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Aircraft — Aircraft engine transport devices

Aéronautique et espace — Dispositifs de transport des moteurs d'aéronefs

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Foreword

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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.

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Introduction

Aircraft engines can be transported as outsize bulkloads restrained to the requirements of the applicable Weight and Balance Manual.

This International Standard, however, covers their transport as aircraft engine transport devices, as a unit being secured in the aircraft by a Class II ISO 8097 restraint system.

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Aircraft — Aircraft engine transport devices

1 Scope

This International Standard specifies functional, dimensional, structural and environmental requirements for the design of aircraft engine transport devices, used to transport aircraft engines in wide-body aircraft. These devices are intended to be used in conjunction with pallets compatible with ISO 8097 Class II restraint requirements. The restraint system parameters and requirements are also to be met for those devices where the pallet structural capability is an integral part of the design. Design parameters specified for air transport of engine transport devices should enable interline capability where feasible with respect to dimensions and loads.

This International Standard specifies minimum air and ground handling features and is intended to ensure interchangeability and compatibility with present and future air transport and ground handling system. The devices specified herein should be designed primarily for air transport and alternatively for surface transport, stowage and maintenance purposes.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 4116:1986, *Air cargo equipment — Ground equipment requirements for compatibility with aircraft unit load devices.*

ISO 4117:1993, *Air and air/land cargo pallets — Specification and testing.*

ISO 4171:1993, *Air cargo equipment — Interline pallets.*

ISO 8097:1993, *Aircraft — Minimum airworthiness requirements and test conditions for certified air cargo unit load devices.*

ISO 9031:1987, *Air cargo equipment — Handling systems for unit load devices (ULDs) — Symbols for pictorial representation.*

IATA, *Unit Load Devices (ULD) Technical Manual* 8th Edition.[1)]

Motor Carriers Safety Regulations. Part 393.100, Subpart 1, *Protection Against Falling or Shifting Cargo.* United States Department of Transportation.[2)]

3 Types of engine transport devices

This International Standard defines two types of engine transport devices as follows:

— Type A: For split engine pack transport (mainly lower deck);

— Type B: For full engine transport (mainly upper deck).

1) Can be obtained from the International Air Transport Association, 2000 Peel St., Montreal, Quebec, Canada H3A 2R4, or Route de l'Aéroport 33, case postale 672, 1215 Geneva 15, Switzerland.

2) Can be obtained from the US Government Printing Office, Washington, DC 20402, USA (Stock No. 5004-00010).

3.1 Type A is used for shipping of split engine packs, e.g. core-engine packs and fan-engine packs

or additional equipment required on air cargo pallets of the below sizes, as applicable.

1 534 mm × 3 175 mm (60,4 in × 125 in)

2 235 mm × 3 175 mm (88 in × 125 in)

2 438 mm × 3 175 mm (96 in × 125 in)

The transport device shall be compatible with ISO 8097 Class II restraint systems.

3.2 Type B is used for shipping full engine packs, generally referred to as "quick engine change" (QEC) kits, compatible with the allowable aircraft volume on integrated air cargo pallets/stands or air cargo pallets of the following sizes:

2 235 mm × 3 175 mm (88 in × 125 in)

2 438 mm × 3 175 mm (96 in × 125 in)

2 438 mm × 4 064 mm[3] (96 in × 160 in)

2 438 mm × 4 978 mm[3] (96 in × 196 in)

2 438 mm × 6 058 mm (96 in × 238,5 in)

The transport device shall be compatible with ISO 8097 Class II restraint systems.

3.3 The restraint of the engine transport device onto the pallet shall use mechanical links providing load paths, which are compatible with ISO 8097, Class II restraint requirements (e.g. turn buckles at net restraint points). For both types of engine transport devices, the use of pallet nets is not recommended.

4 Design objectives

This International Standard is intended to establish design objectives for an aircraft engine transport devices for quick engine change (QEC) packs and split engine packs with consideration of the following interfaces.

4.1 The manufacturer shall take into account and specify in a formal document the following criteria:

— cargo envelope, pallet configuration;

— maximum gross weights[4], centre of gravity (CG) limits, maximum local loads;

— equipment strength (aircraft *g*-load envelope);

— loading procedure/requirements, pallet sequence.

NOTE 1 Total aircraft engine transport devices should be submitted to the appropriate airframe manufacturers who will evaluate the total engine transport device, and pallet interface as pertains to technical and operational requirements.

