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Air cargo unit load devices — Performance requirements and test parameters

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National foreword

This British Standard is the UK implementation of ISO 21100:2020. It supersedes BS ISO 21100:2014, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ACE/57, Air cargo and ground support equipment.

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Air cargo unit load devices — Performance requirements and test parameters

Unités de charge de fret aérien — Exigences de performances et paramètres 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).

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 second edition cancels and replaces the first edition (ISO 21100:2014), which has been technically revised.

The main changes compared to the previous edition are as follows:

— 5.10.3.5, addition of pallets track test to ensure compatibility with straps restraint;

— 5.10.4.3, addition of stiffness requirements for containers base edges;

— Clause 8, ULD configurations A8, B8 and M5 use limited to lower deck containers;

— Clause 8, ULD configuration Q1 change to add pallet and net applicability;

— Clause 9, restraint conditions K, L, P and Q change as a result of testing experience.

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 the performance and testing requirements for approved (certified) cargo unit load devices (containers, pallets and nets) intended to be used for cargo restraint on board civil transport aircraft.

The civil aviation requirements referred to in this document are those concerning certification of transport aircraft and appliances to be installed aboard them, and constitute the set of design and operation requirements internationally agreed in application of International Civil Aviation Organization (ICAO) Annex 8, *Airworthiness of aircraft*, to the Convention on International Civil Aviation. This document provides one means of compliance for unit load devices.

Dimensions and tolerances are expressed in millimetres, with dimensions in inches shown between brackets. The nominal values of outer unit load device base dimensions are those expressed in inches. Forces are expressed in Newton, with forces in pound-force shown between brackets.

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Air cargo unit load devices — Performance requirements and test parameters

1 Scope

This document specifies the minimum requirements for airworthiness approval of air cargo pallets, nets and containers, generally designated as air cargo unit load devices (ULD).

This document is intended to provide a uniform technical reference for air cargo unit load devices approval. As a prerequisite, it is presupposed that the applicable general civil aviation requirements and the aircraft manufacturer's approved Weight and Balance Manual are followed.

This document defines the minimum performance requirements and test parameters for air cargo unit load devices requiring approval of airworthiness for installation in an approved aircraft cargo compartment and restraint system that complies with the cargo restraint and occupant protection requirements of EASA CS-25 or 14 CFR Part 25, except for the 9,0 g forward ultimate inertia force of § 25.561(b) (3) (ii).

This document applies to airworthiness approved air cargo unit load devices intended for carriage on board civil transport category airplanes type certificated under EASA CS-25 or 14 CFR Part 25, or equivalent.

This document exclusively applies to unit load devices airworthiness approval and testing parameters. It does not apply to aircraft design or aircraft operating requirements, which are provided by the approved Weight and Balance Manual for each aircraft type.

Other aspects that do not directly pertain to air cargo unit load devices airworthiness approval and testing are not covered by this document and are defined in other International Standards (see Bibliography), e.g.:

— ULD design specifications,

— ULD in service damage limits,

— ULD restraint malfunction limitations,

— ULD test methods,

— ULD load distribution models,

— ULD maximum allowable contours,

— ULD CG (centre for gravity) location control means,

— ULD pressure equalization methods,

— ULD utilization guidelines.

Air cargo unit load devices qualified prior to publication of this document were approved in accordance with the requirements of ISO 8097:2001. This document is intended as a TSO approval reference for all new models of unit load devices in the sizes and types it covers, in replacement of ISO 8097. For air cargo unit load devices the size or type of which is not covered in this document, see the requirements of ISO 8097:2001, if their size or type is contained therein, or other equivalent criteria, if not.

NOTE 1 ISO 8097 is based on USA National Aerospace Standard NAS 3610 revision 10:1990, Specification for Cargo Unit Load Devices.

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NOTE 2 The requirements for cargo covers are not defined in this document, except insofar as net restraint is incorporated 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 7166, *Aircraft — Rail and stud configuration for passenger equipment and cargo restraint*

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

ISO 10046, *Aircraft — Methodology of calculating cargo compartment volumes*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
base edge
outer perimeter of a *unit load device* (3.8), interfacing with the aircraft *restraint system* (3.7), ensuring the required performance with contribution of adjacent parts of the complete unit load device

3.2
container
<air cargo> rigid structure which interfaces directly with the aircraft cargo handling and *restraint system* (3.7) and alone performs all the functions of a *unit load device* (3.8)

3.3
cover
<cargo> layer made of flexible material, used to protect cargo on a *pallet* (3.6)

Note 1 to entry: It may or may not incorporate a pallet *net* (3.4) or be permanently attached to one. If a net is incorporated or permanently attached to the cover, the performance and testing requirements applicable to nets in this document are applicable to the net/cover assembly.

