 16049 describes the design criteria for individual restraint strap assemblies, but does not intend specifying in any manner the way they are to be used aboard aircraft to ensure proper restraint throughout the certified flight envelope. It is important that tie-down arrangements meet all the applicable requirements of the Airworthiness Authorities approved 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 straps to be used in each direction of restraint, maximum angles to be observed with the direction of restraint, minimum spacing of attachment points, etc.

1.4 When restraint strap assemblies are attached to the edge rails of a certified air cargo pallet meeting the requirements of ISO 8097, 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 configuration drawing(s).

1.5 The use of reliable and guaranteed restraint strap assemblies does not alone ensure flight safety: it also requires straps to be used and tie-down to be performed in accordance with operating instructions established by the aircraft manufacturer, by competent, suitably trained, personnel as defined in 4.18 of ISO 9002:1994.

1.6 Subject to proper operating instructions in accordance with 1.3 and 1.4, using unit restraint strap assemblies manufactured to an adequate design and a tested ultimate load capability is nevertheless deemed necessary in order to ensure flight safety. Although restraint straps are not formally subject to airworthiness certification, they serve an equivalent purpose and must be designed, fabricated, tested and used with equivalent precautions: this part of ISO 16049 is intended to allow manufacturer's self-certification under an approved ISO 9000 series, or equivalent, quality control programme.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 16049. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 16049 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1833:1977, *Textiles — Binary fibre mixtures — Quantitative chemical analysis*.

ISO 2076:1999, *Textiles — Man-made fibres — Generic names*.

ISO 4117:1993, *Air and air/land cargo pallets — Specification and testing*.

ISO 4171:1993, *Air cargo equipment — Interline pallets*.

ISO 7166:1985, *Aircraft — Rail and stud configuration for passenger equipment and cargo restraint*.

ISO 8097:—[1)], *Aircraft — Minimum airworthiness requirements and test conditions for certified air cargo unit load devices*.

ISO/TR 8647:1990, *Environmental degradation of textiles used in air cargo restraint equipment*.

ISO 9788:1990, *Air cargo equipment — Cast components of double stud fitting assembly with a load capacity of 22 250 N (5 000 lbf), for aircraft cargo restraint*.

ISO 12118:1995, *Air cargo equipment — Identification of double-stud tie-down fittings having an omnidirectional rated load capacity of 22 250 N (5 000 lbf) or above*.

ISO 16049-2:—[2)], *Air cargo equipment — Restraint straps — Part 2: Utilization guidelines and lashing calculations*.

Federal Aviation Regulations (FAR) and Joint Airworthiness Regulations (JAR) Parts 25, *Airworthiness Standards: transport category airplanes*.[3)]

3 Terms and definitions

For the purposes of this part of ISO 16049, the following terms and definitions apply.

3.1
restraint strap assembly
elementary tie-down unit consisting of flat woven textile webbing (one fixed length end and one adjustable end), one tensioning device and two end fittings, used for restraint of cargo on board civil transport aircraft

3.2
tie-down
fact of restraining cargo movements in relation to an aircraft's structure, throughout the range of relative accelerations resulting from the permissible flight envelope, by means of an appropriate use of a number of elementary tie-down devices against each direction of restraint

1) To be published. (Revision of ISO 8097:1995)

2) To be published.

3) FAR Part 25 constitutes the USA Government transport aircraft airworthiness regulations and can be obtained from US Government Printing Office, Mail Stop SSOP, Washington DC, 20402-9328, USA. JAR Part 25 constitutes the European Governments transport aircraft airworthiness regulations and can be obtained from JAA Headquarters, Saturnusstraat 8-10, P.O. Box 3000, NL 2130 KA Hoofddorp, Netherlands.

3.3
flat woven textile webbing
conventional or shuttleless woven narrow fabric made of continuous textile fibres, generally with multiple plies, the prime function of which is load bearing.

NOTE A characteristic of webbing is its tight woven fabric selvedge.

3.4
tensioning device
mechanical device inducing a tensile force in the load restraint assembly, e.g. ratchets, winches, overcentre buckles

See Figure 1, C1 to C6.

