
**Air cargo equipment — Restraint
straps —**

**Part 2:
Utilization guidelines and lashing
calculations**

iTeh STANDARD PREVIEW
Équipement de fret aérien — Sangles d'arrimage —
(standards.iteh.ai) Partie 2: Directives pour l'utilisation et calculs d'arrimage

[ISO 16049-2:2013](https://standards.iteh.ai/catalog/standards/sist/86ffe7e7-eabd-4c85-86a0-2f9105e947f1/iso-16049-2-2013)

<https://standards.iteh.ai/catalog/standards/sist/86ffe7e7-eabd-4c85-86a0-2f9105e947f1/iso-16049-2-2013>



iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 16049-2:2013

<https://standards.iteh.ai/catalog/standards/sist/86ffe7e7-eabd-4c85-86a0-2f9105e947f1/iso-16049-2-2013>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2013

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

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	2
4 General requirements	4
5 Tie-down method	7
5.1 Basic method.....	7
5.2 Directions of restraint.....	7
6 Calculation methods	8
6.1 Load factors.....	8
6.2 Calculation principles.....	9
6.3 Practical calculation.....	10
7 Specific requirements	11
7.1 General.....	11
7.2 Risk of cargo slippage.....	11
7.3 Risk of cargo tilting.....	11
7.4 Long and narrow items.....	12
8 Operator's responsibilities	12
Bibliography	14

ITeh STANDARD PREVIEW
 (standards.iteh.ai)
<https://standards.iteh.ai/catalog/standards/sist/86ffe7e7-eabd-4c85-86a0-2f9105e947f1/iso-16049-2-2013>

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. 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. www.iso.org/patents

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

The committee responsible for this document is ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 9, *Air cargo and ground equipment*.

This second edition cancels and replaces the first edition (ISO 16049-2:2005), which has been technically revised. It was technically revised to fully meet the requirements of Technical Standard Order (TSO/ETSO) C-172.

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*

Introduction

This part of ISO 16049 specifies utilization guidelines and the principles to be used in tie-down/lashing strength calculations for the use of air cargo restraint straps on board civil transport aircraft.

Throughout this part of ISO 16049, 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 lashing arrangements. Deviation from recommended criteria should only occur after careful consideration and thorough service evaluation have shown alternate methods to be satisfactory.

iTeh STANDARD PREVIEW (standards.iteh.ai)

[ISO 16049-2:2013](https://standards.iteh.ai/catalog/standards/sist/86ffe7e7-eabd-4c85-86a0-2f9105e947f1/iso-16049-2-2013)

<https://standards.iteh.ai/catalog/standards/sist/86ffe7e7-eabd-4c85-86a0-2f9105e947f1/iso-16049-2-2013>

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[ISO 16049-2:2013](https://standards.iteh.ai/catalog/standards/sist/86ffe7e7-eabd-4c85-86a0-2f9105e947f1/iso-16049-2-2013)

<https://standards.iteh.ai/catalog/standards/sist/86ffe7e7-eabd-4c85-86a0-2f9105e947f1/iso-16049-2-2013>

Air cargo equipment — Restraint straps —

Part 2: Utilization guidelines and lashing calculations

1 Scope

1.1 This part of ISO 16049 aims to provide general utilization guidelines and calculation methods adequate to guarantee the effectiveness and ultimate load strength of tie-down/lashing arrangements performed to restrain cargo on board civil transport aircraft during flight:

- a) cargo loaded and tied down onto airworthiness approved air cargo pallets, themselves restrained into aircraft lower deck or main deck or upper deck cargo systems meeting the restraint requirements of air cargo pallets approved in accordance with ISO 8097, (NAS3610) or ISO/PAS 21100, or
- b) additional tie-down on aircraft structure when necessitated by pallet maximum gross mass or centre of gravity limits, or
- c) 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, or
- d) individual pieces of load loaded in non-containerized (bulk loaded) baggage or cargo compartments.

