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Air cargo — Restraint slings —

Part 1: Design and testing

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Partie 1: Conception et essais

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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*.

A list of all parts in the ISO 20291 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

The aim of this document is to standardize the design and testing requirements for air cargo restraint sling assemblies used as an alternate to restraint straps for tie-down of cargo on board civil transport aircraft.

The civil aviation requirements referred to in this document are those relating to the design of transport aircraft. They constitute the set of design requirements internationally agreed in the application of International Civil Aviation Organization (ICAO) Annex 6, *Airworthiness 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 of primary importance in providing safe air cargo restraint sling assemblies. Deviation from the recommended criteria should only occur after careful consideration and thorough service evaluation have shown that alternate methods can be used to provide an equivalent 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 countries using that system.

Sling or cable assemblies made of steel wire rope are intended to be used in lieu of cargo restraint straps meeting the requirements of ISO 16049-1, where straps inherent elongation under tension appears unadvisable for a given tie-down arrangement. Typical examples of loads where substitution of cables for straps throughout a given tie-down arrangement can be advisable are those for which even limited movement during flight can be hazardous, such as heavy vehicles, aircraft engine stands, helicopters, machinery.

On the date of publication of this document, no airworthiness approval procedure by Civil Aviation Authorities is applicable to restraint slings. Their use for cargo restraint, however, remains subject to the requirements of the approved aircraft type or sub-type Weight and Balance Manual (see ISO 20291-2).

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Air cargo — Restraint slings —

Part 1: Design and testing

1 Scope

This document specifies the design criteria and testing methods adequate to guarantee the ultimate strength and operational dependability of cargo restraint sling assemblies made of steel wire rope, with a 22,25 kN (5 000 lbf) rated ultimate load capability, as can be used by the airline industry in order to restrain on board civil transport aircraft during flight, including the following:

— 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

— 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, to be restrained onto aircraft structure attachment (tie-down) points.

Two types of wire rope restraint slings are defined:

a) type A: adjustable length restraint sling assemblies, including a tension retaining device and termination fittings attached to the wire rope end eyes;

b) type B: fixed length restraint sling extensions, to be used in conjunction with a type A cable; extensions are usually terminated at both ends by eyes, without additional fittings, and can be attached through hooks or shackles.

The cables specified in this document are intended exclusively for restraint purposes on board aircraft, and not for use as lifting slings.

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 2408, *Steel wire ropes — Requirements*

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

ISO 4171, *Air cargo equipment — Interline pallets*

ISO 4346, *Steel wire ropes for general purposes — Lubricants — Basic requirements*

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

ISO 7531, *Wire rope slings for general purposes — Characteristics and specifications*

ISO 7597, *Forged steel lifting hooks with latch, grade 8*

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

ISO 8793, *Steel wire ropes — Ferrule-secured eye terminations*

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ISO 8794, *Steel wire ropes — Spliced eye terminations for slings*

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

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

ISO 17893, *Steel wire ropes — Vocabulary, designation and classification*

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, ISO 17893 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

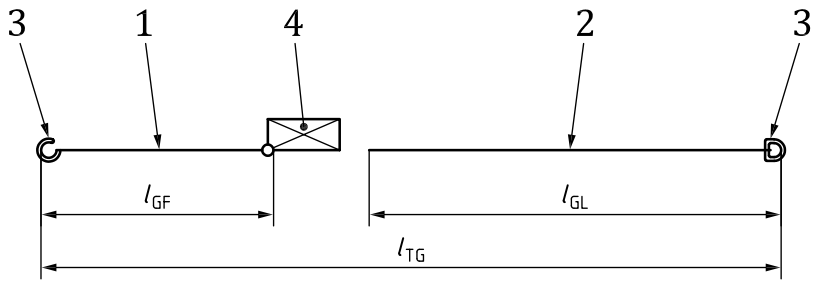
— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
restraint sling assembly
type A
elementary *tie-down* (3.3) unit made of steel wire rope cable with *end fittings* (3.6) and *tension retaining device* (3.5), used for restraint of cargo on board civil transport aircraft

Note 1 to entry: It consists of 1 (one) *fixed length* (3.8.1) end and one adjustable end and can be used in conjunction with one or two extensions(s).