3.5
tension retaining device
metallic part connecting the webbing by clamping action and retaining the force induced in the tensioning device by hand, e.g. cambuckles, sliding bar buckles

3.6
end fitting
metallic device connecting the webbing or the tensioning device to the attachment point on the aircraft structure, the pallet edge rail or the load

See Figure 1, D1 to D6.

NOTE The end fittings most commonly used on air cargo restraint straps include:

— retainer equipped flat hook (see example in Figure 1, D1),

— air cargo tie-down double stud (male) fitting conforming to ISO 9788 and ISO 12118, connected directly (sewn on to the webbing, see example in Figure 1, D3) or by an intermediate ring,

— piece of aircraft restraint (female) rail conforming to ISO 7166.

3.7
tension force indicator
optional device that indicates the tensile force applied to the restraint strap assembly by means of the tensioning device and movement of the load acting on the load restraint device

3.8 Length of restraint strap assembly

3.8.1
fixed end length
l_{GF}
length measured from the force bearing point of the end fitting to the outer turning radius of the connection of the webbing to the tensioning device

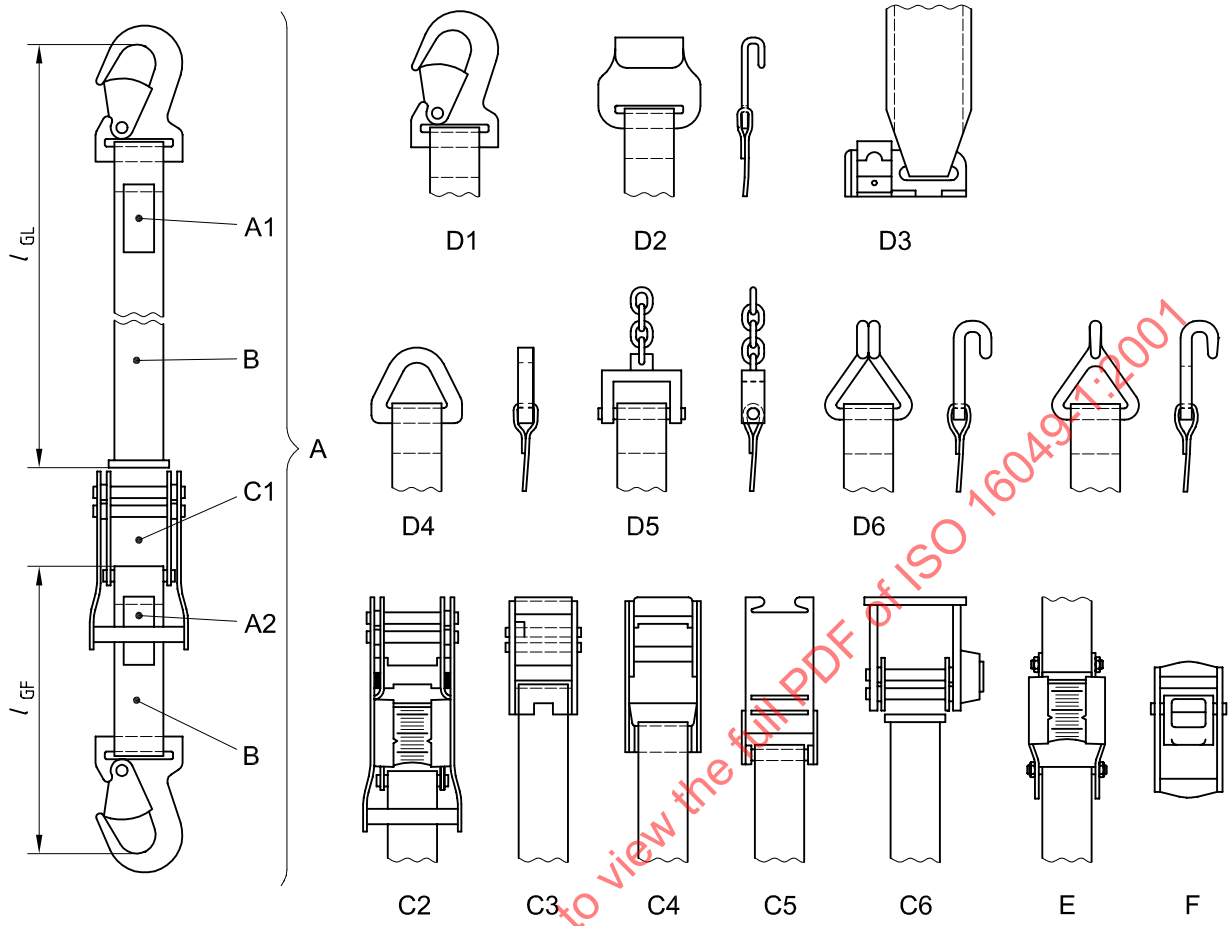
See Figure 2.

