
**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.

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).

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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*.

This third edition cancels and replaces the second edition (ISO 16049-1:2013), which has been technically revised. The main changes compared to the previous edition are as follows:

- in [Figure 1](#), deletion of items D5 and D6, required by TSO/ETSO-C172a, and amendment of item D2;
- in [4.4](#), updating of flammability requirement to the latest amended Regulations.

A list of all parts in the ISO 16049 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

This document 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 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 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 evaluation have shown alternate methods to be satisfactory.

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

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Air cargo equipment — Restraint straps —

Part 1: Design criteria and testing methods

1 Scope

This document specifies 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. These restraint straps are used in civil transport aircraft during flight for:

- a) 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
- b) 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,
- c) the same restraint strap assemblies can also be used in other applications such as:
 - 1) non containerized (bulk loaded) baggage and cargo compartments;
 - 2) to ensure cargo restraint inside an airworthiness approved air cargo container.

NOTE The ultimate loads allowable on the attachment points available in most aircraft bulk compartments and inside many 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.

Compliance with this document provides one means of cargo restraint straps airworthiness approval by Civil Aviation Authorities under TSO/ETSO-C172a, in addition to the other requirements therein.

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

ISO 4171, *Air cargo equipment — Interline pallets*

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

ISO 8097:2001¹⁾, *Aircraft — Minimum airworthiness requirements and test conditions for certified air cargo unit load devices*

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

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

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

1) Endorsement of NAS 3610 revision 10, TSO/ETSO/CTSO/JTSO-C90c.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10254 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 strap assembly

elementary *tie-down* (3.2) unit consisting of *flat woven textile webbing* (3.3) (one *fixed length* (3.8.1) end and one adjustable end), one *tensioning device* (3.4) and two *end fittings* (3.6), 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 shuttle-less woven narrow fabric made of continuous textile fibres, generally with multiple plies, and the prime function of which is load bearing

Note 1 to entry: 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

EXAMPLE Ratchets, winches, over-centre buckles, see examples in [Figure 1](#), items C1 and C6.

3.5 tension retaining device

metallic part connecting the webbing by clamping action and retaining the force induced in the *tensioning device* (3.4) by hand

EXAMPLE Cam buckles, sliding bar buckles, see example in [Figure 1](#), item F.

3.6 end fitting

metallic device connecting the webbing or the *tensioning device* (3.4) to the attachment point on the aircraft structure, the pallet edge rail or the load

Note 1 to entry: See examples in [Figure 1](#), items D1 to D4.

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

- retainer equipped flat hook (see example in [Figure 1](#), item D1);
- air cargo *tie-down* (3.2) double stud (male) fitting conforming to ISO 9788, connected directly (sewn to the webbing, see example in [Figure 1](#), item D3) or by an intermediate ring;
- piece of aircraft restraint (female) rail conforming to ISO 7166.

3.7**tension force indicator**

device that indicates the tensile force applied to the *restraint strap assembly* (3.1) by means of the *tensioning device* (3.4) and movement of the load acting on the load restraint device

3.8**length of restraint strap 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 webbing to the *tensioning device* (3.4)

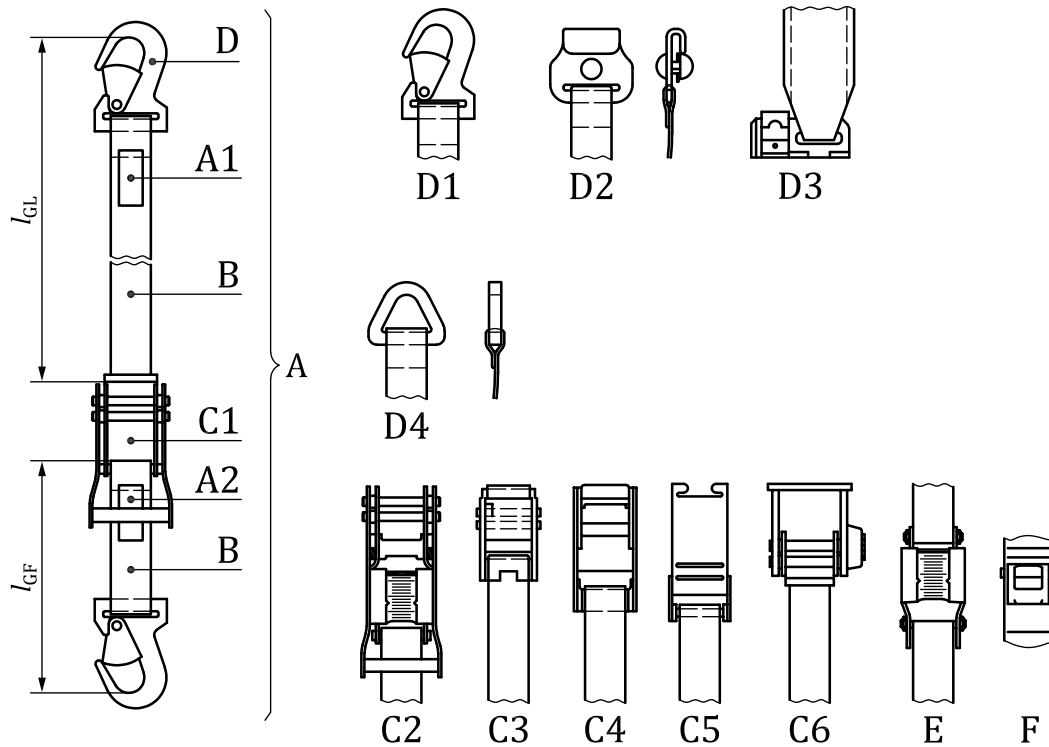
Note 1 to entry: See [Figure 2](#).

