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Air cargo equipment — Air cargo pallets — Utilization guidelines

Equipement de fret aérien — Palettes de fret aérien — Directives d'utilisation

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 16412 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 9, *Air cargo and ground equipment*.

Introduction

Air cargo pallets and their cargo restraint nets constitute aircraft unit load devices (ULD), defined by industry standards and airworthiness certified to technical standard order (TSO) C90c in accordance with the requirements of ISO 8097. This guarantees their design to be intrinsically safe for flight on board compatible aircraft types. However, actual flight safety also requires these certified pieces of equipment to be properly used: numerous occurrences have demonstrated a certified ULD can nevertheless jeopardize flight safety if loaded or restrained in an inadequate manner.

Accordingly, this International Standard aims at providing recognized industry standard methods to achieve the best attainable level of safety when preparing air cargo pallets for loading on board aircraft, taking into account the requirements to be met as a result of the pallet's airworthiness certification requisites, the general requirements expressed in the Aircraft Manufacturers' Weight and Balance Manuals, as well as the various potential areas of concern identified based on experience.

The practical means of compliance with flight safety objectives recommended in this International Standard, are intended to be available as a common base for air carriers (operators) as well as shippers and cargo handling agents when establishing their own in-house publications and staff training programmes.

Throughout this International Standard, 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 pallet build-up arrangements. Deviation from recommended criteria should only occur after careful consideration and thorough service evaluation have shown alternate methods to provide an equivalent level of safety.

Air cargo equipment — Air cargo pallets — Utilization guidelines

1 Scope

This International Standard specifies utilization guidelines to be applied when preparing air cargo pallets for carriage on board civil transport aircraft. It identifies the various concerns to be taken into consideration to ensure flight safety, and provides recognized industry standard methods to achieve it. Commercial requirements in order to ensure protection of the goods carried may also be addressed where applicable, but do not constitute the document's primary goal. It is intended as a guide toward standard practice, and is subject to change to keep pace with experience and technical advances.

NOTE In all countries, standing government regulations apply to air cargo unit load devices airworthiness, continuous airworthiness, and air carriers (operators) certification and operations. This International Standard does not, under any circumstance, supersede the requirements of applicable regulations or the aircraft manufacturer's authority approved weight and balance manual.

This International Standard is applicable to any certified air cargo pallet built up from either a single or a number of pieces of commercial cargo, intended to be loaded on lower, main or upper deck of a civil transport aircraft, whether a freighter or a passenger-carrying aircraft. Its field of application includes all pallets prepared within ground premises, whether at a shipper's facilities or an airport cargo warehouse, including those intended to be loaded into the aircraft in a "floating" position. Its provisions may not entirely apply in the event of "pre-embarked" pallets. In such a case, it is up to the operator to identify and implement the applicable criteria.

This International Standard is not intended to apply to air cargo pallets prepared for military transport aircraft, and does not take into account any specific criteria for military aircraft. Nothing, however, precludes it being used for guidelines in this case, it being the military operator's responsibility to identify and implement any additional applicable criteria.

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

ISO 4171, *Air cargo equipment — Interline pallets*

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

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

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

1) Endorsement of NAS 3610 10th edition.

ISO 16049-2, *Air cargo equipment — Restraint straps — Part 2: Utilization guidelines and lashing calculations*

FAR[2] 14CFR Part 25, *Airworthiness Standards: Transport category airplanes*

FAR[2] 14CFR Part 121, *Air Carriers certification and operation*

Federal Aviation Administration Advisory Circular (AC) 120-59 — *Air Carriers internal evaluation program*

JAR[3] Part 25, *Airworthiness Standards: Transport category aeroplanes*

JAR[3]-OPS 1, *Commercial air transportation (aeroplanes)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
air cargo pallet
any type and size of Class II airworthiness certified aircraft pallet in accordance with ISO 8097:2001

NOTE An air cargo pallet may meet the requirements of either ISO 4117 [heavy duty, stiff, typically 50 mm (2 in) thick, units] or ISO 4171 (most units consist of an aluminium plate base). Used in conjunction with an appropriate pallet net, which may meet the requirements of either ISO 4115 or ISO 4170, it constitutes a complete unit load device.

3.2
pallet net
any type or size of Class II airworthiness certified aircraft pallet net in accordance with ISO 8097:2001

3.3
operator
airline
carrier
entity authorized by an Air carrier Operator Certificate (AOC) from its national Civil Aviation Authority to operate civil transport aircraft flights for commercial carriage of passengers, cargo or mail

NOTE The operator holds responsibility for compliance with Civil Aviation Authorities Regulations on its flights, including when the relevant tasks are performed by sub-contractors.

3.4
floating pallet
air cargo pallet loaded into the aircraft over more than one pallet position, and not fully restrained by the aircraft restraint system

NOTE A floating pallet requires cargo tie-down directly on to the aircraft's structure instead of the pallet's tracks.

3.5
pre-embarked pallet
air cargo pallet loaded empty into the aircraft to be used as a floor on which cargo is later brought and palletized inside the cargo compartment

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2) FAR, *Federal Aviation Regulations*. FAR 14CFR Part 25 constitutes the U.S.A. government transport aircraft airworthiness Regulations, and Part 121 its Regulations applicable to air carriers certification and operation. They can be obtained from the US Government Printing Office, Mail Stop SSOP, Washington DC 20402-9328, U.S.A.

3) JAR, *Joint Aviation Regulations*. JAR Part 25 constitutes the European government's transport aircraft airworthiness regulations and JAR-OPS 1 its regulations applicable to carriers certification and operation. They can be obtained from JAA Headquarters, Saturnusstraat 8-10, P.O. Box 3000, NL 2130 KA Hoofddorp, Netherlands.

NOTE A pre-embarked pallet may or may not be fully restrained by the aircraft restraint system. If it is not, it is also a floating pallet.

3.6
heavy duty pallet
any type or size of Class I or II certified aircraft pallet in accordance with ISO 8097:2001 and with a base core stiffness (E.I. value) of 25×10^6 N·cm^2 per centimetre width of core (2×10^6 lb·in^2 per inch width of core) or more

3.7
pallet extension
pallet wing
device (usually a pair of symmetrical devices) used to extend the contour of an air cargo pallet's load out of its base footprint on the lower deck of wide-bodied aircraft

3.8
wooden pallet
warehouse pallet
any type and size of industrial forkliftable pallet for general use, made of wood or similar materials, used to facilitate handling and stacking of individual pieces of cargo

3.9
shoring
load spreading (method)
spreader stand (equipment)
methods or equipment used to evenly distribute a concentrated cargo load over an air cargo pallet's surface in order to meet the applicable aircraft floor load limitations

3.10
air cargo restraint strap
tie-down strap
elementary tie-down unit consisting of flat woven textile webbing, a tensioning device and two end fittings

[ISO 16049-1]

3.11
lashing GB
tie-down US
methods or equipment used to ensure proper restraint of cargo on to a pallet's edge track or aircraft structure, to replace or complement net restraint when necessary

4 General requirements

4.1 General

4.1.1 Any air cargo pallet and its net shall, prior to release for loading on board an aircraft, be inspected and found satisfactory by competent, suitably-trained personnel who are responsible for checking that it meets all applicable flight safety requirements. See 5.1 and 10.3.

4.1.2 All general requirements in 4.2 to 4.7 shall be met on completion of every pallet build-up process, and checked by the responsible agent prior to pallet release for loading on board an aircraft.

4.2 Mass

4.2.1 The completed pallet's gross mass shall be systematically established by actual weighing on a scale with an accuracy of ± 1 % or better, prior to the pallet being released for loading on to aircraft. This mass shall be entered and used throughout the flight's mass and balance documentation.

4.2.2 The pallet's gross mass shall not exceed its own certified maximum gross mass, as engraved on its edge track, or the rated maximum value for the position it is intended to be loaded on in the aircraft or, when the position or the aircraft type is unknown at the time of build-up, the lowest of the possible (e.g. lower, main or upper deck position) maximum values (whichever is less).

4.3 Area load

4.3.1 The mass loaded on to any given area of significant size (typically more than 10 % to 20 % of the pallet's surface) should meet the maximum area load limitation specified in the weight and balance manual for the lower, main or upper deck position on which it is intended to be loaded in the aircraft.

What shall be taken into account to verify area load limitation is the total bearing area, i.e. that of the outer perimeter defined by all contact points of the load onto the pallet.