NOTE This length may be nil, i.e. the end fitting directly attached to the tensioning device.

3.8.2
adjustable end length
l_{GL}
length measured from the free end of the webbing to the force bearing point of the end fitting

See Figure 2.

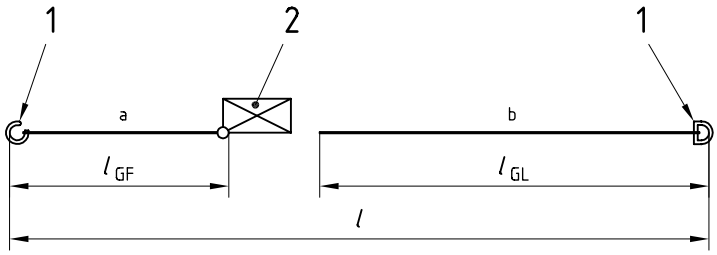
3.8.3
total length
l
(l_{GF}) + (l_{GL}) + length of the tensioning device



Key

A	Restraint strap assembly (complete)
A1, A2	Space for marking (label)
B	Webbing
Tensioning devices:	
C1	Ratchet tensioner
C2	Ratchet tensioner with tension force indicator (see also E)
C3	Sliding bar buckle
C4, C5	Overcentre buckles
C6	Lashing winch
End fittings:	
D1	Snap hook, flat, swivel or twisted, with retainer
D2	Flat hook, with retainer
D3	Double stud tie-down fitting (directly sewn on to webbing)
D4	Triangle, designed to engage with an anchorage
D5	Connector to chain
D6	Wire claw hook (single or double)
E	Tension force indicator (see also C2)
F	Tension retaining device (cambuckle, sliding bar buckle)

Figure 1 — Examples of restraint strap equipment, including tensioning devices, end fittings and tension force indicator



Key

1 End fitting

2 Tensioning device or tension retaining device

[a] Fixed end

[b] Adjustable end

Figure 2 — Two-piece restraint strap assembly

3.9
breaking force
F_B
maximum force that the restraint strap assembly withstands when tested according to 5.5 in a complete form, i.e. with tensioning device and end fittings

3.10
hand force
F_H
force applied to the handle of the tensioning device, which creates the tensile force in the restraint strap assembly

3.11
limit load
L_L
maximum load to be expected in service

NOTE FAR/JAR Part 25, paragraph 25.301 (a) shows this to be two thirds of the ultimate load (3.12), i.e. 14 827 N (3 333 lbf) for a typical rated ultimate load of 22 250 N (5 000 lbf).

3.12
ultimate load
L_U
the limit load multiplied by a safety factor of 1,5

NOTE FAR/JAR Part 25, paragraph 25.303 shows that the restraint strap assembly's rated ultimate load is guaranteed not to exceed the measured breaking force (F_B). It shall be used for computation of cargo tie-down arrangements, based on the ultimate load factors defined in the Airworthiness Authorities approved Weight and Balance Manual, in each direction of restraint, throughout the certified flight envelope of the aircraft type.