4.2 The aircraft engine manufacturers shall consider the following information in a relevant document:

— engine data;

— engine transport device requirements (hoist/crane lift);

— tests;

— ground handling capabilities (forklift tineways);

— total QEC system requirements;

— road/ground transport capability;

— stowage and maintenance capabilities.

NOTE 2 Transport device designs should be submitted to the appropriate engine manufacturers who will evaluate the total engine/transport device package as pertains to technical and operational requirements.

5 Requirements

5.1 Dimensions

Type A shall adapt to a pallet length of 3 175 mm (125 in) and a width of 1 534 mm (60,4 in), 2 235 mm (88 in) or 2 438 mm (96 in).

Type B shall adapt to a pallet length of 3 175 mm (125 in) and a width of 2 235 mm (88 in) or adapt to pallet lengths of 3 175 mm (125 in), 4 064 mm (160 in), 4 978 mm (196 in) and 6 058 mm (238,5 in) and a width of 2 438 mm (96 in).

3) These sizes are not currently included in ISO 8097.

4) The term "weight" is used throughout this International Standard, instead of the correct technical tem "mass", in order to conform to current commercial usage.

5.2 Envelope

The engine modules and transport device shall be positioned on the pallet so that the height and overhang will not interfere with the aircraft cargo door, the cargo compartment lining or cargo loads in the adjacent position. The minimum clearance inside the compartment shall be 50 mm (2 in). A minimum clearance of 50 mm (2 in) in the cargo doorways is also recommended.

5.3 Gross weight weight distribution

The design of the transport device shall take into consideration the gross weight of the engine plus the gross weight of the transport device.

The gross weight of the engine, transport device and the pallet shall be considered when compared to the maximum gross weight capability of the aircraft.

The weight distribution of the engine transport device onto the pallet shall be designed with respect to pallet stiffness and its weight distribution capability. Maximum cargo compartment distributed floor loads shall not be exceeded. For maximum local floor loads, the centre of gravity location is to be considered.

5.4 Centre of gravity (CG)

5.4.1 It should be a design goal to design the engine transport device such that the aircraft engine plus the device shall have the minimum lateral and longitudinal CG eccentricity, and the lowest CG height possible.

5.4.2 The centre of gravity for each engine/engine part plus the transport device shall not exceed the limits of ISO 8097 for the pallet to which it is attached or the applicable limits of the supplementary type certification for the pallet base.

5.4.3 If the requirements of 5.4.2 cannot be met, additional tiedown requirements to the aircraft structure shall be specified, compatible with other requirements specified.

5.4.4 Those pallet sizes adopted which are not covered in ISO 8097 shall meet the maximum CG limits shown in figures 1 to 3. In addition, the centre of gravity shall be at a maximum height of 1 219,2 mm (48 in).

5.5 Equipment strength

Each engine transport device shall be able to carry its total weight under the aircraft ultimate load factor conditions. See 6.1 and 7.

5.5.1 Equipment to be used exclusively for air transport shall be designed to the ultimate load defined by the airframe manufacturer for a specific aircraft.

5.5.2 Equipment for air and truck transport shall be designed with a safety factor that is 2,5 times the operating load defined in 5.7.3.

5.5.3 Any temporary elastic deformation shall be limited to the extent that resulting moments or loads imparted to the engine are not in excess of the limits defined on the ground handling installation drawing provided by the engine manufacturer.

5.6 Tare weight

The tare weight shall be kept at a minimum consistent with the requirements and within limits of good design practices. Aircraft engine pylon hoist limitations shall be considered, if applicable.

5.7 Construction

The engine transport device construction shall be representative of good industrial practice.

5.7.1 The equipment shall be suitably protected to withstand the environment and to meet the criteria specified in clause 9.

5.7.2 Components shall not permit liquids, sand or debris to accumulate within.

5.7.3 For air and truck transport devices, the unit construction shall provide sufficient structural strength to withstand, without permanent deformation, the static loads, the dynamic loads, and the impact shock and the racking stresses resulting from the road carriage at highway speeds, forklift handling, and, if applicable, top lifting while loaded to maximum capacity. The device shall be designed to withstand truck transport operating loads of $\pm 5g_n$ vertical, $3g_n$ fore and aft, and $2g_n$ lateral [g_n = 9,81 m/s^2 (standard acceleration of free fall)].

