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AEROSPACE STANDARD

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Cargo Restraint Straps - Design Criteria and Testing Methods

FOREWORD

This Standard 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.

Throughout this Standard, 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 to be of primary importance in providing safe restraint straps. Deviation from recommended criteria should only occur after careful consideration, extensive testing and thorough service evaluations have shown alternate methods to be satisfactory.

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1. SCOPE:

1.1 This Standard 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:

a. cargo loaded and tied down onto airworthiness certified air cargo pallets, themselves restrained into aircraft lower deck or main deck cargo systems meeting the requirements of NAS 3610, or

b. non-unitized individual pieces of cargo, or pieces of cargo placed onto 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:

c. restraint of non-containerized (bulk loaded) baggage and cargo in aircraft compartments,

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

NOTE 1: The ultimate loads allowable 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 (5,000 lbf) ultimate load restraint straps will therefore be in excess of the allowable for such applications.

1.3 This Standard 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. Tie-down arrangements shall 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 NAS 3610, 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 NAS 3610 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.

1.6 Subject to proper operating instructions as per 1.3 and 1.4 being defined and complied with, 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.

2. REFERENCES:

The following publications contain provisions that, through reference in this text, constitute provisions of this Standard. As of the date of release, the edition indicated was valid. All documents are subject to revision, and parties to agreements based on this Standard are encouraged to apply the most recent edition of the publications indicated below.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, USA.

AS1130F	Air and Air/Surface (Platform) Cargo Pallets
AS1491B	Interline Air Cargo Pallet
AIR1490B	Environmental Degradation of Textiles

2.2 NAS Publications:

Available from Aerospace Industries Association, 1250 Eye Street NW, Washington, DC 20005-3924.

NAS 3610	Minimum Airworthiness Requirements and Test Conditions for Certified Air Cargo Unit Load Devices

2.3 ISO Publications:

Available from ANSI, 11 West 42nd Street, New York, New York, 10036-8002.

ISO 2076: 1989	Textiles - Man-made fibres - Generic names
ISO 7166: 1985	Aircraft - Rail and stud configuration for passenger equipment and cargo restraint (updated MS 33601A track and stud, see below)
ISO 9788: 1990	Air cargo equipment - Cast components of double stud 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 fittings having an omnidirectional rated load capacity of 22 250 N (5,000 lbf) or above.

2.4 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MS 33061A Track and Stud Fitting for Cargo Transport Aircraft, Standard Dimensions for

2.5 Federal Aviation Regulations and U.S. Federal Test Methods Standards:

Available from U.S. Government Printing Office, Mail Stop SSOP, Washington, DC 20402-9328.

Federal Aviation Regulations (FAR) Part 25, Airworthiness Standards: transport category airplanes

U.S. Federal Test Method Standards No. 191A, Method 4108, Strength and elongation, breaking; textile webbing, tape and braided items

U.S. Federal Test Method Standards No. 191A, Method 5309-1, Abrasion resistance of textile webbing

3. DEFINITIONS:

For the purpose of this Standard, the following 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:

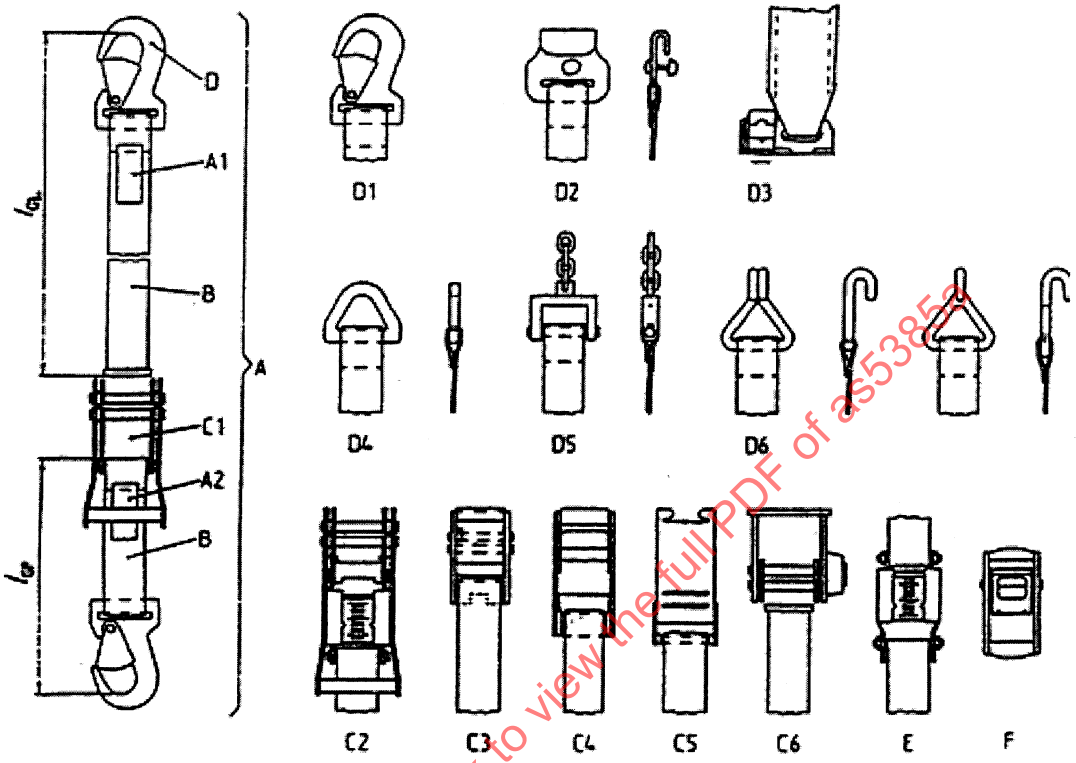
Fact of restraining cargo movements in relation to an aircraft's structure, throughout the range of relative accelerations resulting from the allowable flight envelope, by means of an appropriate use of a number of elementary tie-down devices against each direction of restraint.

3.3 FLAT WOVEN TEXTILE WEBBING:

Conventional or shuttleless woven narrow fabric made of textile fibers, generally with multiple plies, and the prime function of which is load bearing. A characteristic of webbing is its narrow fabric selvedge.

3.4 TENSIONING DEVICE:

Mechanical device inducing a tensile force in the load restraint assembly (e.g., ratchets, winches, overcenter buckles. See examples in Figure 1, C1, C2, and C6).



A	restraint strap assembly (complete)
AI, A2	space for marking (label)
B	webbing
C	tensioning devices
CI	ratchet tensioner
C2	ratchet tensioner with tension force indicator (see also E)
C3	sliding bar buckle
C4, C5	overcenter buckles
C6	lashing winch
D	end fittings
DI	snap hook, flat, swivel or twisted, with retainer
D2	flat hook, with retainer
D3	double stud tie-down fitting (directly sewn onto 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 Device C, End Fitting D and Tension Force Indicator E

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 examples in Figure 1, D1 to D6).

NOTE 2: The end fittings most commonly used on air cargo restraint straps include:

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

b. air cargo tie-down double stud (male) fitting conforming to MS 33601A and ISO 9788, connected directly (sewn to the webbing, see example in Figure 1, D3) or by an intermediate ring, or

c. piece of aircraft restraint (female) rail conforming to MS 33601A.

3.7 TENSION FORCE INDICATOR:

A device (see 8.7) that indicates the tensile force applied to the restraint strap assembly by means of the tensioning device and the movement of the load acting on the load restraint device.