3.13
residual tension
tension force which can be measured in the webbing of a strap assembly attached between two fixed points, after its length has been adjusted and its tension device operated and latched with the reference hand force (F_H), prior to application of any external load

3.14
competent person
designated person, suitably trained according to 4.18 of ISO 9002:1994, qualified by knowledge and practical experience and with the necessary instructions to enable the required tests and examinations to be carried out

3.15
traceability code
series of letters and/or numbers marked on a component or an assembly that enables its manufacturing and in-service history to be retraced, including webbing production batch identification

4 Design criteria

4.1 Compatibility

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

a) the edge rails of air cargo pallets meeting the requirements of ISO 4117 or ISO 4171 (airworthiness certified according to ISO 8097/NAS 3610);

b) aircraft seat tracks or structural attachment points meeting the requirements of ISO 7166;

either directly, or using intermediate attachment hardware such as double stud tie-down fittings.

4.2 Ultimate load

The breaking force (F_B) of the restraint strap assembly, when tested in accordance with 5.5, shall guarantee a rated minimum ultimate tensile load to be specified at purchase as well as through operating instructions.

The rated minimum ultimate load most commonly specified in the airline industry is 22 250 N (5 000 lbf). This is compatible with the best omnidirectional performance obtainable from structural attachment points and intermediary hardware. In the interest of overall economy and world-wide standardization, users are encouraged to use this value.

4.3 Elongation

4.3.1 Care shall be taken in selecting the materials and design most appropriate to minimizing the restraint strap assembly elongation under load, in order to improve its restraint capability.

4.3.2 The total elongation of the complete restraint strap assembly under load, as measured between the force bearing point of the end fittings, i.e. the sum of webbing elongation and any longitudinal deformation of the hardware (tensioning device or end fitting), shall not exceed 10 % when submitted to the rated ultimate load (L_U).

4.3.3 Webbing slippage through the tensioning device (see 4.7.5) is permissible only during pretension (i.e. while the tensioning device is being actuated and latched), and if:

a) it does not exceed 0,5 % of the maximum total length of the complete restraint strap assembly, when submitted to the residual tension force resulting from release of the tensioning device handle in the closed position, and

b) it no longer occurs under any load between zero and the rated ultimate load (L_U), after the tensioning device handle has been latched.

4.3.4 The total elongation when submitted to intermediate loads shall not exceed the linear relationship between the maximum values stated in 4.3.2 and 4.3.3. (see Figure 3).

4.4 Inflammability

4.4.1 The webbing, as used in the restraint strap assembly, i.e. including sewing and any treatment, shall meet the inflammability test criteria of FAR/JAR Part 25 Appendix F, Part I, paragraph (a)(1)(v): it may not have a burn rate greater than 100 mm min^{-1} (4 in min^{-1}) when tested horizontally with the apparatus and test procedures required in Appendix F, Part I, paragraph (b)(5).

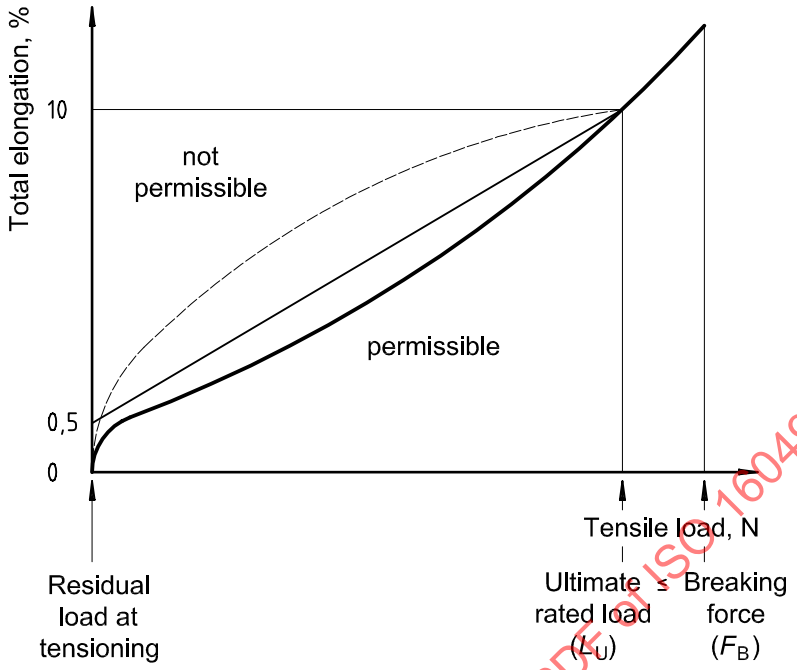


Figure 3 — Linear relationship between elongation and tensile load

4.4.2 The inflammability test shall be performed on a minimum of three specimens, and the average of the results calculated. The results shall be recorded in a test report to be provided to the purchaser at or before time of delivery of each production batch.