NOTE Area load is not to be mistaken for local load (the load divided by the actual contact area). Local load limitations may or may not be defined in the aircraft's weight and balance manual, but they seldom are critical for aircraft structural safety on typical air cargo pallets. They may raise concern only when they result in significant local deformation of the pallet sheet, which may result in difficulties in moving over roller conveyors (a reliable factual indication of excessive deformation) or affect pallet restraint hardware functionality. This should be taken care of by increasing the actual contact bearing area through intermediate elements, such as wood, plywood or wooden pallets between load supports and pallet sheet.

4.3.2 Whenever the aircraft type is unknown at the time of build-up, a maximum area load limitation of 975 $kg \cdot m^{-2}$ (200 lb/ft^2) for ISO 4171 type pallets or 1 950 $kg \cdot m^{-2}$ (400 lb/ft^2) for ISO 4117 type or heavy duty pallets may be used.

4.3.3 Any deviations in specific circumstances should be allowed only to the extent determined by an operator-performed specific engineering study taking into account the characteristics of the load and the pallet, the overall pallet centre of gravity location, and structural allowances of the aircraft's manufacturer.

4.3.4 Elementary shoring procedures such as using wooden pallets to enlarge a cargo's footprint on the pallet should be considered first and are in many circumstances sufficient to ensure compliance with the maximum area load restriction. In very heavy or concentrated load cases, study and implementation of a proper shoring arrangement may be necessary. See Clause 6.

4.4 Running load

4.4.1 The aircraft floor's maximum running load, in $kg \cdot m^{-1}$ (lb/in) measured parallel to the aircraft's centerline, is usually met by complying with the pallet position's maximum permissible gross weight.

4.4.2 For heavy and concentrated loads shorter than the pallet, a running load check may be necessary when the load's dimension measured parallel to the aircraft's centerline exceeds two fuselage frame spacings, i.e. 1,0 m to 1,2 m (40 in to 50 in). In such a case, a shoring calculation taking into account the pallet's stiffness/load distribution effectiveness is required, and may result in the necessity of longitudinal shoring. See Clause 6.

4.4.3 When a piece of cargo overhangs the pallet parallel to the aircraft's centerline and prevents the adjacent pallet position(s) in the aircraft from being occupied, the total running load for the pallet may sometimes be determined based on the total floor length occupied in the aircraft, subject to compliance with the area load limitation and all other requirements of the weight and balance manual, should this result in exceeding the pallet position's own certified maximum gross weight or other limits, with restraint or additional restraint being performed directly on the aircraft structure.

4.5 CG location (plan view)

4.5.1 The pallet load's overall centre of gravity (CG) shall be within the maximum plan view limits specified at maximum gross mass by the pallet's certification configuration in accordance with ISO 8097.

NOTE The pallet's certification configuration in accordance with ISO 8097 is engraved or permanently marked on the pallet edge rail (e.g. "NAS 3610 — 2A6P" for configuration 2A6), at a location selected to remain legible after the pallet has been loaded with cargo.

4.5.2 If there is uncertainty about the CG. limits to be used for the pallet on hand, a ± 10 % of pallet length and width (± 5 % in length for ISO 4117 sizes) maximum CG deviation from pallet geometric centre may generally be used (refer to the aircraft's weight and balance manual).

4.5.3 For a load lower than the pallet position's maximum gross mass, CG deviation in excess of 10 % may be considered subject to the stated rules and requirements in the aircraft's weight and balance manual. Linear extrapolation of maximum permissible CG limits versus pallet position maximum gross mass may generally be applied, if required, in one direction only.

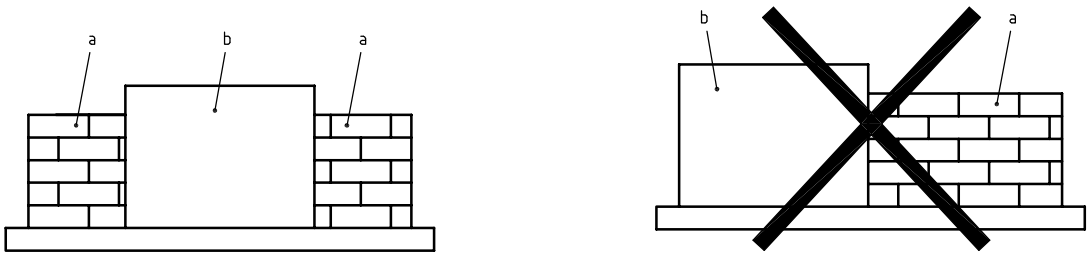
4.5.4 Whenever possible, which is in most circumstances, it is recommended never to simultaneously use maximum permissible CG deviation in both the pallet's length and width directions.

4.5.5 The methods to be used to control the load's overall CG location, vary depending on their nature:

— for a heavy single piece of cargo, the piece's CG location should be marked by the shipper or, if not, physically measured balancing the piece with a forklift or equivalent lifting means;

— for package cargo of homogeneous nature and density, the CG location can be assessed and controlled by ensuring an even level of stacking throughout the pallet's surface;

— in the event of significantly different densities of cargo being loaded on to the same pallet, care should be taken when stacking to ensure symmetrical loading (see example in Figure 1).



a) Right **b) Wrong**

a Low density.

b High density.

Figure 1 — Examples of high and low density mix

4.6 CG location (height)

4.6.1 The pallet load's overall centre of gravity (CG) shall be within the maximum height limit specified at maximum gross mass by the pallet's certification configuration in accordance with ISO 8097 or the aircraft's weight and balance manual.

NOTE The pallet's certification configuration, in accordance with ISO 8097, is engraved or permanently marked on the pallet edge (e.g. "NAS 3610 — 2A6P" for configuration 2A6), at a location selected to remain legible after the pallet has been loaded with cargo.

4.6.2 If there is uncertainty about the maximum CG. height to be used for the pallet on hand, a maximum of half the pallet contour's maximum height may, in most cases, be used, when the contour height does not exceed 2,44 m (8 ft).

4.6.3 For a load lower than the pallet position's maximum gross mass, greater CG heights may be considered, subject to the stated rules and requirements in the aircraft's weight and balance manual. Linear extrapolation of maximum permissible CG height versus pallet position maximum gross mass may generally be applied, if required.

4.6.4 Whenever possible, which is in most circumstances, it is recommended never to simultaneously use maximum permissible CG deviation in both the height and plan view directions.

4.6.5 The methods to be used to control the load's overall CG height vary depending on their nature:

— for a heavy single piece of cargo, the piece's CG height should be marked by the shipper or, if not, calculated or physically measured;

— for stacked smaller cargo, overall CG height can be assessed and controlled by ensuring any higher density cargo is loaded first at the bottom of the pallet stack: see 5.2.2.

4.7 Contour

4.7.1 The pallet load, once completed, shall not exceed the maximum permissible pallet contour for the aircraft position on which it is intended to be loaded. In most circumstances this is one of the standard contours defined by the industry for either lower deck or main/upper deck loading on commonly operated transport aircraft types (see 4.7.3).

Where an aircraft pallet position has a special contour and cannot safely accommodate a pallet built up to a standard industry contour, the operator shall provide pallet build-up agents with a precise definition of the maximum contour to be met, and should, where useful, consider mandating the use of a pallet contour template as a means of checking it.

4.7.2 The principles for defining maximum permissible pallet contours are specified in ISO 10046: the pallet contour's minimum clearance from the aircraft internal envelope shall be 100 mm (4 in), 75 mm (3 in) on the top. Net hardware may be within this clearance, providing it remains at any point at least 50 mm (2 in) clear from the aircraft envelope.

4.7.3 Except where cargo overhang (see 4.7.4) is allowed, the maximum pallet contour's outer plan view limits shall be vertical and inset by a minimum of 50 mm (2 in) from the pallet's outer edges. The net hardware may be within this clearance, providing it remains at any point inside the vertical planes of the pallet edges.

NOTE The industry-agreed standard pallet contours are shown in IATA ULD Technical Manual 50/0 [20] Appendix E, and are compatible with the aircraft types listed in that manual's Appendix F.

4.7.4 Cargo overhang outside the thus defined maximum pallet contour may be allowed only horizontally, and where sufficient clear space exists at the intended aircraft position. Any overhanging cargo shall keep a minimum 50 mm (2 in) clearance from any part of the aircraft internal envelope or any adjacent pallet position. Appropriate additional restraint is required (see 8.2).