3.4
net
<air cargo pallet> webbing or rope net for restraining load onto an air cargo *pallet* (3.6)

3.5
numeric simulation
simulation of physical test condition and reaction of *unit load device* (3.8) employing numerical analysis, computational geometry and computer graphics to obtain proof support and design verification, validated by demonstration that parameters, algorithms and analytical methods used provide results of at least equivalent reliability to the outcome of a specified actual test

3.6
pallet
<air cargo> *unit load device* (3.8) consisting of a flat platform with a flat undersurface of standard dimensions, on which goods are assembled and secured by a *net* (3.4) before being loaded as a unit onto the aircraft, and which interfaces directly with the aircraft handling and *restraint system* (3.7)

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3.7
restraint system
equipment for supporting and restraining *unit load devices* (3.8) in an aircraft against the ground/flight loads

Note 1 to entry: It usually consists of such items as rollers, side guides, and locks for securing unit load devices to the aircraft structure. It does not include unit load devices, barrier *nets* (3.4) and tie-down straps.

3.8
unit load device
ULD
device for grouping, transferring and restraining cargo for transit

Note 1 to entry: It may consist of a *pallet* (3.6) with a *net* (3.4) or it may be a *container* (3.2).

4 Classification

4.1 Types

Type 1 (for reference only): Unit load devices (ULDs) designed for use in an approved aircraft restraint system that conforms to all flight and ground cargo restraint and occupant protection requirements of EASA CS-25 or 14 CFR Part 25, including the 9,0 g forward ultimate inertia force of § 25.561 (b)(3)(ii).

NOTE Type 1 ULDs are not shown in this document. Refer to ISO 8097:2001 (NAS 3610 revision 10).

Type 2: ULDs designed for use in an approved aircraft cargo compartment and restraint system that conforms to the flight and ground cargo restraint and occupant protection requirements of CCAR-25, JAS Part 3, EASA CS-25 or 14 CFR Part 25, except for the 9,0 g forward ultimate inertia force of § 25.561(b) (3) (ii), which is complied with either by supplementary installation of a barrier net or bulkhead, or by specifying an approved placement of the ULD in the aircraft.

4.2 Sizes

This document provides for the sizes of unit load devices listed in Table 1, expressed as nominal dimensions in the overall plan form of a pallet or a container base, in mm (inches).

NOTE Throughout this document, dimensions are expressed in SI units, with inch/pound system values additionally shown between brackets in order to conform to international air cargo industry usage.

Table 1 — Sizes

Size	Nominal dimension
A	2 235 mm × 3 175 mm (88 in × 125 in)
B	2 235 mm × 2 743 mm (88 in × 108 in)
G	2 438 mm × 6 058 mm (96 in × 238.5 in)
K	1 534 mm × 1 562 mm (60.4 in × 61.5 in)
L	1 534 mm × 3 175 mm (60.4 in × 125 in)
M	2 438 mm × 3 175 mm (96 in × 125 in)
N	1 562 mm × 2 438 mm (61.5 in × 96 in)
P	1 198 mm × 1 534 mm (47 in × 60.4 in)
Q	1 534 mm × 2 438 mm (60.4 in × 96 in)
R	2 438 mm × 4 978 mm (96 in × 196 in)
S	1 562 mm × 2 235 mm (61.5 in × 88 in)
NOTE Size codes C, D, E, F, H, I, J, O have been intentionally omitted in this document in order to be in agreement with the industry's (IATA ULD Regulations) identification coding system.	

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4.3 Configurations

4.3.1 This document provides for variations of configuration among pallets, nets and containers of the same type and size, specified in Clause 8 and listed in Table 2. Variations in pallet/net attachment and special interface requirements between components of unit load devices when affecting airworthiness are specified by the configuration drawings. Configurations are denoted by sequence numbers and are identified in accordance with 4.5.

4.3.2 The applicable restraint conditions to be used for testing each unit load device configuration are specified in Clause 9 and listed in Table 18, based on testing of worst-case analysis.