4.5 Environmental degradation

4.5.1 The available data concerning degradation of woven textile fibre performance when exposed to environment factors, as provided in ISO/TR 8647, shall be taken into account for webbing and thread selection and treatment, commensurate with the expected storage and service life of the restraint strap assembly.

4.5.2 An expiry date after which the rated performance may not be expected to be maintained should be provided to the purchaser at or before the time of delivery of each production batch, and should be marked on each strap as part of the required traceability code (see 7.2). The expiry date may take into account the expected storage duration, providing the strap assemblies are delivered and stored in an ultraviolet protective packaging, and any storage condition requirements that may affect performance degradation are specified.

4.5.3 For environmental degradation assessment, it should be assumed that the restraint strap 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.

4.5.4 In addition, the strap assembly components and materials should be selected in order to allow separate recycling of the metallic and webbing parts when the unit is out of use or after its expiry date. Instructions for recycling should be provided.

4.6 Dimensions

4.6.1 **Length**: the length of the fixed end (l_{GF}) and the adjustable end (l_{GL}) shall be specified by the purchaser.

NOTE The length of the fixed end (l_{GF}) may be zero (end fitting attached directly to the tensioning device, or forming an integral part thereof). However, the use of such restraint strap assemblies is not recommended on air-land pallets meeting the requirements of ISO 4117, when equipped with vertical mounted edge rail tie-down slots, due to the risk of interference with aircraft restraint systems or an adjacent pallet during handling.

4.6.2 **Width**: the nominal width of the webbing, measured between the outer faces of selvedges, should preferably be 51 mm ± 1 mm (2 in ± 0,04 in) for a strap with a 22 250 N (5 000 lbf) ultimate load rating. Width between 38 mm (1,5 in) and 63 mm (2,5 in) is acceptable for the same load rating.

4.7 Tensioning device

4.7.1 The type of tensioning or tension retaining device shall be selected on agreement between the manufacturer and the purchaser. The types most commonly used in the air cargo industry are:

a) continuous tension devices (ratchet buckles); or

b) “flat” one-stroke tension devices (overcentre, sliding bar buckles).

Unless otherwise mentioned, the design criteria hereafter apply regardless of the type of device concerned.

4.7.2 The thickness of the device when in its latched position shall be kept to a minimum consistent with its design principle. The following recommended maximum thicknesses should be considered:

a) 50 mm (2 in) for ratchet buckles;

b) 40 mm (1,6 in) for one-stroke devices.

4.7.3 The loose end of the adjustable webbing shall be protected against fraying, and positive means shall be provided to prevent it from getting free from the tension device at maximum length.

4.7.4 Tensioning devices of the “flat” one stroke types should provide, when actuated, a minimum 50 mm (2 in) tensioning length on the webbing.

4.7.5 Tensioning device design shall aim at maximizing friction coefficients in order to obtain self-blocking capability and eliminate any risk of slippage of the webbing against the device once latched, including when the webbing has been 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):

a) it shall not exceed 0,5 % of the maximum total length of the complete restraint strap assembly, when submitted to the residual tension force resulting from latching the device handle in the closed position (see 4.3.4, elongation), and

b) it shall maintain the minimum tensioning length on the webbing when the device is being actuated, in accordance with 4.7.4, and

c) no measurable slippage is permissible under any load between zero and the rated ultimate load (L_U), after the tensionning device handle has been latched. This also applies to the length adjustment device on the adjustable length of the restraint strap assembly.

4.7.6 The tensioning device shall be equipped with a positive, self-engaging, locking system in the closed/tensioned position in order to prevent any risk of self or inadvertent release whether or not under tension.

The design shall provide an immediate visual indication as to whether this lock is in the open or closed position.