4.7.5 Where geometric constraints dictate loading by pallet rotation through the compartment door, the overhang allowance shall ensure that a minimum 50 mm (2 in) clearance from the door frame, and from any part of the aircraft envelope, can be kept at all times through the loading and offloading process.

5 Installation

5.1 Condition check

5.1.1 Each pallet and its net shall be systematically inspected by competent personnel and checked to be in an operative condition prior to being built-up and released for loading on an aircraft.

5.1.2 A pallet shall be deemed inoperative and thus be rejected if it exhibits one or several of the following defects:

— one or several broken or missing corners;

— one missing or loose part of the edge profiles;

— a hole on the base sheet;

— any protrusion, e.g. torn metal, on the underside of the base sheet;

— “dishing” to such an extent that it may not be brought to properly engage the aircraft restraint system;

— pallet worn below minimum dimensional tolerances, if indicated by edge wear indicators.

5.1.3 In addition, an ISO 4117 type pallet shall be deemed inoperative and rejected if it exhibits broken or missing side blocks at two adjacent or three non adjacent side restraint slots.

5.1.4 Inoperative pallets as defined in 5.1.1 and 5.1.2 may only be loaded empty for return to a repair station.

5.1.5 A pallet net shall be deemed inoperative and thus be rejected if it exhibits one or several of the following defects:

— environmental degradation expiry date, if shown on the net’s label, exceeded;

— two or more adjacent cut or missing meshes;

— more than one continuous strand of frayed or otherwise damaged rope or strap;

— missing or inoperative attachment fittings;

— missing tensioning hardware or one or more too short or missing corner ropes.

A rope net’s corner rope (lashing line) may be replaced and render the net operative again, providing the following conditions are met:

— the rope used shall be tested and approved by the net manufacturer;

— the staff shall be authorized and trained to install the rope.

5.1.6 An inoperative pallet net shall be replaced or complemented by an appropriate tie-down arrangement using ISO 16049-1 approved restraint straps, providing all pieces of cargo are effectively individually restrained and all requirements for tie-down arrangements given in 7.3 and ISO 16049-2 are met.

5.2 Cargo stacking

5.2.1 Stacking a variety of pieces of cargo over a pallet shall not be at random. Experience has proven that occurrences can result in hazards for stack stability and/or flight safety, e.g.:

— weaker packagings being crushed, deforming or collapsing under loads;

— ground handling acceleration on the way to the aircraft giving rise to individual stacks separating or to some pieces of cargo shifting where free space exists;

— round-shaped objects tending to roll back and forth under ground or flight acceleration and to press against other packages or the net.

This list is not exhaustive.

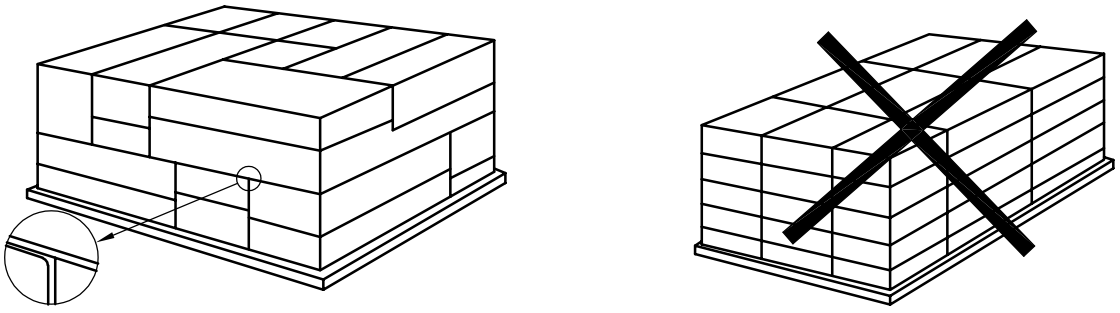
In order to prevent the stacks from becoming unstable or shifting out of the pallet's maximum permissible contour, the precautions given in 5.2.2 to 5.2.7 shall be systematically complied with, and complemented where necessary by means of shifting prevention as described in 5.3.

Ground handling acceleration can be at least as severe as that encountered during flight except in extreme circumstances. A pallet that was trucked or otherwise moved on the ground from its build-up location to the aircraft may be deemed stable if the original stacking did not move. Conversely, any pallet that exhibits stack deformation or shifting out of the maximum permissible contour when arriving at the aircraft should not be loaded into it, and be sent back to cargo warehouse for more stable reconditioning prior to loading.

5.2.2 In order both to meet the CG height requirements (see 4.6) and to ensure stack stability, the heaviest, largest and highest density items shall be loaded first, on the bottom of the stack, then any medium weight or density items over them and finally the fragile, lightest or smallest items on top.

5.2.3 For the heavier items on the bottom of the stack, consideration should be given, based on weight and bearing area, to the spread of load over the pallet surface. If loading is too uneven, an aluminium sheet pallet may deform locally to such an extent that it will become difficult to transport over roller conveyors, or for its edges to fit under the aircraft restraint system. See Clause 6.

5.2.4 Packages on each of the successive layers shall be stacked against each other with no empty space between them. Whenever rectangular shaped boxes or packages are to be stacked, they shall be "T" stacked in overlapping alternate layers, rather than inherently unstable parallel stacks (see Figure 2).



a) Right **b) Wrong**

Figure 2 — Stacking examples

5.2.5 When stacking packages, care shall be taken that their interface is as stable as possible. Any cylindrical packages, e.g. drums, cans, etc. shall be loaded in a standing position (see Clause 8 for alternate or additional precautions concerning specific commodities). Any rolling or uncrated odd shaped item which is likely to shift or not to constitute a stable base for other packages stacked over it should be blocked or chocked by other, stable cargo. Heavy uncrated odd shaped items should be loaded on a wooden pallet located on the pallet surface.

5.2.6 It shall be checked that every package stacked on the periphery of the load is significantly larger than the pallet net's mesh size in order to prevent it possibly becoming loose during a flight. If packages are too small to be palletized they should be either blocked in all directions between larger pieces of cargo or, if this is not possible, banded or otherwise assembled together in groupings of sufficient size.

5.2.7 Packaging fiberboard is sensitive to dampness. If soaked in water, it looses mechanical strength, which often results in package being crushed and ultimately the whole stack collapsing. In order to prevent this from happening, built-up pallet loads that may have to be stored exposed to rain should be protected

— with a covering plastic sheet (cargo cover) installed on pallet completion prior to net installation, if all fiberboard packages placed on the bottom of the stack are supported by wooden pallets or equivalent higher than the pallet's surface (i.e. protected from possible water accumulation) or

— with a bottom plastic sheet placed on the pallet prior to build-up and raised around load periphery, then overlapped by a top sheet, if fiberboard packages are laid directly onto the pallet surface (risk of water accumulation).

Any plastic sheet materials used for cargo covers should have fire retardant properties and it is recommended they meet the appropriate flammability requirements set forth in FAR 14CFR Part 25 and JAR Part 25 Appendix F (see 9.1.2).

5.3 Shifting protection

5.3.1 Pallet contour shifting during flight may constitute a hazard, as the load may come into contact with the aircraft structure or other elements. However, the basic stacking rules given in 5.2 may sometimes prove insufficient to guarantee against this, e.g.:

— when the pallet is built-up to a contour higher than its width;

— when the amount of cargo to be loaded is such that there remains available space on the pallet;

— with too numerous (generally over 8 to 10) layers of small packages;

— with naturally unstable or deformable cargo, e.g. textile bundles, etc.

The pallet net, even tightened, is elastic and deformable by nature (parallelogram) and hence cannot be totally effective in opposing such cargo shifting (unlike the use of tie-down by straps which, if properly carried out, is less likely to lead to deformation and is more effective against cargo shifting).

In such circumstances, it is therefore necessary to exercise judgment and, if a risk of shifting is foreseen, to provide additional means of protection according to one of the methods given in 5.3.2 to 5.3.5.

5.3.2 A primary method is the adding of additional tie-down forming triangles to oppose the possibility of parallelogram deformation of the net. Prior to installing the net, tie-down straps are installed tightened to a maximum in the horizontal direction, bearing between half and two thirds of pallet load's height.

5.3.3 When small to medium size packages are stacked, e.g. where they have a square plan view and hence cannot be loaded in overlapping layers as described in 5.2.4, tying-down as described in 5.3.2 is more effective if continuous angle pieces made of fiberboard, plastic, wood, etc. are installed, prior to strapping, at each corner of the pallet load up to about two thirds of its height. Alternately, a pallet rack (see 9.4.1) may be used to ensure the stack will remain within a maximum permissible contour.