4.3.3 The ULD restraint conditions and ultimate loads included herein are intended to represent a worst-case capability for the ULD. They are not intended to represent aircraft cargo handling system restraint designs. Actual aircraft implementations may vary from the ULD test parameters stated herein in such areas as number and spacing of restraints, among others, as long as they stay within the worst-case ULD capabilities.

4.4 Forms

Form C = Container

Form N = Net

Form P = Pallet

4.5 Classification identifier

The pallets, nets, and containers described in this document shall be identified by the numbers derived as shown. Types, sizes, configurations, and forms shall be limited to those in configuration drawings. “ISO 21100-2A7P” = Type 2, Size A (2 235 mm × 3 175 mm, 88 in × 125 in), Configuration sequence A7, Pallet.

5 Performance requirements

5.1 Materials

The suitability and durability of materials used shall be established on the basis of experience or tests. Materials shall conform to approved industry specifications that ensure their having the strength and other properties specified in the design data.

5.2 Fabrication methods and workmanship

The methods of fabrication used shall produce a consistently sound structure. If the fabrication processes (such as gluing or heat treatment) require close control to reach their objectives, the processes shall be performed under an approved process specification. Workmanship shall be consistent with high-grade aircraft manufacturing practices.

5.3 Protection

All components of the unit load devices shall be suitably protected against deterioration or loss of strength in service due to weathering, corrosion, abrasion or other causes where the type of material used requires such protection. The unit load device shall have provisions for ventilation or drainage where necessary for protection.

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5.4 Construction

The unit load device shall be constructed to adequately encompass the cargo and shall provide for proper support and restraint of the cargo. All components shall be designed to withstand rough handling. The design shall minimize the possibility of improper installation. All pallet/net attachment devices shall conform to ISO 7166 track and stud configuration, for single stud fittings, or ISO 9788 for double stud fittings.

5.5 Marking

Each pallet, net, and container shall be legibly and permanently marked in an area clearly visible after the article is loaded with cargo, with the following information:

a) the name and address of the manufacturer;

b) the weight of the article to the nearest kilogram or pound, with the applicable unit;

c) the serial number and date of manufacture;

d) the part number of the article and its identification in the code system set out in 4.5;

e) if the article is not omni-directional, the words “FORWARD”, “AFT”, and “SIDE” shall be conspicuously and appropriately placed;

f) the burning rate determined for the article under 5.7;

g) the applicable TSO (Technical Standard Order) approval number;

h) any limitations or restrictions.

5.6 Inspection provisions

There shall be means to allow close examination of each part requiring inspection, adjustment, or lubrication.

5.7 Fire protection

It is presupposed that the materials used in the construction of pallets, nets, and containers meet the appropriate provisions set forth in CCAR-25, JAS Part 3, EASA CS-25 or 14 CFR Part 25 Appendix F.

5.8 Rapid decompression

Unit load devices shall be designed to protect the airplane structure and the occupants as result of a sudden release of pressure. The suitability of the design shall be established by analysis and/or tests or numeric simulation. ISO 11242 specifies the requirements and possible methods.

5.9 Dimensions and tolerances

Each pallet, net, and container of a given configuration shall conform to the requirements specified by the drawing for that configuration. General tolerances for all configuration drawings, unless otherwise noted, are ±0,01 mm for two places decimals, ±0,1 mm for one place decimals, ±1 mm without a decimal (in inches: ±0.01 in for three place decimals, ±0.03 in for two place decimals, ±0.1 in for one place decimals).

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5.10 Strength

5.10.1 Ultimate load criteria

5.10.1.1 Ultimate loads for each unit load device configuration are specified in the page defining that configuration. These loads shall be considered as acting separately, except as noted, and shall be applied in accordance with the specified centre of gravity limits, which shall be taken into account simultaneously.

5.10.1.2 Longitudinal eccentricity is expressed in percentage of the longitudinal dimension of a pallet or container base, and it is measured from the lateral centreline of the pallet or container base. Longitudinal dimensions correspond to the forward and aft directions specified by the plan views in applicable figures.

5.10.1.3 Lateral eccentricity is expressed in percentage of the lateral dimension of a pallet or container base, and it is measured from its longitudinal centreline. Plus and minus signs indicate forward and aft directions from the lateral centreline, and right and left directions from the longitudinal centreline of the pallet or container base respectively.