Note 2 to entry: See Figure 1.



Key

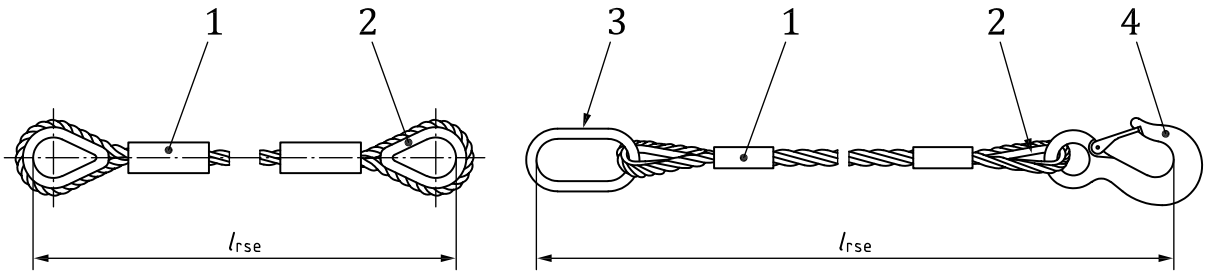
1 fixed end
2 adjustable end
3 end fitting
4 tension retaining device
l_{GF} fixed length
l_{GL} *adjustable length* (3.8.2)
l_{TG} *total length* (3.8.3)

Figure 1 — Adjustable (type A) restraint sling assembly

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3.2
restraint sling extension
type B
fixed length (3.8.1) steel wire rope (cable) with end eyes but no *tension retaining device* (3.5), with or without *end fittings* (3.6), used in conjunction with a *restraint sling assembly* (3.1) to extend usable length between attachment points

Note 1 to entry: See Figure 2.



Key

1 ferrule
2 thimble
3 end fitting (ring)
4 end fitting (hook)
l_{rse} *length of restraint sling extension* (3.9)

Figure 2 — Fixed length (type B) restraint sling extensions

3.3
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 devices against each direction of restraint

3.4
tensioning device
mechanical device inducing and maintaining a tensile force in the load restraint assembly

EXAMPLE Lever, ratchet, winch, cam, over-centre device, or equivalent.

3.5
tension retaining device
part connecting to the wire rope and retaining any force induced between the ends of the assembly

3.6
end fitting
connecting component
metallic device connecting a wire rope end to the attachment point on the aircraft structure, the pallet edge track, another restraint element, or the load to be restrained

Note 1 to entry: See examples in Figure 3, D1 to D3.