5.3.4 When package layers exhibit a tendency to expand or slip over each other, an effective preventive method is the encircling of the highest ones with strongly tightened straps or rigid banding strip.

5.3.5 When stacking particularly crushable/deformable packages, e.g. bags, textile bundles, etc., it may be necessary to constitute a stable flat intermediate floor with planks, plywood, wooden pallets, or a spare aircraft pallet between layers or alternate layers. Where a bulging load presents a risk of impinging on the pallet's outer tracks (net attachment and restraint area), this should be prevented by locating planks on the edge along the tracks prior to installing the net.

5.4 Net installation

5.4.1 Prior to installing the pallet net, a check shall be made that its certification is compatible with that of the pallet in accordance with the applicable configuration in ISO 8097. See 5.1.5 for net condition check.

NOTE When the net is permanently attached to one side of the pallet, certification compatibility needs to be checked only at original installation.

5.4.2 While installing the net over the load, a check shall be made that every single package is effectively restrained horizontally and vertically. See 5.2.6 in the event of a package being too small for the mesh size. No piece of cargo shall protrude through the net mesh, and no net rope or strap shall directly come into contact with a metal cutting edge of a piece of cargo.

5.4.3 The net attachment fittings should be attached to the pallet's track at locations as close as possible from those defined in the applicable configuration in ISO 8097.

5.4.4 The net, once attached and closed, shall be tightened as much as is practical without raising the pallet edges to the extent that they may not be brought to properly engage the aircraft restraint system.

5.4.5 At loading on to the aircraft, net closure and tightening should be rechecked for possible loosening due to load settling during ground transportation. See the last paragraph of 5.2.1 in the event of deformation outside the maximum permissible contour.

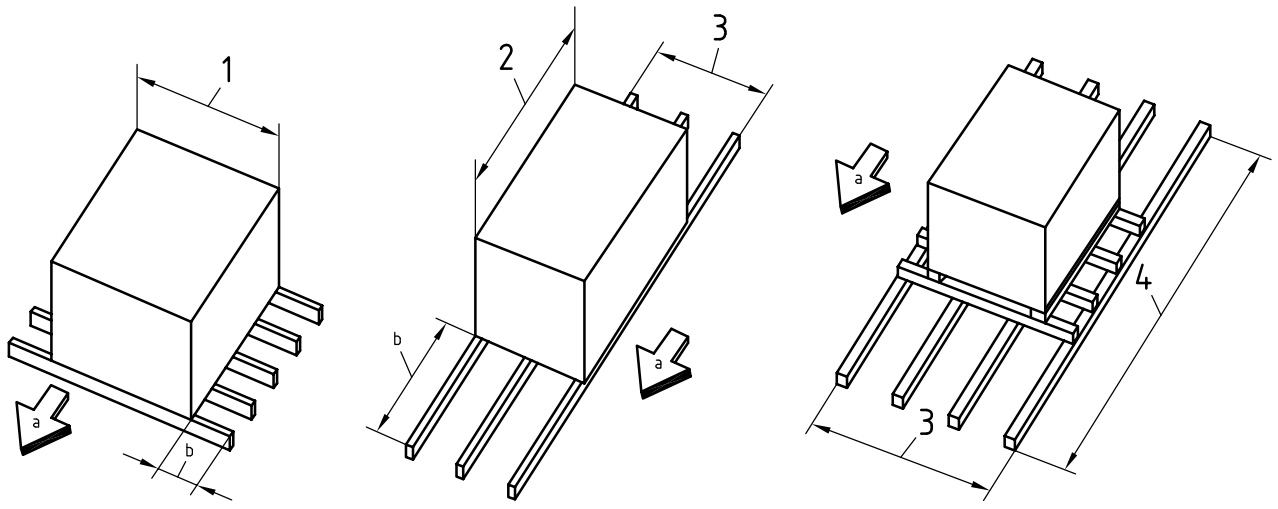
6 Shoring

6.1 General

6.1.1 Shoring can become necessary for heavy [over 1 000 kg (2 200 lb)] concentrated loads in order to meet either the applicable aircraft area load (see 4.3) or running load (see 4.4) limitations, or both.

Minimum elementary shoring can also become necessary for practical reasons, even in instances where neither the area load nor the running load limitations is exceeded, e.g. on an aluminium sheet, in accordance with ISO 4171, type pallet, in order to avoid local deformation which might render it difficult to move on rollerized conveyors. An automobile directly loaded on to such a pallet usually does not exceed either limitation, yet its wheels will create local base sheet deformation, which should be avoided by placing sufficiently stiff material, e.g. thick and sufficiently long planks, below each wheel. This is an unnecessary precaution with a heavy duty pallet.

6.1.2 Accordingly, shoring can be performed either laterally in relation to the aircraft centerline (area load limitation) or longitudinally (running load limitation) or both simultaneously (see Figure 3).



a) Lateral shoring **b) Longitudinal shoring** **c) Lateral and longitudinal shoring**

Key

1 cargo width
2 cargo length
3 shoring width
4 shoring length

a Forwards.
b Free span.

Figure 3 — Shoring examples

6.1.3 Whenever a planned change of aircraft may result in changing the pallet orientation within the aircraft, longitudinal shoring shall be performed in both directions to ensure the running load limitation is met in both positions.

6.2 Methods

6.2.1 Shoring methods basically consist of locating the concentrated load on an arrangement (load spreader stand) of adequately stiff materials providing a larger base in order to better distribute the total load over a larger area. The critical parameter in achieving this result is the total stiffness of the materials used, expressed as an EI value in $N{\cdot}cm^{-2}$ ($lb{\cdot}in^{-2}$)[4] given by the equation:

$$EI = E \times I$$

where

E is the Young modulus of the material, in newtons per square centimetre (pounds per square inch)[4];

I is the vertical moment of inertia of the individual piece of material, in centimetres (inches).

6.2.2 The pallet's own EI value may be taken into account for computing total shoring stiffness. For general information only (refer to actual data from the pallet type's manufacturer), typical EI value ranges for state of the art aluminum pallets on the market are shown in Table 1.

Table 1 — Typical EI values (pallets)

Values in $N{\cdot}cm^{-2}$ ($lb{\cdot}in^{-2}$)

Pallet specification	ISO 4171		ISO 4117	
Dimensional code in accordance with ISO 8097	**A**	**M**	**R**	**G**
Pallet dimensions mm (in)	2 235 × 3 175 (88 × 125)	2 438 × 3 175 (96 × 125)	2 438 × 4 978 (96 × 196)	2 438 × 6 058 (96 × 238,5)
EI value lengthwise	10×10^6 to 16×10^6 ($0{,}35 \times 10^6$ to $0{,}55 \times 10^6$)	11×10^6 to 18×10^6 ($0{,}4 \times 10^6$ to $0{,}6 \times 10^6$)	6×10^9 to 17×10^9 ($0{,}2 \times 10^9$ to $0{,}6 \times 10^9$)	6×10^9 to 17×10^9 ($0{,}2 \times 10^9$ to $0{,}6 \times 10^9$)
EI value crosswise	14×10^6 to 23×10^6 ($0{,}5 \times 10^6$ to $0{,}8 \times 10^6$)	14 x 10^6 to 23×10^6 ($0{,}5 \times 10^6$ to $0{,}8 \times 10^6$)	11×10^9 to 34×10^9 ($0{,}4 \times 10^9$ to $1{,}2 \times 10^9$)	15×10^9 to 42×10^9 ($0{,}5 \times 10^9$ to $1{,}5 \times 10^9$)

6.2.3 The materials used over the pallet to constitute the shoring arrangement can have extremely different stiffness/EI values, due to both the difference in E value and even more the difference in moment of inertia, I. Typical Young modulus values for commonly used materials are shown in Table 2.

4) Conversion factor: 1 $lb{\cdot}in^{-2}$ = 0,7 $N{\cdot}cm^{-2}$= 7 kPa.

Table 2 — Typical E values (shoring materials)

Values in $N \cdot cm^{-2}$ ($lb \cdot in^{-2}$)

Material	Pine	Oak	Aluminium beam	Steel beam
Young modulus E	$0,8 \times 10^6$ to $1,2 \times 10^6$ ($1,1 \times 10^6$ to $1,7 \times 10^6$)	10^6 to $1,5 \times 10^6$ ($1,4 \times 10^6$ to $2,1 \times 10^6$)	7×10^6 (10×10^6)	20×10^6 (28×10^6)

The vertical moment of inertia, I, is given for a full rectangular cross section of width, w, and height, h, by the formula

$$I = w \times h^3 / 12$$

Hence, it increases to the third power of the material's height (refer to actual data from the beam's manufacturer in the event of shaped beams being used).