3.8 LENGTH OF RESTRAINT STRAP ASSEMBLY:

3.8.1 Length (l_{GF}): Length of a fixed end, 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).

3.8.2 Length (l_{GL}): Length of an adjustable end, 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.

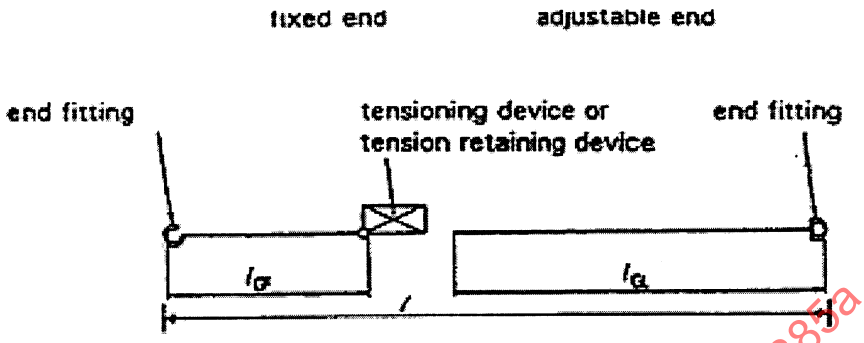


FIGURE 2 - Two-Piece Restraint Strap Assembly

3.9 BREAKING FORCE (BF):

The maximum force that the restraint strap assembly withstands when tested in a complete form, i.e., with tensioning device and end fittings.

3.10 HAND FORCE (HF):

Force applied to the handle of the tensioning device, which creates the tensile force in the restraint strap assembly.

3.11 LIMIT LOAD (LL):

The maximum load to be expected in service. See FAR Part 25, paragraph 25.301 (a). It is two-thirds of the ultimate load (see hereafter); 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 (UL):

The limit load multiplied by a safety factor of 1.5; see FAR Part 25, paragraph 25.303. The restraint strap assembly's rated ultimate load shall be guaranteed not to exceed the measured breaking force (BF). 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:

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

3.14 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.

3.15 TRACEABILITY CODE:

Series of letters and/or numbers marked on a component or an assembly which 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 compatible with:

a. the edge rails of air cargo pallets meeting the requirements of AS1130F or AS1491B (airworthiness certified according to NAS 3610),

b. aircraft seat tracks or structural attachment points meeting the requirements of MS 33601A

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

4.2 Ultimate Load:

The breaking force (BF) of the restraint strap assembly, when tested in accordance with 5.5 hereafter shall guarantee a rated minimum ultimate tensile load to be specified at purchasing 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 worldwide 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 (UL).

4.3.3 Webbing slippage through the tensioning device (see 4.7.5 hereafter) is allowable only during pretension (i.e., while the tensioning device is actuated and locked), 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 the 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 (UL), after the tensioning device handle has been locked.

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).