For lightweight air transport devices, the unit construction shall provide sufficient structural strength to withstand, without permanent deformation, the static load, the dynamic loads, and the shock and racking stresses resulting from air transport. See 7.2 for ultimate load.

With the engine transport device configured for truck transport, a shock mount system having a natural frequency in the 7 Hz to 10 Hz range is rec-

ommended, and shall meet the requirements of the appropriate engine manufacturer. It shall be demonstrated that such a system in combination with a truck air suspension system will reduce the requirements to a flight load level as for air and truck transport devices given above 7.2.1 and 7.2.2.

NOTE 3 It is understood that when certain g_n levels defined for the appropriate engine/engine parts are likely to be exceeded, these actual g_n levels have to be recorded and can require an inspection of the engine/engine parts. This can apply to both, air and ground transport.

5.7.4 The unit base shall be flat and continuous. The bottom surface of the base shall not cause point loads or have sharp edges in contact with the pallet.

5.7.5 No structure, fittings or other objects shall protrude below the bottom surface of the base.

5.7.6 The unit base shall structurally adapt to the specified pallet sizes equipped with continuous net attachment tracks along the edge rail.

5.7.7 Unit base design shall take into account the aircraft power drive system and their inability to move a unit load device (ULD) when the pallet flexes away from the friction drive devices.

5.7.8 Forklift tineway provisions shall be included for type B devices. The pocket size shall be a minimum of 317,5 mm (12,5 in) wide and 114,3 mm $^{0}_{-6,35}$ mm (4,5 mm $^{0}_{-0,25}$ mm) high. Pocket spacing shall be a function of geometric parameters of the engine and pockets shall be equidistant from the centre of gravity.

5.7.9 Multipurpose transport devices which can accommodate more than one engine type and/or engines from more than one manufacturer shall be designed to allow for approved configurations only taking into account all relevant parts, i.e. shockmounts.

5.8 Pallet base

The unit base shall rigidly attach to the pallet base.

The pallet base can be supplied with the transport device assembly, however, the applicable pallet base or bases and the transport device shall be approved as a unit by the appropriate airworthiness authorities.

The pallet bases shall be approved in accordance with ISO 8097 or the applicable supplementary type certificate (STC).

Allowable pallet maximum gross weight and load factors shall apply.

6 Restraint provisions

6.1 Aircraft restraint provisions

Pallet base restraint shall be in accordance with ISO 8097 Class II restraint systems for Types A and B devices. Those pallet sizes adopted, which are not covered in ISO 8097, such as 2438 mm × 4 064 mm (96 in × 160 in) and 2 438 mm × 4 978 mm (96 in × 196 in), shall meet the minimum restraint configurations of figures 1 to 3.

6.1.1 Aircraft restraint provisions of the pallet being used shall be retained. Attachment fittings shall not prevent access required by aircraft restraints and/or the ability for one person, without the use of tools, to set the required aircraft restraints.

6.1.2 The load path of the unit restraint, system shall conform to the ISO 8097 Class II restraint system. The restraint load path should be held to a minimum where possible.

6.1.3 The airframe manufacturer may define operational requirements for positioning of complete aircraft engine packs and/or compressible loads in front of the latter, so as to ensure for ISO 8097 Class II aircraft restraint systems, the safety barrier net integrity and function, as required for a crash condition.

6.2 Engine restraint provisions

Provision shall be made to secure the engine to the unit using design attach points and fittings as specified by the engine manufacturer.

7 Aircraft and ground transport loads

7.1 Gross weights of engine plus transport device

Where feasible, maximum load capacities of ISO 8097 may be applied. However, the load capacities given in table 1 will be applicable as a design guide reflecting existing engine transport design weights and actual aircraft capability.

Table 1

Type	Size mm	Load capacity kg
A (Lower deck)	1 534 × 3 175	3 174
	2 235 × 3 175	4 626
	2 438 × 3 175	5 035
B (Upper deck)	2 235 × 3 175	6 032
	2 438 × 3 175	6 804
	2 438 × 4 064	6 804
	2 438 × 4 978	10 451
	2 438 × 4 978	10 658
	2 438 × 6 058	11 340

7.2 Ultimate load criteria

The values given in table 2 may be taken as a design guide for maximum ultimate load criteria in line with ISO 8097 for individual aircraft types and defined positions, these values being in most cases lower, rarely higher.