6.2.4 Therefore, any shoring arrangement will be considerably stiffer and thus more effective for load spreading if the materials used are located in such a way as to maximize their height: e.g. rectangular cross section items such as lumber shall always be used on their edge, with their largest dimension vertical.

NOTE When rectangular cross section items (e.g. lumber) present an overturning risk, they should be located by pairs adjacent to each other in order to avoid their tilting/overturning, while keeping each of them on edge to retain maximum vertical EI.

6.3 Computation

6.3.1 As the aircraft floor structure under heavy loads cannot itself be considered rigid, computation of the required shoring size (length/width) and stiffness for a given load should use the engineering equations applicable for beams on elastic foundations, entering the parameters reflecting the aircraft compartment floor's elasticity (obtained from the aircraft manufacturer).

NOTE Engineering equations applicable for beams on elastic foundations can be found in generally available construction engineering manuals.

6.3.2 The mass of shoring materials used shall be included in the load, resulting in an iterative computation.

6.3.3 These are complex equations, the use of which pertains to qualified structural engineers. Accordingly, computation cannot be performed by cargo field staff. Carriers usually elect to provide it with simpler pre-computed guidelines applicable for common load cases, including the use of basic shoring materials such as:

— planks or plywood: due to limited thickness, only effectively usable for local or point load protection, or shoring loads up to approximately 500 kg (1 100 lb);

— wooden pallets: an effective practical shoring tool for loads up to approximately 1 000 kg (2 200 lb) on ISO 4171 type pallets, or 2 000 kg (4 400 lb) on ISO 4117 type pallets, bearing on each wooden pallet; a floor of several wooden pallets may thus constitute an effective means of shoring for fairly heavy loads, though only with limited free span (bearing area enlargement);

— commonly available lumber preferably rectangular in cross section, to be set on edge (by twos if unstable), not flat (see 6.2.4).

6.3.4 Some operators also use beneath the load (inadequate for free span/bearing area enlargement) fiberboard honeycomb plates, which have the double advantage of being stackable to reach up to a supporting point beneath the load and crushing in an even manner so that they automatically equalize the load bearing on the pallet. Their use is particularly recommended when shoring odd shaped cargo.

6.3.5 Loads heavier or more concentrated than defined in such basic guidelines may require the use of stiffer materials such as **I** beams or equivalent, and shall be referred to a qualified engineering office to adequately compute the necessary shoring arrangement prior to cargo acceptance and pallet build-up. Carriers may elect either to entertain the appropriate engineering capability in-house under their own responsibility or to refer all or certain items to the aircraft manufacturer for guidance.

7 Restraint

7.1 Net restraint

7.1.1 The normal means of restraining cargo on a pallet is by using the corresponding airworthiness certified net. When properly installed and closed over the pallet load, it forms a certified ULD meeting the ultimate restraint requirements of the ISO 8097 configuration concerned, thus providing an effective means of restraint (i.e., will not release its contents) up to the ultimate load factors applicable to the pallet position (see its weight and balance manual) within the aircraft's certified flight envelope.

7.1.2 It should not, however, be construed that the net will always automatically constitute a totally effective means of restraint, regardless of the nature and shape of cargo. The fact that it was designed and tested to successfully withstand considerable ultimate loads in each direction of restraint does not rule out the possibility of significant net deformation occurring at much lower in-service loads, as a result of both material elasticity and geometric deformation potential, inherent to a rectangular overall shape plus the shape of the net's own mesh.

7.1.3 As outlined in 5.3.1, significant load shifting or deformation out of contour (without being released from the net) which may not always be entirely avoided with a net gives rise to a potential for aircraft structural damage. Typical cases when this can occur are:

— empty space left on the pallet between an edge and the load: the load can shift;

— very low pallet load: the net, even at maximum adjustment, may not closely fit the load and hence may leave it free to move below it;

— unstable cargo stacks being crushed, bulging or otherwise deforming as a result of either ground or flight acceleration so that they bear against the net and push it out of maximum permissible pallet contour.

7.1.4 As such situations represent potential hazards (not to mention possible delays due to the difficulty of offloading a pallet that has deformed out of contour while on board), they shall be identified and prevented using shifting protection methods (see 5.3) and complementary straps tie-down.

7.2 Straps complement

7.2.1 Tie-down straps may have to be used as a complement to net restraint (this is not the same as total tie-down by straps as a net replacement, see 7.3), e.g. in, but not necessarily limited to, such typical cases as listed in 7.1.3:

— upward, in the event of a very low load being inadequately restrained by the net;

— horizontally, to avoid load movement into empty areas of the pallet;

— horizontally to reinforce potentially unstable cargo stacking.

7.2.2 In such instances, in order to ensure a good fit, the straps should preferably be installed prior to installing and closing the net. They should be tightened without bending the pallet's edge, which does not change their load capability but reduces their potential elastic elongation margin, thus more effectively opposing unwelcome load movement under acceleration. When used for stack reinforcement, straps should form a triangular shape, not a quadrangular one, in order to oppose deformation as much as feasible (a quadrangle is always geometrically deformable, a triangle is not).

7.2.3 The net keeps ensuring the ultimate load restraint function. Hence, the number of complementing straps does not necessarily need to be computed based on ultimate restraint capability: their strength may be calculated based on limit load only (2/3 of ultimate load in the direction of restraint concerned) and be limited to the mass of those pieces of cargo they effectively retain.

7.3 Straps tie-down

7.3.1 The net may also have to be totally replaced by a straps tie-down arrangement, when it is inappropriate for the load or inadequate to effectively restrain it under extreme acceleration, e.g.:

— transport of vehicles, helicopters, aircraft engines etc.;

— cargo overhanging the pallet, which cannot be restrained by the net, etc.

Preference should always be given to the use of the net whenever it can ensure proper restraint.

7.3.2 Such a tie-down shall be performed using approved straps meeting all the design, testing and quality control requirements of ISO 16049-1. In view of the loading mass usually associated with air cargo pallets, it is recommended to use only 22 250 N (5 000 lb force) guaranteed ultimate load straps, together with double stud tie-down fittings of the same capability. No mixing of straps of different ultimate strength, material or make (e.g. different tensioning mechanisms) is permissible.

7.3.3 The total tie-down arrangement shall be symmetrical in relation to the pallet's centerline and should meet the general, specific and ultimate strength calculation requirements of ISO 16049-2. The tie-down fittings' location on the pallet's tracks should be as close as possible from those defined in the applicable ISO 8097 configuration, and shall at least ensure a 0,5 m (20 in) minimum spacing. Calculation in this case shall take into account the ultimate load factors in each direction of restraint defined for the aircraft type by the weight and balance manual.

7.3.4 The tie-down arrangement with straps shall be systematically checked by authorized and qualified personnel prior to pallet release for loading aboard an aircraft.

8 Specific commodities

8.1 General

Many specific commodities frequently submitted by air cargo shippers present specific hazards for flight safety if improperly handled, and result in palletization difficulties. The general palletization rules in Clauses 4 to 7 may be insufficient to totally ensure safety, and/or may require being adapted to the particular commodity on hand.

Though a comprehensive list of such cases would be quite lengthy, some of the most common examples are shown in 8.2 to 8.7, together with guidelines on how best to handle them.

8.2 Overhangs

8.2.1 The operator should publish in his operating instructions the maximum permissible overhang on each or certain aircraft pallet positions, and make this information available to cargo agents building-up pallets to be loaded aboard its flights. The maximum permissible overhangs shall at all points meet the minimum clearances from the internal aircraft envelope as described in 8.2.4.

8.2.2 Any overhanging load shall be raised on the pallet floor by a minimum of 100 mm (4 in) in order not to risk damaging the aircraft cargo system, and to allow for access to aircraft restraints. This is usually easily achieved by using a floor of wooden pallets over the pallet's surface. See 8.4.2 in the event of load flexibility.

8.2.3 Overhanging cargo should, inasmuch as feasible, be located in a symmetrical manner over the pallet. If this cannot be fully achieved, particular care is required in ensuring and checking the area load (see 4.3), running load (see 4.4) and CG. location (see 4.5) limitations of the pallet are met.