Disengagement of the locking system shall be possible only by a deliberate hand action, without the use of tools, up to a strap tension of at least 20 % of the rated ultimate load, without an uncontrollable spring effect creating a hazard to the operator.

4.7.7 The tensioning device shall be designed so that the locking system can be engaged and a residual tension of at least 4 % and at most 10 % of the rated ultimate load can be obtained with a reference hand force (F_H) not exceeding 500 N (112 lbf) exerted on to the handle.

4.7.8 The tensioning device shall be designed so that, in the absence of any tension, it is possible by intentional action only to continuously slide the adjustable end of the webbing through it in order to lengthen or shorten the restraint strap assembly's total length [see 4.7.5 c) above in the absence of positive action].

4.8 End fittings

4.8.1 The type(s) of end fittings, which may be different at each end of the restraint strap assembly, shall be selected on agreement between the manufacturer and the purchaser. See the note to 3.6 as regards the types most commonly used.

Unless otherwise mentioned, the design criteria hereafter apply regardless of the type of fitting concerned.

4.8.2 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.

4.8.3 Flat hooks shall be equipped with a retainer preventing any risk of self or inadvertent disengagement whether or not under tension.

Disengagement of the retainer shall be possible only by a deliberate hand action, without the use of tools. It may be possible to disengage the retainer only after full tension release on the restraint strap assembly.

4.8.4 Wire hooks, D rings, or equivalent shall be duly welded in order to prevent any risk of self-opening under load.

4.8.5 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 in accordance with 5.5 shall be performed twice, using each of the fittings as the attachment point.

4.9 Webbing and sewing

4.9.1 The materials and any treatment such as heat stabilization, flame resistance, dye, anti-abrasion, stiffening, etc. used for webbing and threads shall be identified in the manufacturer's documentation for each restraint strap assembly model, together with a summary of the tested characteristics of the yarn and the woven product.

NOTE Materials most commonly used in the air cargo industry include high tenacity continuous multifilament fibres made of:

— polyamide (PA)

— polyester (PES)

— polypropylene (PP)

See ISO 2076:1999 for material definition. If necessary, the contents of the constituent materials may be determined by chemical analysis in accordance with ISO 1833.

4.9.2 All seams shall be made from thread of which the Young modulus does not exceed that of the webbing and shall be made with a locking stitch. Cross-stitching or equivalent shall be used for webbing seams likely to incur all or part of the tension load.

NOTE The sewing thread may be of a different colour from that of the webbing, in order to facilitate visual inspection.

4.9.3 Consideration should be given to anti abrasion treatment of the webbing, commensurate with the expected service life of the restraint strap assembly. See 5.8 for abrasion testing.

4.10 General

4.10.1 All parts or inner or outer edges of the tensioning device and the end fittings that can come into contact with the webbing under load shall be suitably rounded in order to prevent the risk of cutting. A minimum radius of 3,2 mm (0,125 in) for unmoving parts (in relation to the webbing) or 6,4 mm (0,25 in) for moving parts (in relation to which the webbing can slide) should be considered.

4.10.2 All metal parts shall be coated. Consideration should be given to anti-corrosion treatment, commensurate with the expected storage and service life of the restraint strap assembly.

4.10.3 There shall be no sharp edges, corners or protrusions that may come into contact with the webbing or the operator's hands. All such items shall be suitably chamfered.

4.10.4 The tensioning device, tension retaining device if any, 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. Particular attention should be paid to preventing the risk of a spring effect when releasing the tensioning device handle to the open position under load.

5 Testing methods

5.1 General

5.1.1 The following tests shall be conducted in order to ensure that the integrity and function of the restraint strap assembly are maintained throughout the rated load range. Equivalent alternative methods (see the Bibliography) may be used providing that the details of the method used 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 strap assembly under load. Additional tests for measuring the performance of the isolated webbing are optional.

5.1.3 Three test specimens randomly selected from the same production batch shall be used for each test, and the test results recorded for each specimen. The rated ultimate load (L_U) shall not exceed the lowest recorded breaking force (F_B).