7.3 Ground transportation

7.3.1 Ground transportation requirements shall meet or exceed those outlined in the current issue of the Department of Transportation Motor Carriers Safety Regulation, Part 393.100, Subpart I and/or national safety regulations as applicable.

7.3.2 Weight and measures of equipment for truck transport shall meet national traffic regulations.

8 Assembly and disassembly

8.1 Attachment fittings

8.1.1 Fittings shall be located so that they cannot damage or be damaged by aircraft hardware and/or adjacent units if they inadvertently are left open or become open in transit.

8.1.2 No special tools or equipment shall be required to secure fittings.

8.1.3 Means should be provided to give visual and mechanical indication that fittings are positively secured.

8.1.4 Where possible, fittings and assembly components should be interchangeable.

8.1.5 Handles, straps and fittings shall withstand a minimum of 22 250 N (5 000 lbf) pull in any direction.

8.1.6 When assembled or diassembled, there shall be no loose parts which can easily be lost. Small assembly components and parts shall be chain or metal cable attached.

8.2 Preparation for shipment and loading

Assembly/diassembly manning for preparation of transport device equipment and time required before loading into the aircraft should be held to a minimum.

Table 2

Type	Position	Ultimate load criteria				
		Forward	Aft	Side	Up	Down
A	Aircraft	$1{,}5g_n$	$1{,}5g_n$	$1{,}5g_n$	$3g_n$	$6g_n$
	Airport: groundhandling	$3g_n$	$3g_n$	$0{,}5g_n$	$0{,}75g_n$	$2{,}5g_n$
B	Aircraft	$1{,}5g_n$	$1{,}5g_n$	$1{,}5g_n$	$3g_n$ [1)]	$6g_n$ [1)]
	Airport: groundhandling	$3g_n$	$3g_n$	$0{,}5g_n$	$0{,}75g_n$	$2{,}5g_n$

NOTE — As far as lifting the loaded unit is concerned, national regulations shall be applied.

1) For DC 10, up value is $3{,}1g_n$ and down value is $6{,}1g_n$.

8.2.1 The minimum objectives for type A (lower deck) devices shall be the following:

a) maximum manning: one person;

b) maximum assembly/disassembly time: 5 min;

c) maximum equipment: one 5 035 kg/1 219 mm (11 100 lb/48 in) load centre forklift or equivalent.

8.2.2 The minimum objectives for type B (upper deck) devices shall be the following:

a) maximum manning: two persons;

b) maximum assembly/disassembly time: 10 min;

c) maximum equipment: one 12 084 kg/ 1 219 mm (26 640 lb/48 in) load centre forklift or equivalent.

8.3 Provision for return haul

See 8.1.6 and 11.4 d).

9 Environmental criteria

9.1 Operating conditions

Equipment should be capable of operating under the following conditions:

a) temperature range of − 54 °C to + 71 °C (− 65 °F to + 160 °F);

b) relative humidity of 100 %;

c) exposure to salt sea atmosphere;

d) sand and dust particles, wind velocity of 97 km/h (60 mile/h);

e) exposure to rain, snow and sleet;

f) all fluids normally contained on engines and on aircraft.

9.2 Materials and processes

9.2.1 Materials and processes selected shall give consideration to extremely hard usage to which the unit will be subjected to provide for a maximum service life.

9.2.2 All metal parts shall be protected against corrosion.

9.2.3 All nonmetallic parts and/or joints which are liquid absorbent shall be sealed and/or treated.

9.2.4 All materials shall be fire-retardant in accordance with regulatory requirements.

9.2.5 All materials and/or components shall be protected against deterioration or loss of strength in service and storage due to weathering, corrosion, galvanic action, or other causes where the type of material used requires such protection.

10 Marking requirements

The transport device shall be clearly and permanently marked in a location visible after the engine is installed. The letter size shall be large enough to ensure good readability. Markings shall include the following items:

a) manufacturer, part number and serial number;

b) engine(s) that can be transported on the stand;

c) applicable pallet base by ISO 8097 code number or manufacturer's name and part number if STC item;

d) the weight of the stand to the nearest kilogram and pound;

e) maximum allowable gross weight of engine transport device;

f) aircraft type to which the loadability of the total engine transport package is limited, if applicable, also aircraft configuration/load position, in accordance with an approved document;

g) type of approval for the unit and issuing airworthiness authority;

h) whenever the transport device constitutes a single integrated unit together with its base pallet, it shall be marked in addition with the appropriate unit load device identification code, to be obtained from the IATA ULD registrar 2000 Peel St., Montreal, Quebec, Canada H3A 2R4.