1.2 This part of ISO 16049 applies to cargo tie-down/lashing arrangements using exclusively air cargo restraint straps conforming to ISO 16049-1. Its general recommendations may also be used for tie-down arrangements using other means (e.g. steel cables, rope, other types of straps), but under the user’s responsibility as to their adequacy and the strength calculations required.

NOTE 1 Where tie-down is performed onto aircraft structure as per 1.1 b) or c), additional restrictions can be stated in the aircraft’s Authority approved Weight and Balance Manual.

NOTE 2 The use of chains or other rigid devices for tie-down onto civil transport aircraft floor tracks is not part of the scope of this part of ISO 16049, since it is not recommended due to the possibility of generating excessive stresses in the aircraft structure, except where explicitly approved in the manufacturer’s Authority approved Weight and Balance Manual.

1.3 This part of ISO 16049 aims to provide industry recognized means of complying with Airworthiness Authorities general regulations applicable to load securing on board civil transport aircraft (see 14 CFR Part 25 and EASA CS-25), and aircraft manufacturers Authority approved Weight and Balance Manuals for each aircraft type as specified therein. It is not the intent of this part of ISO 16049 to specify when restraint straps should be used, but how they should be used. It does not, under any circumstance, supersede the requirements of any of the above documents that take precedence at all times.

2 Normative references

The following referenced documents are indispensable for the application 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 7166, *Aircraft — Rail and stud configuration for passenger equipment and cargo restraint*

ISO 8097:2001, *Aircraft — Minimum airworthiness requirements and test conditions for certified air cargo unit load devices*¹⁾

1) Endorsement of NAS 3610 revision 10, TSO/ETSO/CTSO/JTSC C-90c.

ISO 16049-2:2013(E)

ISO 9788, *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 10254, *Air cargo and ground equipment — Vocabulary*

ISO 16049-1, *Air cargo equipment — Restraint straps — Part 1: Design criteria and testing methods*

ISO/PAS 21100, *Air cargo unit load devices — Performance requirements and test parameters (TSO/ETSO/CTSO/JTSO C-90d)*

CAAC CCAR-25, *Airworthiness Standards — Transport Category Airplanes*

European Aviation Safety Agency (EASA) Certification Specification CS-25, *Airworthiness Standards: transport category aeroplanes*²⁾

EASA European Technical Standard Order ETSO C172 — *Cargo Restraint Strap Assemblies*³⁾

European Aviation Safety Agency (EASA) EU-OPS 1.035, *Quality system*⁴⁾

Japanese Airworthiness Standard Part 3 (Civil Aeronautics Law Article 10 § 4)⁵⁾

USA Code of Federal Regulations (CFR) Title 14 Part 25, *Airworthiness Standards: transport category airplanes*. (“14 CFR Part 25”)⁶⁾

USA Federal Aviation Administration Technical Standard Order TSO C172 — *Cargo Restraint Strap Assemblies*⁷⁾

Federal Aviation Administration (FAA) Advisory Circular AC 120-59, *Air carriers internal evaluation programs*⁸⁾

NOTE Also see other informative references in Bibliography.

ITeH STANDARD PREVIEW
(standards.iteh.ai)

3 Terms and definitions

ISO 16049-2:2013

[https://standards.iteh.ai/catalog/standards/sist/86ffe7e7-eabd-4c85-86a0-](https://standards.iteh.ai/catalog/standards/sist/86ffe7e7-eabd-4c85-86a0-2f9105e947f1/iso-16049-2-2013)

[2f9105e947f1/iso-16049-2-2013](https://standards.iteh.ai/catalog/standards/sist/86ffe7e7-eabd-4c85-86a0-2f9105e947f1/iso-16049-2-2013)

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

3.1 tie-down lashing

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

2) EASA CS-25 constitutes the European governments transport aircraft airworthiness Regulations, and can, as well as EU-OPS, be obtained from European Aviation Safety Agency (EASA), Otto Platz 1, Postfach 101253, D-50452 Cologne, Germany, or its web site at <http://www.easa.europa.eu/>.