5.10.1.4 Centre of gravity height is expressed in mm (inches) above the bottom surface of pallet or container base.

5.10.2 Restraint criteria

Restraint system details for each restraint condition are specified by the figure referenced in restraint drawing. Tolerances for the restraint system are the same as those specified in 5.9 for configuration drawings.

5.10.3 Pallets and nets

5.10.3.1 If a pallet (or net) is to be substantiated individually, a qualified net (or pallet) of the same configuration code may be assumed for analysis or used for test. A qualified and compatible net (or pallet) of different configuration code may be used provided it equals or exceeds the strength requirements of the pallet (or net) being substantiated. For substantiating a net, any net tensioning devices shall be engaged: a pallet doesn't need to be used for testing, provided that all net fittings are at the locations specified in the unit load device configuration.

5.10.3.2 Pallet edge tracks and net fittings shall conform to the geometric and tolerance requirements of ISO 7166 or, in the case of double stud fittings, ISO 9788, or equivalent with at least equal ultimate strength.

5.10.3.3 All net fittings incorporating a single tie-down stud for attachment to pallets shall have a minimum ultimate load capacity of 8 900 N (2 000 lbf) in all directions, horizontal to vertical. Double stud tie-down fittings shall have a minimum ultimate load capacity of 17 800 N (4 000 lbf) in all directions, horizontal to vertical. The load application point shall be 21 mm (0.83 in) or less from the head end of the stud.

5.10.3.4 Except where otherwise stated, all track-type single stud tie down receptacles incorporated in the pallet construction shall have a minimum ultimate load capacity of 8 900 N (2 000 lbf), or 22 250 N (5 000 lbf) for a double stud receptacle, in all directions, horizontal to vertical. The load application point shall be 23 mm (0.90 in) or more from the bottom of the track groove.

5.10.3.5 It is presupposed that pallets edge tracks withstand without rupture an ultimate load of 22 250 N (5 000 lbf) applied in any direction through a double stud fitting meeting the requirements of ISO 9788, for a duration of 3 seconds in accordance with CCAR-25, JAS Part 3, EASA CS-25 or 14 CFR Part 25 § 25.305(b). The load application point shall be 23 mm (0,90 in) or more from the bottom of the track groove.

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5.10.4 Base performance

5.10.4.1 Minimum base area loads for each unit load device configuration are specified in the page defining that configuration. These loads shall be applicable to any area representing at least 10 % of the total base area, while the unit load device is supported by the aircraft system. All unit load devices (containers or pallets) bases shall have a minimum area load capacity of 10 kPa (209 lbf/ft^2).

5.10.4.2 All pallet base edges shall have a minimum vertical EI value of 5×10^7 N·cm^2 (1.75×10^6 lbf·in^2).

5.10.4.3 All container base edges shall have a uniform cross section and a minimum vertical EI value of 5×10^7 N·cm^2 (1.75×10^6 lbf·in^2). However, the doorway side base edge of 1 562 mm (61.5 in) or less wide containers shall have a uniform cross section and a minimum EI value of $2{,}5 \times 10^7$ N·cm^2 (8.75×10^5 lbf·in^2).

Local deviations in uniformity are allowable at specific locations (e.g., corner fittings, identification recesses, track tie-down receptacles, forklift tineways, or similar).

5.10.4.4 All ULD base edge profiles shall be rounded or chamfered in order to ensure a smooth interface with aircraft unit load device conveyance and restraint systems.

5.11 Environmental degradation

The materials used in the construction of pallets, nets, and containers shall take into account the effects of environment conditions, such as temperature, humidity, and UV (ultra violet) degradation, expected in service.

6 Tests

6.1 Test requirements

Tests and/or analysis or numeric simulation shall be conducted as necessary to show compliance with this document.

6.2 Test parameters

Tests for any given ULD configuration shall be conducted using the maximum ultimate loads and centre of gravity deviations shown in this document for that ULD configuration, with the ULD being restrained in accordance with the indicated testing restraint condition(s). Analysis or numeric simulation, if used, shall use the same assumptions.

Pallets shall be tested in combination with an approved net of the same size and configuration. Nets do not need to be tested in combination with a pallet, but their attachment fittings shall be located in accordance with the applicable ULD configuration drawing.

