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Air cargo equipment — Restraint straps —

Part 2: Utilization requirements and recommendations and lashing calculations

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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).

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

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 16049-2:2013), which has been technically revised. The main changes compared to the previous edition are as follows::

— new 4.14, Figure 3 and Table 1 regarding maximum number of tie-down locations on a pallet;

— deletion in 5.1, Basic methods, of Figure 4 former first drawing without lateral restraint dedicated straps;

— specification in 6.2, Calculation principles, of centreline angle and floor angle;

— deletion in 6.3, Practical calculation, and Bibliography of references to IATA AHM 311 and AHM 450;

— new 6.4, Calculation sheet.

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.

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Introduction

This document 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.

The civil aviation requirements referred to in the present document are those relating to operation of transport aircraft. They constitute the set of operation requirements internationally agreed in application of International Civil Aviation Organization (ICAO) Annex 6, Operation of aircraft, to the Convention on International Civil Aviation.

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 lashing arrangements. Deviation from recommended criteria should only occur after careful consideration and thorough service evaluation have shown the alternate methods ensure the same level of safety.

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 2: Utilization requirements and recommendations and lashing calculations

1 Scope

This document aims at providing general utilization requirements and recommendations 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 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.

This document 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 b) or c) above, additional restrictions can be stated in the aircraft's Authority approved Weight and Balance Manual.

NOTE 2 The use of chains, rods, or other rigid devices for tie-down onto civil transport aircraft floor tracks, which can generate excessive stress in the aircraft structure, is not part of the scope of this document. .

This document aims at providing industry recognized means of complying with Airworthiness Authorities general requirements applicable to load securing on board civil transport aircraft (see CCAR-25, JAS Part 3, 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 document to specify when restraint straps should be used, but how they should be used.

Meeting the methods requirements of this document is not alone sufficient to ensure flight safety: this document is based on the assumption that cargo tie-down will be designed, performed, and checked prior to aircraft departure in accordance with appropriate operating instructions conforming to the Weight and Balance Manual of the aircraft concerned, by competent, suitably trained, personnel as defined for example in ISO 9001:2015, 6.2.2 (see Clause 8).

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.

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

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

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

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

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

ISO 21100, *Air cargo unit load devices — Performance requirements and test parameters*

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
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 (3.3), by means of an appropriate use of a number of elementary tie-down devices against each direction of restraint

3.2
tie-down arrangement
geometric layout of an assembly of elementary *tie-down* (3.1) 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
<for a given aircraft type or sub-type> set 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* (3.3) of the aircraft

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

3.5
ultimate load
UL
limit load (3.4) multiplied by a safety factor of 1,5

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

Note 2 to entry: It is used for calculation of cargo *tie-down arrangements* (3.2), based on the ultimate *load factors* (3.10) defined in the Airworthiness Authority approved *Weight and Balance Manual* (3.14), in each direction of restraint, throughout the certified *flight envelope* (3.3) of the aircraft type.

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

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3.6
fore
direction of restraint, relative to the aircraft structure, determined parallel to the aircraft centreline towards the direction of flight

3.7
aft
directions of restraint, relative to the aircraft structure, determined parallel to the aircraft centreline opposite to the direction of flight

3.8
side
direction of restraint, relative to the aircraft structure, determined perpendicular to the aircraft centreline and parallel to its floor, left-hand or right-hand

3.9
upward
upward direction relative to the aircraft structure

3.10
load factor
acceleration, expressed as a multiple of the standard acceleration of gravity ("g" = 9,806 65 $m.s^{-2}$), in each direction of restraint (*fore* (3.6), *aft* (3.7), *sides* (3.8), *upward* (3.9)), that will result in limit or ultimate, as is the case, forces on the *tie-down arrangement* (3.2) proportional to the mass of the piece of cargo being restrained

Note 1 to entry: The load factors are provided by Airworthiness Authority approved *Weight and Balance Manual* (3.14) for aircraft type or sub-type.

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

3.11
restraint strap assembly
strap
basic *tie-down* (3.1) 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.

3.12
tie-down fitting
basic piece of hardware, either single stud (see ISO 7166) or double stud (see ISO 9788), with an omni-directional capability, allowing to attach (a) *strap(s)* (3.11) or other elementary *tie-down* (3.1) 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).

3.13
floating
<air cargo pallet or equivalent flat support device> located onto 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* (3.11) attached to aircraft structural points

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3.14
Weight and Balance Manual
WBM
manual, or sub-part of the Airplane Flight Manual, approved by the appropriate airworthiness Authorities as part of aircraft type certification

Note 1 to entry: It may be part of the Type Certificate (TC) of the aircraft type or sub-type concerned, or of a Supplemental Type Certificate (STC) for an aircraft type's conversion or its cargo loading system. A WBM Supplement, where provided, forms part of the approved WBM.

3.15
competent person
designated person, with suitable training, qualified by knowledge and practical experience and with the necessary operating instructions established

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.

Note 2 to entry: See 4.1 for the operating instructions.

4 General requirements

4.1 Operating instructions shall be established by the aircraft operator, under control of his reporting Civil Aviation Authority. The operating instructions shall identify the general airworthiness requirements and the applicable aircraft Weight and Balance Manual, and should incorporate the requirements of this document, or an 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 21100, operating instructions shall take into account the general requirements of the appropriate ISO 8097 (NAS 3610) or ISO 21100 configuration drawing(s) as to tie-down points locations and spacings.

4.3 Actual tie-down/lashing on pallets or aircraft in accordance with these instructions shall be performed and checked exclusively by competent, suitably trained, personnel. For example, the personnel trained in accordance with ISO 9001:2015, 6.2.2 or equivalent pertinent industry training and proficiency standards (see Clause 8) is advised.

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

4.5 Tie-down shall be performed using straps designed and tested in accordance with ISO 16049-1, 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). It is presupposed that the tie-down is approved under TSO/ETSO/CTSO/JTSO C172a.

It is presupposed that the rated ultimate strength resulting from testing of the strap model used is used for calculation of the tie-down arrangement's strength (see Clause 6), using the safety factor of 1,5 prescribed by applicable regulations, e.g. CCAR-25, JAS Part 3, 14 CFR Part 25 and CS-25, paragraph 25.303. In the event of other straps or alternate 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.

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