3) See footnote 2.

4) See footnote 2.

5) The Japanese Airworthiness Standard Part 3 (ISBN 4-89279-661-1) constitutes the Japanese government transport aircraft airworthiness approval Regulations, and can be obtained from the Civil Aviation Bureau (CAB) of the Ministry of Land, Infrastructure, Tourism and Transport, Tokyo, Japan, or its web site at <http://www.mlit.go.jp/en>.

6) The Code of Federal Regulations (CFR) Title 14 Part 25, abbreviated throughout this standard as “14 CFR Part 25”, constitutes the USA government transport aircraft airworthiness Regulations, and can be obtained from the US Government Printing Office, Mail Stop SSOP, Washington DC 20402-9328, USA, or its website at <http://www.gpoaccess.gov/>. Advisory Circulars can be obtained from the FAA at its website <http://www.faa.gov/>.

7) See footnote 6.

8) See footnote 6.

3.2**tie-down arrangement**

geometric layout of an assembly of elementary tie-down devices affixed and tensioned around a piece of cargo in order to ensure its tie-down against each direction of restraint

3.3**flight envelope**

set, during flight of a given aircraft type or sub-type, of allowable values for accelerations which may be encountered during flight in the various directions relative to the aircraft's structure, as determined during the aircraft certification flight testing and certified by the Airworthiness Authority within the aircraft's type certificate

3.4**limit load****LL**

maximum load to be expected in service as a result of the certified flight envelope of the aircraft

Note 1 to entry: It is two thirds of the ultimate load (see 3.5).

3.5**ultimate load****UL**

limit load multiplied by a safety factor of 1,5 prescribed by 14 CFR Part 25 and CS-25, paragraph 25.303

Note 1 to entry: It is used for calculation of cargo tie-down arrangements, based on the ultimate load factors defined in the Airworthiness Authority approved Weight and Balance Manual, in each direction of restraint, throughout the certified flight envelope of the aircraft type.

3.6**fore and aft**

directions of restraint, relative to the aircraft structure, determined parallel to the aircraft centreline towards the direction of flight, or opposed to it

3.7**sides**

directions of restraint, relative to the aircraft structure, determined perpendicular to the aircraft centreline and parallel to its floor, lefthand or righthand

3.8**upward**

upward direction relative to the aircraft structure

3.9**load factors**

accelerations, expressed as multiples of the standard acceleration of gravity ($g = 9,806\ 65\ \text{m}\cdot\text{s}^{-2}$), in each direction of restraint (fore, aft, sides, upward), that will result in limit or ultimate, as is the case, forces on the tie-down arrangement proportional to the mass of the piece of cargo being restrained

Note 1 to entry: They are provided by Airworthiness Authority approved Weight and Balance Manual for aircraft type or sub-type.

Note 2 to entry: The load factors may be limit or ultimate.

3.10**restraint strap assembly****strap**

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

Note 1 to entry: See ISO 16049-1 for description, design criteria and testing requirements.

**3.11
(tie-down) fitting**

basic piece of hardware, either single stud (see ISO 7166) or double stud (see ISO 9788), with an omnidirectional capability, allowing to attach (a) strap(s) or other elementary tie-down unit(s) to the floor tracks or tie-down receptacles of an aircraft's structure or the edge tracks of an air cargo pallet

Note 1 to entry: Tie-down fittings most commonly include an attachment ring, but may also be directly sewn onto a strap as a permanent end fitting thereof (see ISO 16049-1).

**3.12
floating**

<pallet> air cargo pallet, or equivalent flat support device, located on an aircraft's cargo compartment rollerized conveyor but not restrained by the cargo system, the pallet and its load constituting "non unitized" cargo and being restrained by a set of straps attached to aircraft structural points

**3.13
competent person**

designated person, suitably trained according to 6.2.2 of ISO 9001:2008 or equivalent pertinent industry training and proficiency standards, qualified by knowledge and practical experience and with the necessary operating instructions established according to 4.1

4 General requirements

4.1 Operating instructions shall be established by the aircraft operator, under control of his/her reporting Civil Aviation Authority. The operating instructions shall ensure compliance with the general airworthiness requirements and the applicable aircraft Weight and Balance Manual, and should incorporate the requirements of this part of ISO 16049, or equivalent industry standard (see Bibliography).