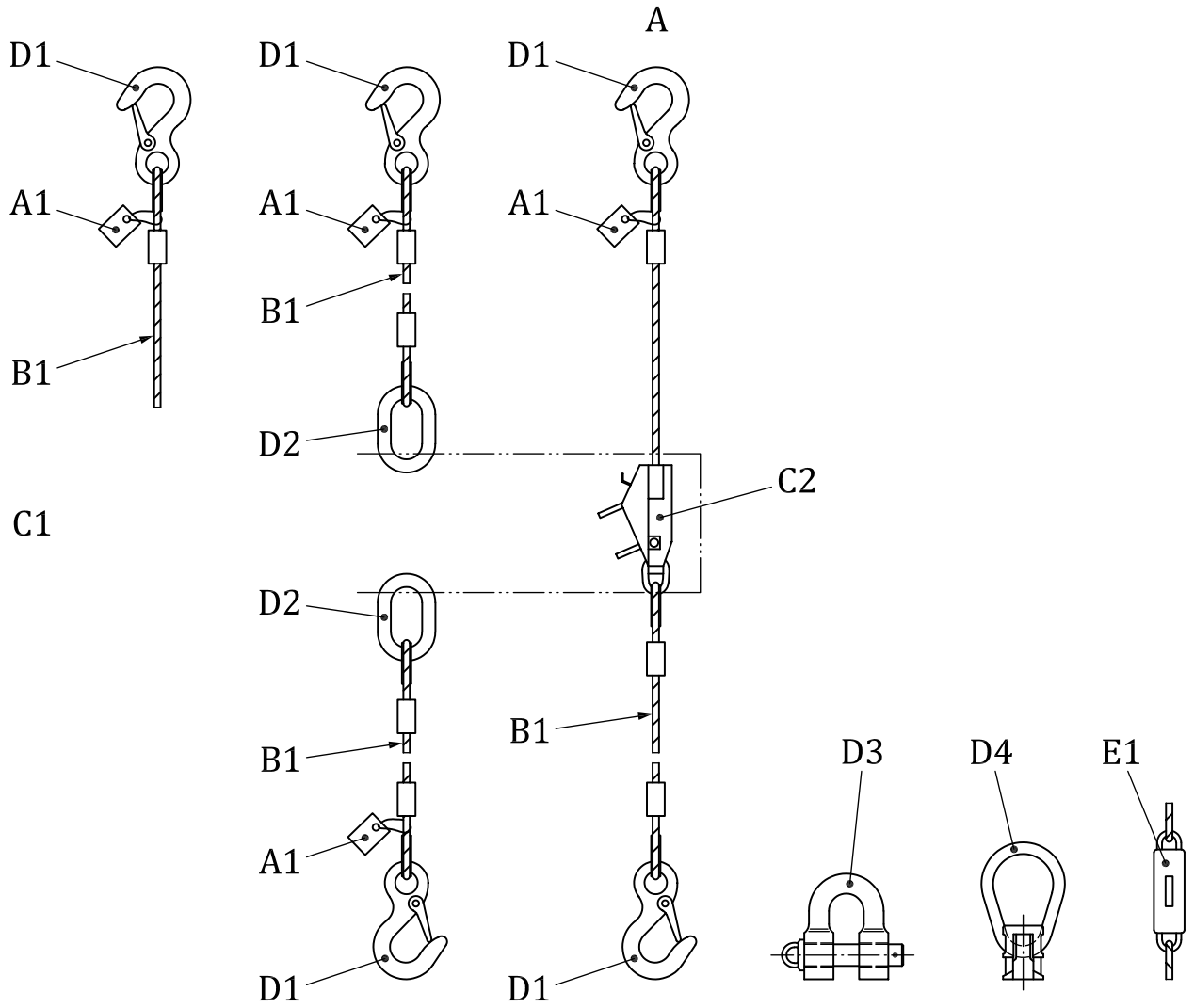
Note 2 to entry: The end fittings most commonly used on air cargo restraint slings include:

a) retainer or latch equipped hook (see example in Figure 3, D1),

b) air cargo *tie-down* (3.3) double stud (male) fitting (see example in Figure 3, D4) conforming to ISO 9788, connected to the cable directly or through an intermediate ring,

c) ring (see example in Figure 3, D2) or wire rope end loop (eye) compatible with hooks.

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Key

A	restraint sling assembly (complete)	**D**	connecting elements
A1	marking (label)	**D1**	hook with retainer or latch
B	tension holding element	**D2**	end ring
B1	steel wire rope	**D3**	shackle with steel pin
C	*tensioning device* (3.4) (optional)	**D4**	double stud tie-down fitting
C1	possible tension arrangement	**E1**	*tension force indicator* (3.7)
C2	example of rope tensioner	**D**	connecting elements

Figure 3 — Examples of restraint sling equipment

3.7
tension force indicator
device that indicates the tensile force applied to the *restraint sling assembly* (3.1)

Note 1 to entry: See example in Figure 3, C.