8.2.4 Restraint of overhanging cargo cannot generally (except when using the container's contour on the lower deck of wide-bodied aircraft) be achieved using the pallet net. Accordingly, it should be performed by complementary or total straps tie-down as described in 7.2 or 7.3. In the event of significant asymmetrical overhang, regardless of its mass, upward tie-down of the overhanging part may have to be performed directly on the aircraft's structure, in order to avoid both the possibility of the load tipping under vertical acceleration or that of overloading pallet restraints through longer leverage.

8.3 Long loads

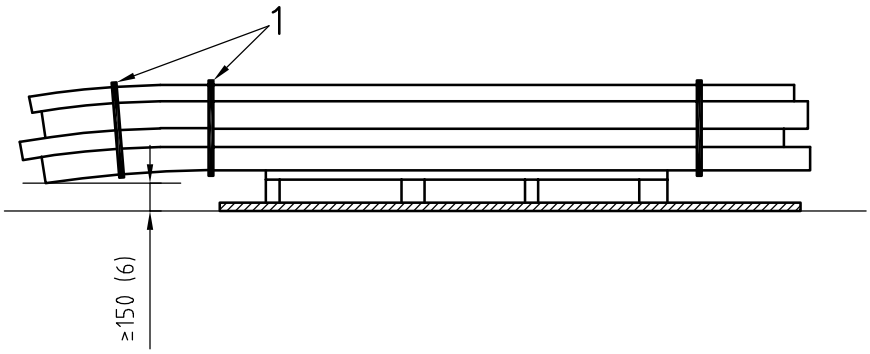
Particularly long loads such as pipes, tubes, beams, shall be handled as overhangs in accordance with 8.2. In addition, they may require the following additional precautions.

a) Long and narrow loads usually exhibit flexibility. The overhanging part(s) tend to bend downwards in a static condition, and may bend much more in the event of in-flight turbulence, to the extent of hitting the aircraft floor. In order to prevent this from happening:

   — judgment should be exercised by palletization staff, and the cargo raised, as necessary, by more than indicated in 8.2.2; in general, a minimum 150 mm (6 in) clearance from the conveyor plane is required at the lowest end of flexible overhangs, requiring higher support on the pallet;

   — flexibility should be minimized by strong banding together of several long items into a bundle, prior to palletization; banding should be performed using steel strips or at least, if unavailable, strongly tightened tie-down straps (see Figure 4).

Dimensions in millimetres (inches)



Key

1 banding

Figure 4 — Long items' flexibility

b) An often overlooked potential effect is the long load's overhang and deflection resulting in it bearing much more at the pallet's ends than in its centre, which may result in unseen local pallet overloading in excess of the area load and/or running load limitations. In the event of such heavy items, this shall be checked prior to pallet release for loading on to an aircraft.

c) Longitudinal (fore and aft) tie-down of such long pieces may become ineffective due to straps easily slipping away. Accordingly:

   — each single item shall be individually tied-down fore and aft, unless a bundle is strongly and tightly assembled by continuous end devices that constitute a reliable basis for joint tie-down;

— all fore and aft restraint straps shall be protected against the possibility of slipping downward, by being strongly tightened over a protrusion of the load or the end device or, if unavailable, by a retaining rope passing over the load.

NOTE See ISO 16049-2, for specific requirements, for additional tie-down precautions and usable devices.

8.4 "Tall" loads

8.4.1 A "tall" load is one, the height of which, significantly (at least twice) exceeds its smallest horizontal dimension, or the centre of gravity (CG) of which is significantly higher than mid-height. It is susceptible to tipping over under horizontal acceleration, which may result in interference with the aircraft structure and potentially severe damage.

8.4.2 Such cargo should be palletized fully enclosed on both potential tipping sides by other cargo reaching higher than its own CG height. If not feasible, the "tall" piece(s) of cargo should be attached to a lumber or steel supporting stand thus widening its base and providing bracing against the risk of tipping.

8.4.3 If neither of the above solutions is feasible, "tall" cargo cannot be restrained solely by a net, which will not prevent its tipping. It shall be tied down using straps, with specific well-tightened straps in each horizontal direction opposing possible tilting, kept higher than the load's C.G. by using load protrusions if available or a retaining rope over the load.

8.5 Drums, cans, barrels

8.5.1 Drums, cans, barrels and similar cylindrical packagings, unless banded together on a flat base such as a wooden pallet, shall never be palletized horizontally but set vertically on their rim or bottom, preferably on the lower build-up level directly on to the pallet's surface (see 5.2.2). It is recommended to handle heavy (e.g. 200 l/44 gal) drums with appropriate equipment, e.g. special drum tongs mounted on a forklift, in order to avoid the risk of puncture.

NOTE Standard 200 l (44 gal) drums can be stacked up to 18 units on a 2 235 mm × 3 175 mm (88 in × 125 in) pallet or 19 units on a 2 438 mm × 3 175 mm (96 in × 125 in) one, per layer (see 8.5.3 in the event of two layers).

8.5.2 Whenever one or several drums or cans are located immediately adjacent to the pallet's edge track, even behind the net, there is a risk of their being punctured by aircraft restraint hardware. In order to prevent this from happening:

— either, the load of drums should be raised by at least 100 mm (4 in), e.g. on wooden pallets or

— planks should be located on edge along the pallet's track immediately inside the net, in order to protect the lower part of the drums.

8.5.3 Whenever two or more layers of cans or drums are used, a horizontal intermediate floor, consisting of lumber, wooden pallets, plywood or a spare aircraft pallet, should be provided between layers to ensure stability of the top one(s). This provision may be waived in the event of the drums or cans being designed with an effective stackability feature where they are embedded in each other. Even in this case, actual stack stability should be checked prior to allowing more than two layers.

8.5.4 The possibilities of stack instability or shifting should be systematically evaluated prior to pallet release for loading aboard an aircraft. See 5.3 for means of shifting protection.

8.5.5 See 8.7 in the event of drums, cans or similar packaging containing regulated dangerous goods.

8.6 Reels, spools

8.6.1 Cable reels, metal wire spools and similar cylindrical shaped industrial cargo are usually heavy and present both a stability risk and a load shoring difficulty. Inasmuch as feasible, they should always be carried in the "horizontal" position, i.e. with the load lying on one of its flat surfaces. Whenever this is not feasible and

they must be carried “vertically”, i.e. lying on one side (generating line) of the cylinder, the precautions described in 8.6.2 to 8.6.6 should be applied.

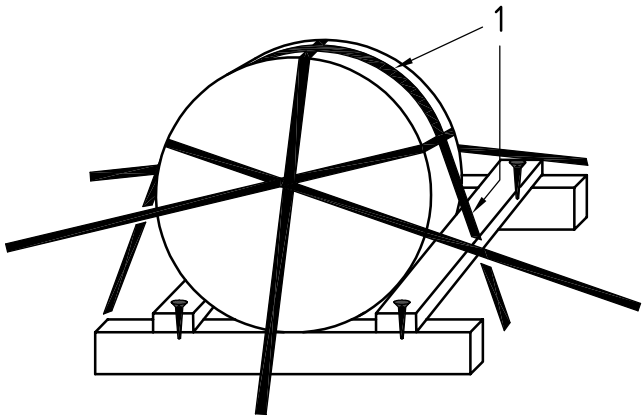
8.6.2 Since the load effectively bears onto only one point (cylinder generating line), regardless of its weight a support stand is required. It shall ensure that the maximum area load limitation (see 4.3) is met and be of a design and strength commensurate with the piece’s weight and dimensions. Depending on these, it may consist of lumber or require a steel construction. See Clause 6 for calculation of the minimum required stand base size and stiffness.

8.6.3 The support stand should include chocks or battens opposing any rolling movement, nailed or bolted on to the stand’s base, strong and high enough (commensurate with the applicable limit horizontal load factor) to withstand horizontal acceleration without rolling, independent from restraint by the tie-down devices.

8.6.4 In the event of a narrow spool which may thus also qualify as a “tall” load (see 8.4), when designing the stand consideration shall also be given to preventing any risk of tipping.

8.6.5 Restraint may be achieved by the pallet net, providing it can be effectively secured around the load and there remains no room for horizontal shift. If there remains empty space, either complementary (see 7.2) or total (see 7.3) tie-down by straps is required.