4.2 In addition, when restraint straps are attached to the edge rails of a certified air cargo pallet meeting the requirements of ISO 8097 (NAS 3610) or ISO/PAS 21100, operating instructions shall take into account the general requirements of the appropriate ISO 8097 (NAS 3610) or ISO/PAS 21100 configuration drawing(s) as to tie-down points locations and spacing.

4.3 Actual tie-down/lashing on aircraft in accordance with these instructions shall be performed and checked exclusively by competent, suitably trained, personnel as defined in 6.2.2 of ISO 9001:2008 or equivalent pertinent industry training and proficiency standards (see [Clause 8](#)).

4.4 Regardless of the tie-down method used (see [Clause 5](#)), all the following rules shall be complied with.

4.5 Tie-down shall be performed using straps designed and tested in accordance with ISO 16049-1 and Authority approved under TSO/ETSO/CTSO JTSO C172, onto tracks or receptacles meeting the requirements of ISO 7166, and using fittings meeting the requirements of either ISO 7166 (single stud) or ISO 9788 (double stud).

The rated ultimate strength resulting from testing of the strap model used shall be used for calculation of the tie-down arrangement's strength (see [Clause 6](#)), using the safety factor of 1,5 prescribed by 14 CFR Part 25 and CS-25, paragraph 25.303. In the event of other straps or alternative tie-down equipment (e.g. ropes, cables) being used under the operator's responsibility, the following general rules shall nevertheless apply, and the minimum guaranteed ultimate strength of the specific equipment used shall be used for strength calculation.

4.6 If several elements (e.g. straps, fittings, structural attachment points) of different ultimate strengths are used together, the strength of the resulting total tie-down element shall be limited to the strength of the weakest item.

4.7 A total tie-down arrangement should be performed using exclusively straps of the same model, in order to ensure differences in elasticity will not result in unequal tension of the straps and premature failure of certain ones in the event of a major acceleration being encountered during flight. If different models must be used, at least the straps material (e.g. polyamide, polyester, etc.) and rated ultimate strength shall be identical for any single direction of restraint.

4.8 Tie-down arrangements shall be symmetrical, i.e. performed using an equal number of tie-down attachment points (fittings or equivalent) on any two opposite sides of the piece of cargo, and the same number of straps, acting in the same direction(s) of restraint, onto any two symmetrically located attachment points. See [Figure 1](#).

4.9 A single tie-down fitting may, subject to ring geometrical compatibility and any Weight and Balance Manual restrictions or limits as to load factors simultaneity, be attached to up to three straps acting in as many different directions, but shall be attached to no more than one acting in any single direction of restraint (fore, aft, side or upward).

4.10 A strap attached to fittings on opposite sides of the piece of cargo and passing over or around it is to be accounted for twice its rated ultimate load capacity, under the condition it remains free to slide along the piece of cargo and not attached to it, so that the load is equally distributed between both ends of the strap. A strap attached to the piece of cargo may be accounted for only once.

4.11 For upward restraint, a minimum of two straps, regardless of the mass to be restrained, shall be used over the top of the piece of cargo, one on each side of its centre of gravity. When a higher number of upward straps is used, they should be evenly distributed around the centre of gravity.

4.12 Each strap should make a minimum possible angle, not to exceed 30° , with the direction of restraint for which it is accounted for (see [Figure 1](#)). In practical terms, to ensure angles a_1 , a_2 , a_3 on the figure are no more than 30° in relation to, respectively, directions A, B and C, it should be checked that distances d_1 , d_2 and d_3 , respectively, are less than half of distances D_1 , D_2 and D_3 .