6.3 Test methods

The method(s) used for testing any ULD configuration shall ensure conformity with the testing conditions and ultimate load parameters specified for that configuration in this document. It is presupposed that the ultimate load is applied in each specified direction for a minimum duration of 3 s, in accordance with CCAR-25, JAS Part 3, EASA CS-25 or 14 CFR Part 25 § 25.305 (b). Analysis or numeric simulation, if used, shall provide an equivalent assurance of conformity guarantee. A test and/or analysis report shall be established to record the details of the method(s) used and substantiate the results obtained.

NOTE When two ULD sides (e.g. opposite ones) and the corresponding restraint conditions are identical, testing can be performed on one side only.

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6.4 Test results

Under ultimate load, the tested ULD or parts thereof may exhibit damage or permanent deformation, but shall not deform or rupture to the extent of discharging its contents. Analysis or numeric simulation, if used, shall confirm that the ULD would not deform or rupture to the extent its contents would be discharged under the test conditions.

7 Additional information

7.1 Intended use

Type 2 nets, pallets, and containers (ULDs) described in this document are intended for use only in an approved aircraft cargo compartment and restraint system where compliance with the 9,0 g forward ultimate inertia force of CCAR-25, JAS Part 3, EASA CS-25 or 14 CFR Part 25 § 25.561 (b)(3)(ii) is achieved either by supplementary installation of a barrier net or bulkhead, or by specified approved placement of the ULD in the aircraft.

NOTE Type 1 ULDs are not shown in this document. Refer to ISO 8097:2001 (NAS 3610 revision 10).

7.2 Unit load device capacities

Maximum gross weight capacities are not shown for the unit load devices covered by this document. Actual gross weight limits for devices in a given airplane are determined in compliance with CCAR-25, JAS Part 3, EASA CS-25 or 14 CFR Part 25 and listed in the approved Weight and Balance Manual for that airplane.

7.3 Container contours

Performance and testing parameters are independent from container contours, which hence are not shown in this document. Maximum allowable container contours shall provide clearance from the relevant aircraft cargo compartment's inner envelope. Contours shall be determined for the intended aircraft types or compartments in accordance with ISO 10046.

7.4 Pallet configurations

Pallet configuration drawings indicate net attachment points. Continuous edge track is allowable all around the pallet's periphery, except where differently noted.

8 Unit load device configurations

8.1 General

Unit load devices configurations, characteristics, and ultimate load capacities shall conform to the relevant ULD configuration subclause. See Table 2.

NOTE 1 The net attachment points shown on ULD configuration drawings do not, or not entirely, apply to containers.

NOTE 2 Configuration drawings are not on scale.

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Table 2 — ULD configurations

ULD configuration	Type	Applicable to:			Nominal base dimensions	Minimum base area load	Sub-clause
(UC)		C	P	N	mm (inches)	kPa (lb/ft^2)	
A7	2	X	X	X	2 235 × 3 175 (88 × 125)	10 (209)	8.2
A8	2	X	X	X	2 235 × 3 175 (88 × 125)	10 (209)	8.3
B7	2	X	X	X	2 235 × 2 743 (88 × 108)	10 (209)	8.4
B8	2	X	X	X	2 235 × 2 743 (88 × 108)	10 (209)	8.5
G1	2	X	X	X	2 438 × 6 058 (96 × 238.5)	20 (418)	8.6
K4	2	X	X	X	1 534 × 1 562 (60.4 × 61.5)	10 (209)	8.7
L5	2	X	X	X	1 534 × 3 175 (60.4 × 125)	10 (209)	8.8
L6	2		X	X	1 534 × 3 175 (60.4 × 125)	10 (209)	8.9
M4	2	X	X	X	2 438 × 3 175 (96 × 125)	10 (209)	8.10
M5	2	X	X	X	2 438 × 3 175 (96 × 125)	10 (209)	8.11
N1	2	X	X	X	1 562 × 2 438 (61.5 × 96)	10 (209)	8.12
P1	2	X			1 198 × 1 534 (47 × 60.4)	10 (209)	8.13
Q1	2	X			1 534 × 2 438 (60.4 × 96)	10 (209)	8.14
R1	2	X	X	X	2 438 × 4 978 (96 × 196)	20 (418)	8.15
S1	2	X	X	X	1 562 × 2 235 (61.5 × 88)	10 (209)	8.16

NOTE ULD configuration sequence codes A7, A8, B7, B8, K4, L5, L6, M4, M5 were assigned in order to differentiate from former ISO 8097 (NAS 3610) ULD configurations, with non-identical maximum CG eccentricities and/or with non-identical lateral ultimate load criteria.

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