8.6.6 Such tie-down should meet the general criteria in ISO 16049-2, as to calculation of the number of straps in each restraint direction. But it may be unreliable, due to the cylindrical shape, unless performed with due additional installation precautions. When a wide enough central hole exists, it usually constitutes an effective location to locate tie-down straps. When not available, the straps arrangement should take into account the shape of the cargo and prevent any possibility of straps slipping away by using retaining ropes over the load (see Figure 5).



Key

1 retaining ropes

Figure 5 — Example of elementary spool stand and tie-down

8.7 Dangerous goods

8.7.1 In the event of a pallet load containing one or several package(s) of dangerous goods (hazardous materials) as defined and regulated by the ICAO Technical Instructions [10] and IATA Dangerous Goods Regulations [11], the additional precautions described in 8.7.2 to 8.7.8 shall be applied.

8.7.2 All dangerous goods packages shall be individually inspected at the time of pallet build-up in order to check their integrity, and any package found defective shall be rejected. They shall be loaded upright and blocked by other cargo so as to prevent any movement in flight which could change their orientation. If this is not feasible, they shall be individually tied down.

8.7.3 Packages of incompatible dangerous goods as defined in the ICAO Technical Instructions [10] and IATA Dangerous Goods Regulations [11] shall be separated from each other by other, non-hazardous cargo or cargo compatible with both. If this is not feasible, they shall be individually tied down so as to prevent any possible interaction between them in the event of leakage.

8.7.4 When loading dangerous goods bearing the “Cargo Aircraft Only” (CAO) label on to a pallet to be exclusively loaded on a freighter aircraft, such packages shall be loaded so that they can be seen, handled, and, where size and weight permit, separated from other cargo in flight. The carrier shall publish in his operating instructions, detailed requirements for this purpose, taking into account its flight crew's training and the actual main or upper deck pallets layout of his freighter aircraft.

8.7.5 In order to protect dangerous goods packages from damage, they should be handled exclusively by hand, except those packages assembled in an overpack with a forkliftable base, and 200 l (44 gal) drums where they can be handled by a forklift equipped with special drum tongs.

8.7.6 The additional precautions for drums and cans (see 8.5) and pallet load shifting protection (see 5.3) shall be systematically complied with where applicable.

8.7.7 The pallet shall be conspicuously tagged to indicate it contains package(s) of dangerous goods.

8.7.8 All other applicable regulatory requirements shall be strictly complied with.

9 Pallet accessories

9.1 Pallet covers

9.1.1 Pallet covers are plastic, textile or composite material sheet items that can be installed over a pallet load, usually under the net, principally for commercial quality reasons, i.e. to protect cargo against rain and snow. However, they may also contribute to flight safety in specific circumstances, e.g.:

— airworthiness mandated fire resistant covers required in certain FAR/JAR 25.857 Class B (Combi aircraft main deck) compartments (see 9.1.4) or

— proper use of common type pallet covers to prevent crushing of wet packagings, hence contributing to avoiding cargo stacks shifting out of contour or collapsing and potentially interfering with the aircraft structure (see 5.2.7).

9.1.2 Ordinary pallet covers commonly used for weather protection of cargo in FAR/JAR 25.857 Class C (lower deck) and Class E (freighter main or upper deck) cargo compartments consist of plastic sheets [typically 0,03 mm to 0,05 mm (1,2 thousandths to 2 thousandths of an inch) thick polyethylene film with fire retardant additives], which may be either transparent or opaque, and are usually considered expendable/not re-usable.

They should have fire retardant properties and, while not explicitly required by the regulations, compliance with the inflammability requirements of FAR/JAR Part 25 (Amdt 25-72 of July 20, 1990, or subsequent revisions thereof) Appendix F Part I paragraphs (a)(2)(iv) and (a)(1)(ii) (self extinguishing and exhibiting an average burn length not exceeding 203 mm (8 in) or an average flame time after removal of the flame source not exceeding 15 s) is recommended.

9.1.3 Damage to ordinary pallet covers as described in 9.1.2 is acceptable, including punctures.

9.1.4 Fire resistant pallet covers mandated by Airworthiness Directive in certain FAR/JAR 25.857 Class B Combi aircraft main deck compartments are made of much stronger reinforced glass fiber based or composite materials, and normally not considered expendable but re-usable. They do not consist of sheets, but are closed covers to be slipped over the whole pallet load. They meet much more severe performance and testing requirements since they are intended and designed to totally contain a fire for a long duration, without it being able to burn through. Cover punctures are not acceptable since they will jeopardize fire containment.

9.2 Pallet extenders

9.2.1 Pallet extenders are ancillary devices attached to the pallet's tracks providing a loadable pallet contour extension to fit the maximum permissible lower deck contour on wide-bodied aircraft. They shall conform to the appropriate industry specifications design parameters, dimensional and operating requirements.

9.2.2 Pallet extenders shall be loaded only up to the design maximum load as marked on each unit. They shall be used in conjunction with a certified air cargo pallet net meeting the applicable ISO 8097 configuration's requirements.

9.2.3 Pallet extenders exist in several types, which may e.g. provide either a sloped outer panel or a horizontal extension shelf, of dimensions and load-rating appropriate to the base pallet.

9.2.4 Airworthiness-wise, there are two distinct types of pallet extenders as follows:

a) those where the certified pallet net is attached in a standard manner to the pallet's track at or near the locations defined by the applicable ISO 8097 configuration; they constitute non-certified pallet accessories, similar in this respect to other accessories addressed in 9.4, the only mandatory requirements of which are maximum deflection limits and markings to indicate the maximum permissible load to meet these limits;

b) those where the certified pallet net is attached to the extender itself; in this case, the extender shall be airworthiness certified under an appropriate Supplemental Type Certificate (STC) to guarantee it will effectively transmit the net's ultimate certification loads to the pallet and constitute together with the net an approved restraint system, and shall be marked accordingly together with its net compatibility.

9.3 Pallet couplings

9.3.1 Pallet couplings (spacers) are non-certified ancillary devices used to rigidly connect two airworthiness certified air cargo pallets, conforming either to ISO 4171 or to ISO 4117 design specifications, while being loaded and restrained on board an aircraft, in order to *de facto* constitute a double size pallet [e.g. 2 235 mm × 6 375 mm (88 in × 251 in) or 2 438 mm × 6 375 mm (96 in × 251 in) or 3 175 mm × 4 978 mm (125 in × 196 in) or 2 438 mm × 10 033 mm (96 in × 395 in) or 2 438 mm × 12 192 mm (96 in × 480 in)] where the size or nature of the load justifies it.

9.3.2 Pallet couplings shall attach to the pallet's edge tracks, as far outboard as possible, and guarantee parallelism of both pallets linked and the regular pallet positions spacing in the aircraft's restraint system [on most aircraft types, 25 mm (1 in) between ISO 4171 type pallets, always 76 mm (3 in) between ISO 4117 type pallets, edge to edge] are maintained.

9.3.3 The geometry of pallet coupling devices shall ensure free access to and operation of the aircraft restraint devices appropriate to the type of pallet concerned.

9.3.4 Pallet couplings should be used as non-certified pallet accessories, i.e. each of the linked pallets should be fully restrained in its normal configuration in the aircraft's restraint system, notwithstanding the tie-down arrangement of the load occupying both pallets. This may require special techniques in the case of ISO 4171 type pallets.

9.4 Other accessories

9.4.1 Many other pallet accessories are being used in specific instances, such as, but not limited to:

— non-structural igloos, used to build-up a load over a pallet while protecting it and preventing it from shifting;

— non-aircraft containers (including thermal ones) or modular load units (see [1]) constituting load elements on the pallet;

— racks used to build-up a load from non-easily stackable cargo items while preventing load shifting;

— racks used for heavy and non-easily stackable shipments of meat (“meat bins”);

— structural frames designed to support and distribute hanging loads;

— two tiered racks used for the carriage of automobiles (see [4]);

— non-certified horse or cattle stalls (see [7]);

— certain, non-airworthiness certified, aircraft engine transport stands;

— specialized shoring materials (e.g. fiberboard honeycomb plates).

9.4.2 In specific cases, e.g. dedicated aircraft engine transport stand integrated as a ULD (see [9]), the ancillary item is permanently attached to the pallet and forms an integral part of the ULD. In such a case, the whole unit shall be airworthiness certified under a Supplemental Type Certificate (STC).

9.4.3 All other pallet accessories, even when attached to the pallet’s edge tracks to ensure their proper location and/or avoid shifting, should meet the applicable industry specifications but shall be nevertheless considered non-airworthiness certified accessories, i.e. for all practical and regulatory purposes part of the pallet load, and be restrained on the pallet together with the load preferably by the certified pallet net meeting the ISO 8097 configuration concerned, or, if impossible, a tie-down arrangement meeting the requirements of 7.3.

