AEROSPACE RECOMMENDED PRACTICE

ARP1840™	REV. B
Issued 1986-01 Revised 2007-02 Reaffirmed 2020-11 Superseding ARP1840A	

Aircraft Engine Transport Devices

RATIONALE

A five year review of ARP1840 resulted in major revisions to the original document. A definitions section was added and some renumbering of the paragraphs. Figures 2 and 3 were deleted from the document as these pallets are now included in NAS 3610/AS36100A.

Document was restructured to be more general in nature so as to read as an ARP versus an AS.

Metric measurements were added where they did not exist in previous version.

Figure 1 was maintained as an example of an STC Type pallet.

All remaining changes were either spelling or grammar.

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FOREWORD

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

This ARP1840, however, covers their transport as aircraft engine transport devices, as a unit being secured in the aircraft certified restraint system compatible with ULDs designed to meet loading requirements as set forth by the Airframers Weight and Balance manuals or STC.

The following are definitions of abbreviations and terms used in this document:

a. ENGINE TRANSPORT DEVICE: A rigid structure that is specifically designed to transport specific aircraft engines.

b. PALLET (AIR CARGO): A unit load device consisting of a flat platform with flat undersurface of standard dimensions, on which goods are assembled and secured by a net before being loaded as a unit onto the aircraft handling and restraint system.

c. RESTRAINT SYSTEM: Equipment for supporting and restraining unit load devices in an aircraft against the ground/flight loads. It usually consists of such items as rollers, side guides and locks for securing unit load devices to the aircraft structure. It does not include unit load devices, barrier nets and tie-down straps

d. SPLIT ENGINE PACKS: Aircraft engines which are partially disassembled, i.e., cowlings, fan section and/or tail cones removed.

e. FULL ENGINE TRANSPORT: Engines that are transported fully assembled.

f. UNIT LOAD DEVICE (ULD): Device for grouping, transferring and restraining cargo for transit. It may consist of a pallet with a net or it may be a container.

1. SCOPE

1.1 Types of Engine Transport Devices

This document establishes two types of engine transport devices:

Type A: For split engine pack transport (mainly lower deck)
Type B: For full engine transport (mainly main deck)

1.1.1 Type A

Will be used for shipping of split engine packs,

e.g. Core-engine packs
Fan-engine packs

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

60.4 in x 125 in (1534 mm x 3175 mm) (Size Code L)
88 in x 125 in (2235 mm x 3175 mm) (Size Code A)
96 in x 125 in (2438 mm x 3175 mm) (Size Code M)

The transport device shall be compatible with aircraft restraint systems designed for NAS 3610/AS 36100A type 2 ULDs or equivalent STC approved ones.

1.1.2 Type B

Will be 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 size

88 in x 125 in (2235 mm x 3175 mm) (Size Code A)
96 in x 125 in (2438 mm x 3175 mm) (Size Code M)
96 in x 196 in (2438 mm x 4978.4 mm) (Size Code R)
96 in x 238.5 in (2438 mm x 6057.9 mm) (Size Code G)

and compatible with aircraft restraint systems designed for NAS3610/AS36100A type 2 ULDs or equivalent STC approved ones.

The restraint of the engine transport device onto the pallet shall use appropriate tie down devices complying with any requirements of aircraft Weight and Balance manuals, pallet manufacturer's, or engine transport device manufacturer's instructions.

1.1.3 For both types of engine transport devices the use of pallet nets is not recommended.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AS1130 Air and Air/Surface (Platform) Cargo Pallet

ARP1334 Ground Equipment Requirements for Compatibility with Aircraft ULDs

AS1491 Interline Air Cargo Pallets

ARP1757 Symbology for Standardization of ULD Handling Devices

AS36100A Air Cargo Unit Load Devices - Performance Requirements and Test Parameters

2.2 AIA Publications

Available from Aerospace Industries Association of America, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NAS 3610 Cargo Unit Load Devices - Specification for (Revision 10)

2.3 IATA Publications

Available from International Air Transport Association, Publications Assistant, 800 Place Victoria, P.O. Box 113, Montreal, Quebec H4Z 1M1, Canada, Tel: 1-514-874-0202, www.iata.org.