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

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Key

- A restraint strap assembly (complete)
- A1, A2 space for marking (label)
- B webbing
- C tensioning devices
- C1 ratchet tensioner
- C2 ratchet tensioner with *tension force indicator* (3.7) (see also E)
- C3 sliding bar buckle
- C4, C5 over-centre buckles
- C6 lashing winch
- D end fittings
- D1 snap hook, flat, swivel or twisted, with retainer
- D2 flat hook, with retainer
- D3 double stud *tie-down* (3.2) fitting (directly sewn onto webbing)
- D4 triangle, designed to engage with an anchorage
- E tension force indicator (see also C2)
- F *tension retaining device* (3.5) (cam buckle, sliding bar buckle)

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Figure 1 — Examples of restraint strap equipment, including tensioning device C, end fitting D and tension force indicator E

3.8.2 adjustable length

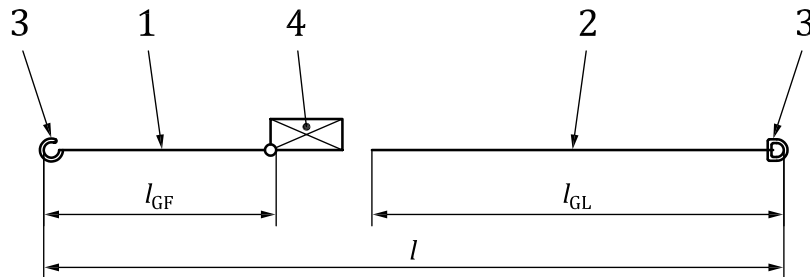
l_{GL}
length of an adjustable end, measured from the free end of the webbing to the force bearing point of the *end fitting* (3.6)

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

3.8.3 total length

l

total of l_{GF} (3.8.1), l_{GL} (3.8.2) and length of the *tensioning device* (3.4)



Key

- 1 fixed end
- 2 adjustable end
- 3 end fitting (3.6)
- 4 tensioning device or *tension retaining device* (3.5)

Figure 2 — Two-piece restraint strap assembly (3.1)

3.9 breaking force

F_B

maximum force that the *restraint strap assembly* (3.1) withstands when tested in a complete form

Note 1 to entry: With *tensioning device* (3.4) and *end fittings* (3.6) according to 5.5.

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3.10 hand force

F_H

force applied to the handle of the *tensioning device* (3.4), which creates the tensile force in the *restraint strap assembly* (3.1)

3.11 limit load

LL

maximum load to be expected in service

Note 1 to entry: See CCAR-25, CS-25, JAS Part 3 or 14 CFR Part 25, paragraph 25.301 (a).

Note 2 to entry: It is 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

UL

limit load (3.11) multiplied by a safety factor of 1,5

Note 1 to entry: See CCAR-25, CS-25, JAS Part 3 or 14 CFR Part 25, subclause 25.303.

Note 2 to entry: It is used for computation of cargo *tie-down* (3.2) 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. The *restraint strap assembly's* (3.1) rated ultimate load is guaranteed not to exceed the measured *breaking force* (F_B) (3.9).

3.13

residual tension

tension force which can be measured in the webbing of a strap assembly attached between two (2) fixed points, after its length was adjusted and its tension device was operated and latched with the reference *hand force* (F_H) (3.10), prior to application of any external load

3.14

competent person

designated person, with suitable training, 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, for example ISO 9001:2015, 6.2.2 or another equivalent quality management standard.

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

Note 1 to entry: See 7.2.

4 Design criteria

4.1 General

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4.1.1 This document specifies the design criteria for 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 presupposed 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.

4.1.2 When restraint strap assemblies are attached to the edge rails of a certified air cargo pallet meeting the requirements of ISO 8097 (NAS 3610) or ISO 21100, operating instructions should 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 configuration drawing(s).

4.1.3 The use of reliable and guaranteed restraint strap assemblies is necessary but not sufficient to ensure flight safety: this document is based on the assumption that straps will be used and tie-down will be performed in accordance with operating instructions established by the aircraft manufacturer, by competent, suitably trained personnel, for example, as defined in ISO 9001:2015, 6.2.2 or an equivalent quality management standard.

4.1.4 Subject to proper operating instructions as per 4.1.1 and 4.1.2 being defined and complied with, using restraint strap 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 to restrain cargo on board civil transport aircraft can be found in ISO 16049-2.

4.1.5 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 ISO 4117 or ISO 4171 (airworthiness approved according to ISO 8097 (NAS 3610) or ISO 21100),