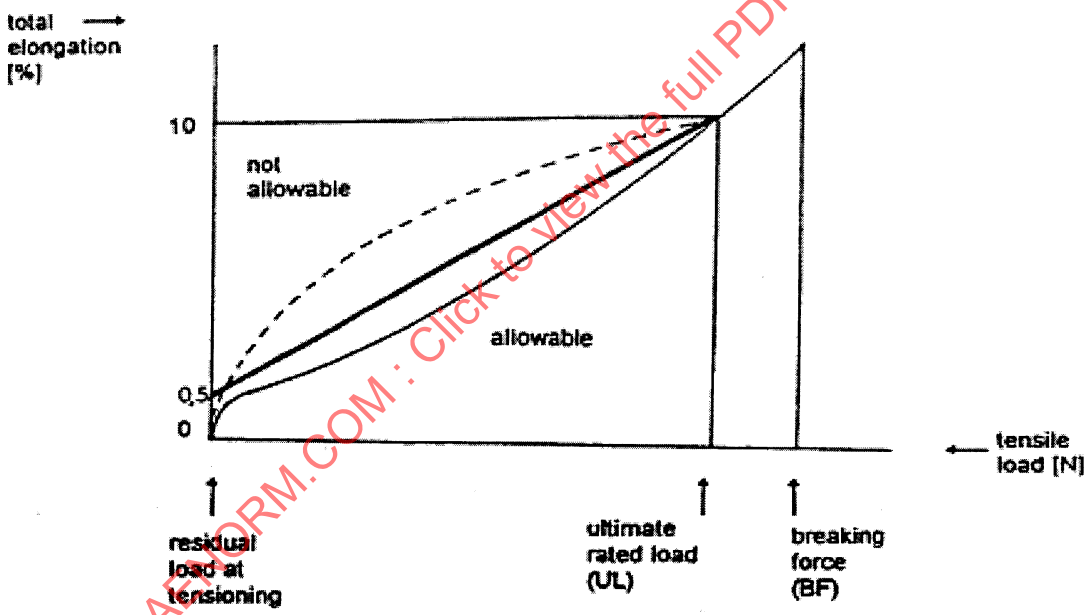


FIGURE 3

4.4 Flammability:

4.4.1 The webbing, as used in the restraint strap assembly, i.e., including sewing and any treatment, shall meet the flammability test criteria of FAR Part 25 Appendix F, Part I, paragraph (a)(1)(v): it may not have a burn rate greater than 100 mm (4.0 in) per minute when tested horizontally with the apparatus and test procedures required in Appendix F, Part I, paragraph (b)(5).

4.4.2 The flammability test shall be performed on a minimum of three specimens, and the results averaged. 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 fiber performance when exposed to environment factors, as provided in AIR1490B, should 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 expiration 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 hereafter).

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 3: 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 AS1130F, 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 (2.00 in ± 0.04 in) for a strap with a 5000 lb (22,250 N) ultimate load rating. Width between 38 mm (1.50 in) minimum and 63 mm (2.50 in) are acceptable for the same load rating.

4.7 Tensioning Device:

4.7.1 The type of tensioning or tension retaining device is to 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 (over center, 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 is design principle. The following recommended maximum thickness should be considered:

a. 50 mm (2.0 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, once closed, 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 minimize any risk of slippage of the webbing against the device once closed, including when the webbing 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 actuated and locked):

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 release of the tensioning device handle in the closed position (see 4.3.3, elongation), and

b. it shall maintain the minimum tensioning length on the webbing once closed, as per 4.7.4, and

c. no measurable slippage is allowable under any load between zero and the rated ultimate load (UL), after the tensioning device handle has been locked.

NOTE 4: The requirement in 4.7.5 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 tool(s), 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 (HF) not exceeding 500 N (110 lbf) exerted onto the handle.

4.7.8 The tensioning device shall be designed so that, in the absence of any tension, it is possible by positive 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 Note 4 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, is (are) to be selected on agreement between the manufacturer and the purchaser. See Note 2 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 tool(s). 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 as per 5.5 hereafter 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 manufacturers documentation for each restraint strap assembly model, together with a summary of the tested characteristics of the yarn and the woven product.

NOTE 5: Materials regularly used in the air cargo industry include: polyamide (PA), polyester (PES), and polypropylene (PP) high tenacity continuous multifilament fibers. If necessary, see ISO 2076 for material definition.

4.9.2 All seams shall be made from thread of the same material as that of the webbing and shall be made with a locking stitch. Cross-stitching shall be used for webbing seams likely to incur all or part of the tension load.

NOTE 6: The sewing thread may be of a different color 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 5.10 hereafter 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 (0.250 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 operators 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 The following tests shall be conducted in order to ensure the integrity and function of the restraint strap assembly are maintained throughout the rated load range. Equivalent alternative methods may be used providing that the details of the method used be duly recorded together with the test results.

5.2 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.

5.3 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 (UL) shall not exceed the lowest recorded breaking force (BF).

5.4 Testing Apparatus:

5.4.1 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 7: Testing a complete restraint strap assembly, even with its length adjusted, requires more distance between the machine's pulling damps 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 ILG + length of the tensioning device +0.5 m (20 in).

5.4.2 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 (BF) shall remain indicated after the rupture.

5.4.3 In order to provide comparable results, the pulling clamps should have a uniform speed of 75 ± 25 mm (3.0 ± 1.0 in) per minute per 1 m (40 in) total length of the specimen being tested.

