INTERNATIONAL STANDARD

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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

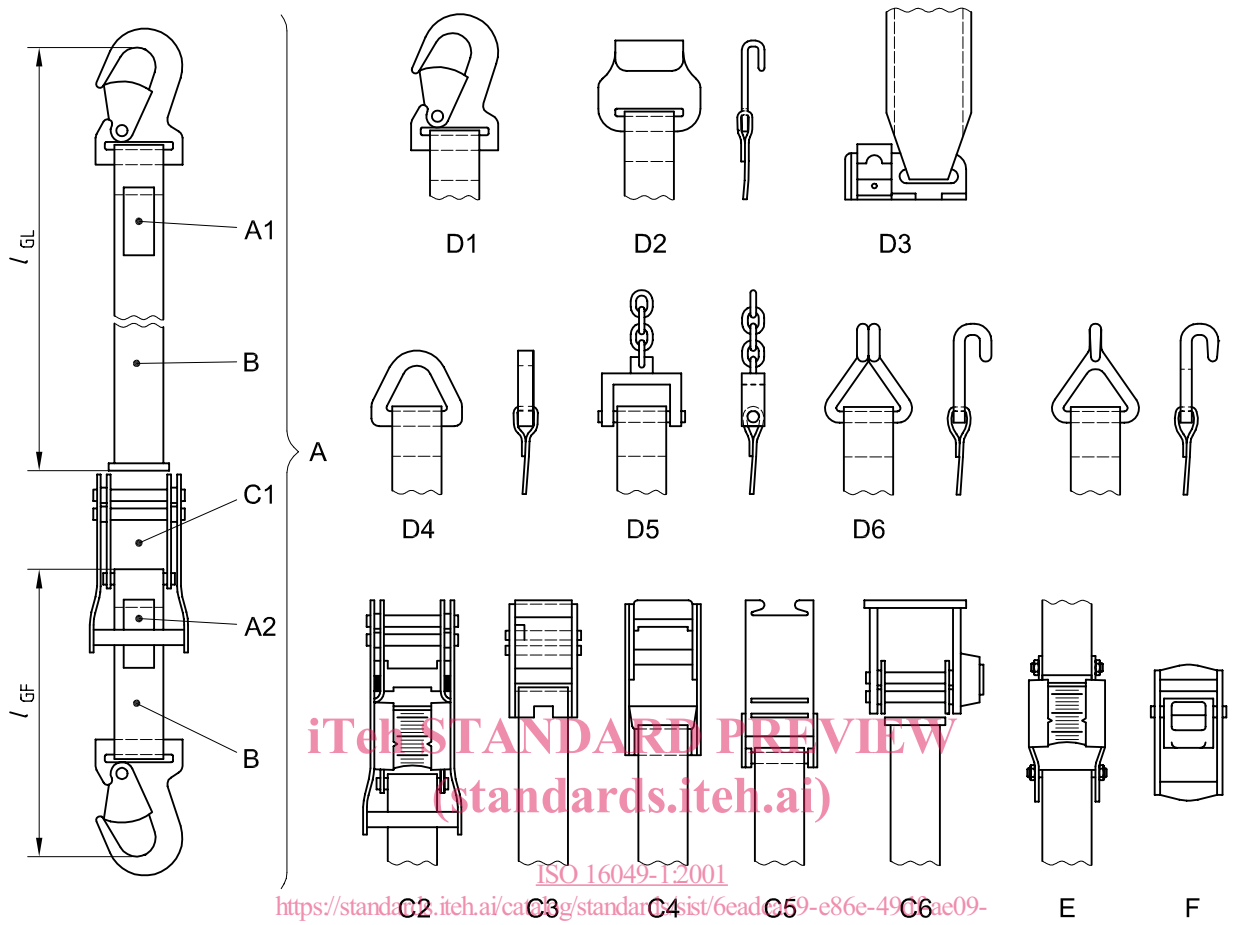
See Figure 2.

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.

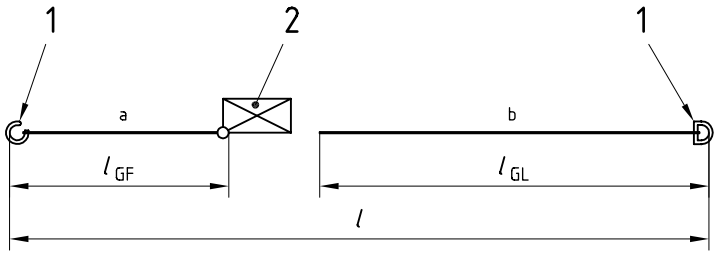
3.8.3
total length
l
(l_{GF}) + (l_{GL}) + length of the tensioning device



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).

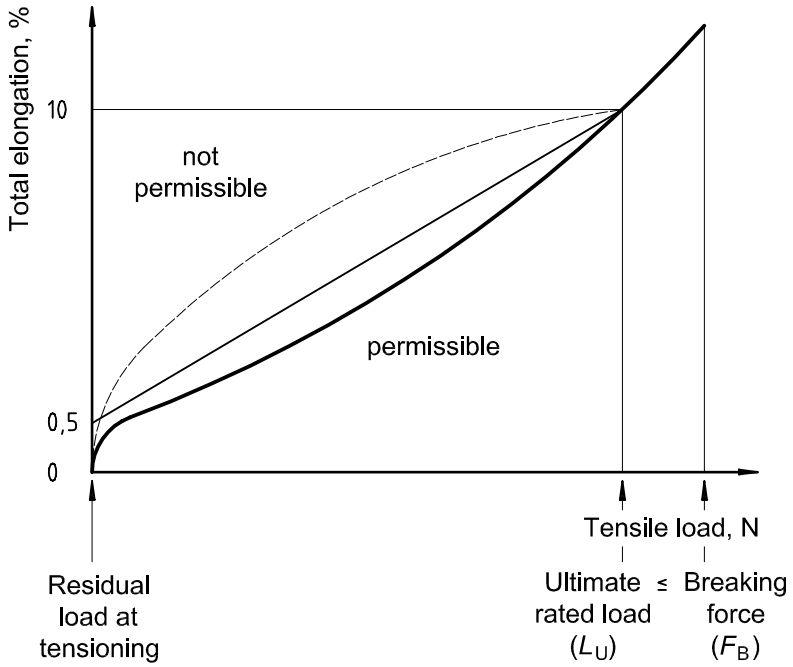


Figure 3 — Linear relationship between elongation and tensile load

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.