5.2 Testing apparatus

5.2.1 Use 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 strap assembly's rated ultimate load.

NOTE Testing a complete restraint strap assembly, even with its length adjusted to a minimum on the adjustable end, requires more distance between the machine's pulling clamps than is usually the case for purely textile webbing tests. Preference should be given to a machine providing a usable length between clamps of at least l_{GF} + length of the tensioning device + 0,5 m (20 in). See 3.8.

5.2.2 Ensure that the machine is equipped with a load recording system (calibrated chart, dial, scale) such that the load exerted at rupture of the specimen, F_B remains indicated after the rupture.

5.2.3 In order to provide comparable results, the pulling clamps should have a uniform speed of (75 ± 25) mm min^{-1} [(3 ± 1) in min^{-1}] per metre of the total length of the specimen being tested.

5.2.4 Prior to the test ensure that the machine is equipped with pulling attachments compatible with the tested restraint strap assembly's end fitting types:

a) for hook type end fittings, use 8 mm (0,3 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°, 45° or 0° to the direction of pulling.

c) for fittings consisting of a piece of aircraft restraint (female) track, use two steel studs conforming to ISO 9788, located at 25,4 mm (1 in) centres parallel to the direction of pulling.

5.3 Load test

5.3.1 **Step 1**: adjust the total length of the restraint strap assembly till no slack exists, action the tensioning device and latch it with an approximate reference hand force of 500 N (112 lbf) at the handle. Record the residual tension force in the strap assembly after latching the handle.

5.3.2 Step 2: start applying tension and observe the tensioning device to determine if slippage of the webbing occurs. If this is the case:

a) if slippage is measurable at any tension load on at least two of the tested specimens, the restraint strap assembly is inadequate and must be rejected;

b) if slippage is measurable at any tension load on only one of the tested specimens (possibly defective), eliminate this one and substitute it with a new one;

5.3.3 Step 3: Increase tension to the rated limit load (L_L) and hold for at least 3 s. Observe the condition of the complete restraint strap assembly.

No permanent deformation of metallic parts and no sewing rupture are permissible.

5.3.4 Step 4: Increase tension to the rated ultimate load (L_L) and hold for at least 3 s. Observe the condition of the complete restraint strap assembly.

Permanent deformation of metallic parts is permissible, unless it results in disengagement. Partial seam rupture is permissible, unless it results in more than 25 % of a given seam becoming loose.

Notwithstanding permissible partial damage, the restraint strap assembly shall keep the tension load fully for at least 3 s.

5.3.5 Step 5: Increase tension until rupture of the restraint strap assembly. Record the measured breaking force (F_B) and the part(s) of the assembly which failed.

5.3.6 Testing is deemed successful if rupture occurs at a load higher than the rated ultimate load (L_U), and any damage observed under the ultimate load does not exceed the allowances in 5.5.4.

5.3.7 Repeat the test for the two other specimens. Record the results. Should one of the specimens fail, i.e. exhibit a breaking force (F_B) lower than the rated ultimate load (L_U), then:

a) either the batch of restraint strap assemblies shall be rejected or

b) it shall be derated, if acceptable to the purchaser, to an ultimate load (L_U) lower than the lowest recorded breaking force.

5.3.8 If the tested restraint strap assembly includes double stud fitting type end fittings, the test procedure specified in 5.3.1 to 5.3.7 shall be repeated three 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 shall therefore require nine specimens. Alternatively, 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. Appreciation of test results shall be in accordance with 5.3.7.

5.4 Elongation test

5.4.1 The elongation test shall be performed on the same specimens simultaneously with the load test.

5.4.2 After step 1, two markers shall be taken on the specimen's webbing, as far apart from each other as possible, one on each side of the tensioning device. Neither mark shall be closer than 38 mm (1,5 in) from an end fitting. The distance (L_1) between marks shall be measured to an accuracy of ± 1 mm (± 0,04 in) or better.

Apply step 2.

5.4.3 Apply step 3; Measure the new distance (L_3) between marks. ($L_3 - L_1$) provides a measurement of the elongation (i.e. sum of elastic deformation), or the actual displacement to be expected in operation.