5.4.4 Ensure that the machine is equipped prior to the test 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 MS 33601A. 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 double-studs conforming to MS 33601A / ISO 9788 (Figure 1, D3), located at 25.4 mm (1.00 in) centers parallel to the direction of pulling.

5.5 Load Test:

5.5.1 Step 1: Adjust the total length of the restraint strap assembly till no slack exists, action the tensioning device and lock it with an approximate reference hand force of 500 N (110 lbf) at the handle. Record the residual tension force in the strap assembly after releasing the handle.

5.5.2 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.

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

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

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

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

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

5.5.5 Step 5: Increase tension to rupture of the restraint strap assembly. Record the measured breaking force (BF) and the part(s) of the assembly that failed.

5.5.6 Testing is deemed successful if rupture occurred at a load higher than the rated ultimate load (UL), and any damage observed under the ultimate load did not exceed the allowances in 5.5.4.

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

a. either the batch of restraint strap assemblies shall be rejected;

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

5.5.8 If the tested restraint strap assembly includes double stud fitting type end fittings, the test procedure from 5.5.1 through 5.5.7 shall be repeated three times, reorienting the segment of steel track per 5.4.4(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. 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. Appreciation of test results shall be as per 5.5.7.

5.6 Elongation Test:

5.6.1 The elongation test shall be performed on the same specimens simultaneously with the load test (see 5.5).

5.6.2 After step 1 (see 5.5.1), two fine ink marks shall be made 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 (L1) between marks shall be measured with an accuracy of ±1 mm (±0.04 in) or better.

Apply step 2 (see 5.5.2).

5.6.3 Apply step 3 (see 5.5.3). Measure the new distance (L3) between marks. (L3-L1) provides a measurement of the elongation (i.e., sum of elastic deformations), or the actual displacement to be expected in operation.

5.6.4 Apply step 4 (see 5.5.4). Measure the new distance (L4) between the marks.

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

$$E_n = \frac{(L_n - L_1) \times 100}{L_1} \quad \text{(Eq. 1)}$$

5.6.6 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 En, including any slippage, shall not exceed 10% (see 4.3.2).

5.6.7 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.

5.7 Cyclic Load Test (optional):

5.7.1 A cyclic load test should be performed to simulate the recurrent load cycles resulting from movements of the aircraft (e.g., ground maneuvers, in-flight turbulence) or repeated use of the restraint strap assembly.

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

5.7.3 The restraint strap assembly is to 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.

5.7.4 After the test, the restraint strap assembly shall be inspected for defects. There should be no permanent deformation or abnormal wear on metallic parts. The webbing should not have settled by more than 25 mm (1.0 in). No slippage through the tensioning device should have been recorded at any moment of the test.

5.8 Flammability Test:

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

5.9 Webbing Elongation Test (optional):

5.9.1 In addition to the elongation test of the complete restraint strap assembly as per 5.6, a test may be conducted to measure the elongation under load of the isolated webbing.

5.9.2 The test tension loads to be used should be those specified in steps 3 through 5 of 5.5.

5.10 Webbing Abrasion Test (optional):

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

5.10.2 After the specified abrasion test, step 1, 2, and 5 of the load test as per 5.5 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.

5.11 Test Record:

5.11.1 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, production batch, as well as location, date and results of the various tests.

5.11.2 The test results to be mentioned shall include:

a. mandatory:

- load test steps 1 through 5 (see 5.5.1 through 5.5.5),
- assembly elongation test (see 5.6.2 through 5.6.4), for the three test specimens required (nine in the event of testing at 90°/45°/0° for double stud end fittings, see 5.5.8; in this case, if only 90° testing was performed, a separate test report of the isolated fitting ultimate load test at 45° and 0° angles shall be attached).
- treated webbing flammability test (see 5.8),
- environmental degradation evaluation statement (expiry date if applicable: see 4.5); and, if performed,

b. optional:

- cyclic load test (see 5.7),
- webbing elongation test (see 5.9),
- webbing abrasion test (see 5.10)