3.8 length of restraint sling assembly

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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 wire rope to the *tension retaining device* (3.5)

Note 1 to entry: See Figure 1.

Note 2 to entry: This length can be zero, i.e., the end fitting directly attached to the *tensioning device* (3.4).

3.8.2
adjustable length
l_{GL}
maximum length of an adjustable end, measured from the tension device to the force bearing point of the *end fitting* (3.6)

Note 1 to entry: See Figure 1.

3.8.3
total length
l_{TG}
sum of *fixed length* (3.8.1), *adjustable length* (3.8.2) and length of the *tension retaining device* (3.5)

3.9
length of restraint sling extension
l_{rse}
length measured between the force bearing points of each terminal, whether thimbles, hooks or rings

Note 1 to entry: See Figure 2.

3.10
breaking force
BF
maximum force that the *restraint sling assembly* (3.1) withstands when tested in a complete form, i.e. with *tension retaining device* (3.5) and *end fittings* (3.6)

3.11
hand force
HF
force applied to adjust, latch, or unlatch the *restraint sling assembly* (3.1)

3.12
limit load
LL
maximum load to be expected in service

Note 1 to entry: See CAAC CCAR-25, CS-25, JAS Part 3 or 14 CFR Part 25, § 25,301 (a).

Note 2 to entry: It is two thirds of *ultimate load* (3.13), i.e. 14,8 kN (3 333 lbf) for a rated ultimate load of 22,2 kN (5 000 lbf).

3.13
ultimate load
UL
limit load (3.12) multiplied by a safety factor of 1,5

Note 1 to entry: See CAAC CCAR-25, CS-25, JAS Part 3 or 14 CFR Part 25, § 25,303.

Note 2 to entry: It is used for computation of cargo *tie-down* (3.3) arrangements, based on the ultimate load factors defined in the aircraft Weight and Balance Manual in each direction of restraint, throughout the certified flight envelope of the aircraft type. The *restraint sling assembly's* (3.1) rated ultimate load must not exceed the measured *breaking force (BF)* (3.10).

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3.14
residual tension
tension force which can be measured in the rope of a cable assembly attached between two fixed points, after its length was adjusted and it was operated and latched with the reference *hand force (HF)* (3.11), prior to application of any external load

3.15
competent person
designated person, suitably trained, 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 ISO 9001:2015, 7.2.

4 Design requirements

4.1 General

4.1.1 Unless otherwise specified, the design requirements hereafter equally apply to type A and type B restraint slings as defined in Clause 1.

4.1.2 This document specifies the design criteria for individual restraint sling assemblies but does not intend to specify 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 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 cables to be used in each direction of restraint, maximum angles to be observed with the direction of restraint, minimum spacing and ultimate load capacity of attachment points, etc.

4.1.3 When restraint sling assemblies are attached to the edge rails of a certified air cargo pallet meeting the requirements of ISO 8097 (NAS 3610) or ISO 21100 (AS 36100), 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 (NAS 3610) or ISO 21100 (AS 36100) configuration drawing(s).

4.1.4 Subject to proper operating instructions per 4.1.2 and 4.1.3 being defined and complied with, using restraint sling 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 with cables to restrain cargo on board civil transport aircraft can be found in ISO 20291-2.

4.1.5 The restraint sling 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, TSO C90c) or ISO 21100 (AS36100, TSO C90d), or

b) aircraft floor tracks or structural attachment points meeting the requirements of ISO 7166,

either directly or using ISO 9788 double stud tie-down fittings as intermediate attachment hardware.

4.2 Construction

4.2.1 Wire rope shall meet the requirements of ISO 2408, should be of ISO 2408:2017, Annex C class 6x7-FC or 6x7-IWRC, grade 1 960 N/mm^2, 6 mm (0.25 in) diameter, of minimum breaking force 23,4 kN or 25,3 kN, and should be galvanized (zinc-coated) or stainless steel, of a construction appropriate to guarantee the required breaking force while keeping maximum flexibility.

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