5.4.4 Apply step 4. Measure the new distance (L_4) between marks.

5.4.5 The measured elongation (E) at step n, expressed in percentage, is provided by the equation:

$$E_n = \frac{(L_n - L_1) \times 100}{L_1}$$

5.4.6 Repeat the test for the two other specimens. Record the results. Average the values obtained for the three specimens, and round up the results to the nearest 1 %. The resulting value of E_4, including any slippage, shall not exceed 10 % (see 4.3.2).

5.4.7 If the tested restraint strap assembly includes double stud fitting type end fittings, thus requiring three tests at different angles, the elongation test needs only to be conducted once on each specimen, e.g. with the tension load normal (90°) to the track surface.

5.5 Cyclic load test (optional)

5.5.1 A cyclic load test should be performed to simulate the recurrent load cycles resulting from movements of the aircraft (e.g. turbulence) or repeated use of the restraint strap assembly.

5.5.2 The test apparatus is there to apply to the complete restraint strap assembly a tension load varying between zero and the limit load (L_L), and release it. This constitutes one cycle.

5.5.3 The restraint strap assembly shall be submitted to 100 such cycles (or more, if specified according to the expected service life) at a frequency between 0,1 Hz and 0,4 Hz.

5.5.4 After the test, the restraint strap assembly shall be inspected for defects. There shall be no permanent deformation or abnormal wear on metallic parts. The webbing shall not have settled by more than 0,5 % of its length. No slippage through the tensioning device shall have been recorded at any moment of the test.

5.6 Inflammability test

The webbing in its production condition, after any treatment, shall be tested for inflammability performance in accordance with FAR/JAR Part 25 Appendix F. See 4.4.

5.7 Webbing elongation test (optional)

5.7.1 In addition to the elongation test of the complete restraint strap assembly specified in 5.4, a test may be conducted to measure the elongation under load of the isolated webbing.

5.7.2 The test tension loads to be used shall be those specified in steps 3 to 5 of 5.3.

5.7.3 One of the test methods listed in the Bibliography may be used.

5.8 Webbing abrasion test (optional)

5.8.1 A webbing abrasion test shall be performed, commensurate with the expected service life of the restraint strap assembly (see 4.9.3).

5.8.2 After the specified abrasion test, steps 1, 2 and 5 of the load test specified in 5.3 shall be performed in order to determine the loss in breaking force, if any, and the influence of resulting abrasion on the webbing slippage characteristics.

5.8.3 One of the test methods listed in the Bibliography may be used for the abrasion test.

5.9 Test record

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

5.9.2 The test results to be mentioned shall include:

a) mandatory:

- load test steps 1 to 5 (see 5.3.1 to 5.3.5),
- assembly elongation test (see 5.4.2 to 5.4.4), for the three test specimens required (nine in the event of testing at 90°/45°/0° for double stud end fittings, see 5.3.8. In this case, if only 90° testing is performed, a separate test report of the isolated fitting ultimate load test at 45° and 0° angles shall be attached),
- treated webbing inflammability test (see 5.6),
- environmental degradation evaluation statement or test report (expiry date if applicable: see 4.5.2);

b) optional:

- cyclic load test (see 5.5),
- webbing elongation test (see 5.7),
- webbing abrasion test (see 5.8).

6 Quality Control

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

6.2 In view of the possibility of such a minor change having been overlooked, detailed visual inspection and sample tests should take place prior to delivery and entry into service of each production batch or shipment of ordered restraint strap assemblies.

6.3 Recommended minimum sampling rates (one test sample normally consisting of three complete units selected at random from the same batch, for load and elongation testing), are given in Table 1:

Table 1 — Recommended minimum sampling rates

Number of units	Number of samples
up to 1 000	1
1 000 to 5 000	2
5 000 to 10 000	3
10 000 to 20 000	4
over 20 000	5

6.4 The parties (manufacturer and purchaser) shall contractually agree on a continuous (testing and production) quality assurance system based on the model of ISO 9002 or national equivalent recognized by the regulatory Airworthiness Authority. Whenever the manufacturer operates under such a third party accredited system, the test sampling rates recommended in 6.3 may vary but shall provide at least the same level of confidence.