9.4.4 Airworthiness requirements, including inflammability, do not apply to cargo packagings or items considered to be part of the load. However, it is recommended that re-usable pallet accessories meet the flammability requirements applicable to tie-down equipment (including containers, bins and pallets), i.e. FAR/JAR Part 25 (Amdt 25-72 of July 20, 1990, or subsequent revisions thereof) Appendix F Part I paragraphs (a)(2)(iv) and (a)(1)(v) : they should exhibit a burn rate not exceeding 203 mm (8 in) when tested horizontally in accordance with the test conditions defined in Appendix F Part I.

10 Operator requirements

10.1 General

Flight safety depends on the effectiveness and dependability of cargo build-up and restraint on pallets prior to their being loaded aboard aircraft. Accordingly, it is essential that carriers, as required by their operating certification, fully meet their responsibilities as given in 10.2 to 10.4.

10.2 Operating instructions

10.2.1 The carrier should ensure that the cargo equipment procured and operated, including air cargo pallets, pallet nets, tie-down straps and fittings, meets the applicable regulatory requirements and industry specifications, and is subject to appropriate procurement and maintenance quality control.

10.2.2 The carrier shall establish and distribute to all concerned, including sub-contractors and shippers where they are allowed to build-up air cargo pallets for loading aboard aircraft, pallet build-up operating instructions taking into account the requirements of the approved weight and balance manual(s) for the aircraft type(s) operated, as well as the recommendations of this International Standard.

10.2.3 The carrier shall take all necessary steps to ensure his operating instructions are fully understood and applied by at least one suitably trained competent person (see 10.3) or under his direct supervision, including the establishment and implementation of such procedure as can guarantee an aircraft will not be dispatched with cargo pallets on board unless each pallet has been inspected and found satisfactory by such a competent person prior to release for loading aboard the aircraft.

10.2.4 The above requirements also apply whenever all or part of palletization is sub-contracted, and should be included by the carrier in the corresponding handling contracts.

10.3 Training and qualification

10.3.1 The carrier shall establish and implement recurrent training programmes to ensure his pallet build-up operating instructions are fully understood and practiced by a sufficient number of competent persons throughout his organization, his subcontractors and any shippers he allows to directly prepare air cargo pallets for loading aboard aircraft.

10.3.2 The basic contents of such training programmes should include at least the contents of this International Standard, and be taught using field training and practical demonstrations with actual cargo inasmuch as feasible. They should also include information on the limitations applicable to the specific aircraft type(s) and where necessary pallet positions operated, and may include more in-depth knowledge on specific issues, e.g. shoring or tie-down.

10.3.3 It is recommended such training be individually recorded after a proficiency check has been performed, both theoretical and practical (at actual pallet build-up). Such individuals may be deemed qualified to perform built-up pallets inspection and release for loading aboard an aircraft.

10.4 Quality control

10.4.1 As any activity with a potential impact on flight safety, pallet build-up processes shall be monitored and their quality and effectiveness be regularly assessed by an independent organization in the framework of each carrier's internal evaluation and quality control programme (see FAR 14 CFR Part 121 and AC 120-59, JAR-OPS 1).

10.4.2 Accordingly, each pallet build-up site preparing air cargo pallets for loading on aircraft should be subject to inspection, investigation or audit from the carrier quality control department, including when it is located at a sub-contractor's or an agreed shipper's premises.

10.4.3 It is also recommended any shipper's, cargo agent's or airport cargo handling company's facility performing pallets build-up for loading on board a carrier's aircraft maintains its own continuous quality control programme under an appropriate quality control programme meeting the requirements of ISO 9001 [6] or equivalent pertinent industry standard.

10.4.4 In addition, it is recommended any significant incident, in flight or on the ground at aircraft loading, related to or resulting from improper palletization be subject to carrier quality control department investigation, in order to be analysed and corrective action to be taken to avoid its re-occurrence.

Bibliography

[1] ISO 3676, *Packaging — Unit load sizes — Dimensions*

[2] ISO 4115, *Air cargo equipment — Air/land pallet nets*

[3] ISO 4170, *Air cargo equipment — Interline pallet nets*

[4] ISO 8268, *Air cargo equipment — Automobile transport devices — Basic requirements*

[5] ISO 9000:2000, *Quality management systems — Fundamentals and vocabulary*

[6] ISO 9001:2000, *Quality management systems — Requirements*

[7] ISO 9469, *Air cargo equipment — Unit load devices for transportation of horses*

[8] ISO 10254, *Air cargo and ground equipment — Vocabulary*

[9] ISO 11241, *Aircraft — Aircraft engine transport devices*

[10] ICAO *Technical Instructions for the Safe Transport of Dangerous Goods by Air* [5)]

[11] IATA, *Dangerous Goods Regulations* [6)]

[12] IATA, Airport Handling Manual AHM 330, *Preparation for loading of cargo*[7)])

[13] IATA, Airport Handling Manual AHM 376, *Acceptance standards for the interchange of transferred ULDs* [7)]

[14] IATA, Airport Handling Manual AHM 534, *Weight control of load* [7)]

[15] IATA, Airport Handling Manual AHM 645, *Loading precautions for incompatible loads* [7)]

[16] IATA, Airport Handling Manual AHM 671, *Securing of load* [7)]

[17] IATA, Airport Handling Manual AHM 677, *Handling and loading of BIG or overhang items* [7)]

[18] IATA, Airport Handling Manual AHM 692, *Ramp handling and loading procedures, training and qualifications* [7)]

[19] IATA, Airport Handling Manual AHM 810, *IATA standard ground handling agreement* [7)]

[20] IATA, ULD Technical Manual 50/0, *Requirements for interlining of ULDs* [7)]

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5) Can be obtained from International Civil Aviation Organization, Document Sales Unit, 1000 Sherbrooke St W, Suite 400, Montreal, Quebec H3A 2R2, Canada, or any of its regional representations in Egypt, France, Kenya, Mexico, Peru, Senegal or Thailand.

6) IATA Dangerous Goods Regulations, ULD Technical Manual and Airport Handling Manual can be obtained from International Air Transport Association, Publications Assistant, 800 Place Victoria, P.O. Box 113, Montreal, Quebec H4Z 1M1, Canada.

7) SAE documents can be obtained from Society of Automotive Engineers, 400, Commonwealth Drive, Warrendale PA 15096-0001, U.S.A.

[21] IATA, ULD Technical Manual UTM 50/1, *Pallet for NAS 3610 Class II restraint systems* [7)]

[22] IATA, ULD Technical Manual UTM 50/2, *Aircraft pallet net* [7)]

[23] IATA, ULD Technical Manual UTM 50/9, *16' or 20' pallet for NAS 3610 Class II restraint systems* [7)]

[24] IATA, ULD Technical Manual UTM 60/1, *Pallet extensions* [7)]

[25] IATA, ULD Technical Manual UTM 60/2, *Cargo restraint straps* [7)]

[26] IATA, ULD Technical Manual Chapter 11, *Technical recommendations — Modular Load Units* [7)]

[27] SAE ARP5486, *Air cargo pallets — Utilization guidelines*[8)]

[28] SAE ARP5595, *Cargo restraint straps — Utilization guidelines* [8)]

[29] SAE ARP5596, *Cargo shoring guidelines* [8)]

[30] SAE AS1130 F, *Air and Air/Surface (Platform) Cargo Pallets* [8)]

[31] SAE AS1131 C, *Air and Air/Surface (Platform) Cargo Pallet Nets* [8)]

[32] SAE AS1491 B, *Interline Air Cargo Pallets* [8)]

[33] SAE AS1492 B, *Interline Air Cargo Pallet Nets* [8)]

[34] SAE AS1825 A, *Methodology of Calculating Aircraft Cargo Volumes* [8)]

[35] SAE AS1988 A, *Air Cargo Pallet Extenders* [8)]

[36] SAE AS5385, *Cargo Restraint Straps — Design Criteria and Testing Methods* [8)]

[37] SAE AS36100, *Air cargo Unit Load Devices — Performance Requirements and Test Parameters* [8)]

[38] Aircraft manufacturers' Weight and Balance Manual(s) for the aircraft type(s)/sub-type(s) concerned [8)]

8) Can be obtained from the individual airframe manufacturers concerned.

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