11 Testing

11.1 General

The tests are static in nature to minimize complexity and cost of required testing facilities. As far as practical, applied static loads shall take into account the

combined static and dynamic loads anticipated in service.

11.1.1 It is intended that tests shall be nondestructive in nature and shall not result in damage unless ultimate load conditions are employed.

11.1.2 Test equipment and methods of testing described are not meant to be restrictive. Alternative equivalent methods may be employed if they can be shown to lead to the same results.

11.1.3 In selected cases, tests may be repeated under ultimate load conditions when required for substantiation of analytical data. If this becomes necessary, the unit so tested shall not be used in service until all component parts are inspected and those that exhibit permanent deformation are replaced.

11.2 Test criteria

11.2.1 All deflections shall be measured during testing. No permanent deflection is acceptable.

11.2.2 Permanent deformation is permitted under ultimate load conditions, if ultimate load testing is required. A unit design shall be considered acceptable if the unit exhibits permanent deformation but does not deform to the extent of discharging cargo or breaking free from the restraint system.

All hardware exhibiting this type of deformation shall be replaced if the unit being tested is to be used for engine shipment.

11.3 Recommended test equipment

11.3.1 When restraint or movement on conveyor systems is evaluated, the test system shall be in accordance with ISO 4117.

The following test equipment is recommended.

— Rows of rollers on approximately 508 mm (20 in) centres with each row composed of 38 mm (1,5 in) diameter rollers 76,2 mm (3 in) long uncrowned with edge radius of 1,5 mm (0,06 in) spaced on 254 mm (10 in) centres, for longitudinal transport. Latches and guide rails of suitable strength shall be provided to guide the device along the conveyor and secure it at its restraint points.

— Ball transfer units for omnidirectional transport with 25,4 mm (1 in) diameter balls located on a 127 mm × 127 mm (5 in × 5 in) grid pattern. Pallet travel is in all directions across the grid.

— Swivel casters with 25,4 mm (1 in) diameter wheels having a contact length of 50,8 mm (2 in) located on a 305 mm × 305 mm (12 in × 12 in) grid pattern. Pallet travel is in all directions across the grid.

11.3.2 When conducting structural tests, sufficient payload to meet test load requirements shall be provided, or appropriate load producing devices may be used.

11.4 Testing requirements

The following shall be demonstrated at full capacity loads:

a) Assembly: Demonstrate time elapsed, manning, and equipment required;

b) Loading: Demonstrate ability to load and prepare an engine for shipment. Time elapsed, manning, and equipment required;

c) Lifting: Demonstrate top lifting, and forklifting requirements and ability to control the load during

   1) assembly,

   2) placement of loaded units with pallet attached on conveyorized ramp equipment.

d) Disassembly and preparation for return haul: Demonstrate ability to disassemble.

e) Over-the-road transportation: Demonstrate ability of unit to withstand the following normal over-the-road driving conditions using full size truck/semi trailer with air brakes and/or equivalent, within the limits as defined by the engine manufacturer

   1) vibration,

   2) severe pavement shock loads,

   3) emergency stopping,

   4) sudden acceleration,

   5) sharp turns at 56 km/h (35 mile/h);

f) Aircraft loading: Demonstrate the ability to move in and out of aircraft equipped with power drive cargo loading systems. Demonstrate the ability to properly lock and/or restrain the complete unit system in the aircraft without special tool and/or assistance.

11.5 Proof load test

11.5.1 The first article (transport device) designed and fabricated exclusively for air transport shall be proof load tested to the maximum operating load defined by an airframe manufacturer or to values representing 67 % of the ultimate load defined by an airframe manufacturer for a specific aircraft (see 5.5.1).

11.5.2 The first article (transport device) designed and fabricated for air and truck transport shall be proof load tested to the maximum operating loads defined in 5.7.3. Dynamic testing of the shock mounted system is not required, but data showing compliance with 5.7.3 shall be submitted with the first article test report.

11.5.3 Proof loads shall be applied independently and shall act at the engine centre of gravity. No weld failure or permanent material deformation shall exist after the proof tests have been accomplished. A fluorescent type, or equivalent, inspection of the equipment is recommended following the proof load test.