IATA ULD Technical Manual 50/0, Requirements for Interlining of ULD

IATA ULD Technical Manual 50/1, Pallets for Class II Restraint Systems (NAS3610/AS36100A)

IATA ULD Technical Manual 50/9, 16’ & 20’ Pallets for Class II Restraint Systems (NAS3610/AS36100)

2.4 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 3394 Dimensions of rigid rectangular packages - Transport packages

ISO 3676 Packaging - Unit load sizes - Dimensions

ISO 7166 Aircraft - Rail and stud configuration for passenger equipment and cargo restraint

ISO 8097 Minimum airworthiness requirements and test conditions for certified air cargo unit load devices

ISO 21100 Air cargo unit load devices - Performance requirements and test parameters

2.5 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/.

Technical Standard Order TSO C90 - Cargo Pallets, Nets and Containers

Federal Aviation Regulations Title 14 CFR Part 25 - Airworthiness Standards: Transport Category Airplanes

Motor Carriers Safety Regulations Part 393.100 Subpart I, Protection Against Falling or Shifting Cargo, United States Department of Transportation Stock No. 5004-00010

3. DESIGN OBJECTIVES

3.1 General

This document is intended to establish design objectives for an aircraft engine transport device for quick engine change (QEC) packs and split engine packs with consideration of the following interfaces:

3.1.1 The Airframe Manufacturers

Aircraft Loadability Interface (ALI) Spec. or Weight and Balance Manual outsize cargo restraint requirements.

- Cargo envelope, Pallet configuration
  - Maximum gross weights, CG limits, maximum local and area loads
  - Equipment strength (A/C g-load envelope)
  - Loading procedure/requirements, pallet sequence.

NOTE: 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, if the WBM indicated limitations can not be met or specific transport assistance is requested. Further requirements to be met for engine change are included in relevant documentation.

- Bootstrap hoist point geometry in TEM (Tool and Equipment Manual)
- Pylon hoist limitations in MM (Maintenance Manual)

3.1.2 The Aircraft Engine Manufacturers

Purchase Performance Specification (PPS) or other engine manufacturer's specification.

- 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: 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.

4. REQUIREMENTS

4.1 Dimensions

4.1.1 Type A

Shall adapt to a pallet length of 125 in (3175 mm) and a width of 60.4 in (1534 mm), 88 in (2235 mm), or 96 in (2438 mm).

4.1.2 Type B

Shall adapt to pallet length of 125 in (3175 mm) and a width of 88 in (2235 mm) or adapt to pallet lengths of 125 in (3175 mm), 160 in (4064 mm), 196 in (4978.4 mm), and 238.5 in (6057.9 mm) and a width of 96 in (2438 mm).

4.2 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 2 in (50 mm). A minimum clearance of 2 in (50 mm) in the cargo doorways is also recommended.

4.3 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.

4.3.1 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.

4.3.2 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 C.G. location is to be considered.

4.4 Center of Gravity

4.4.1 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 C.G. eccentricity, and the lowest C.G. height possible.

4.4.2 The center of gravity for each engine/engine part plus the transport device should not exceed the limits of NAS 3610/AS36100A for the pallet to which it is attached or the applicable limits of the supplementary type certification for the pallet base.

4.4.3 If the requirements of 4.4.2 cannot be met, additional tie down requirements to the aircraft structure shall be specified, compatible with other requirements specified.

4.5 Equipment Strength

Each engine transport device shall be able to carry its total weight under the aircraft ultimate load factor conditions. See 5.1 and 6.

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

4.5.2 Equipment for air and truck transport should be designed with a safety factor that meets the maximum operating loads stated in 4.7.3.1, or air mode ultimate loads stated in 4.5.1 and 6.2, whichever is highest.

4.5.3 Any temporary elastic deformation must 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.

4.6 Tare Weight

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

4.7 Construction

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

4.7.1 The equipment shall be suitably protected to withstand the environment and to meet the criteria specified in Section 8.

4.7.2 Components shall not permit the accumulation of liquids, sand or debris.

4.7.3 Air and Truck or Air Only Transportation Devices

4.7.3.1 Air and Truck Transport Device

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 ±5 g vertical, 3 g fore and aft, and 2 g lateral.

4.7.3.2 Light Weight Air Transport Device

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. Refer to 6.2 for ultimate load.

4.7.3.3 With the engine transport device configured for truck transport, a shock mount system is recommended, and shall meet the requirements of the appropriate engine manufacturer. It is to be demonstrated that such system in combination with a truck air suspension system will reduce the requirements of 4.7.3.1 to a flight load level as per 6.2.1 and 6.2.2.

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

4.7.4 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.

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

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

4.7.7 Unit base design shall take into account the airplane power drive systems and their inability to move a ULD when the pallet flexes away from the friction drive devices.

4.7.8 Forklift tineway provisions shall be included for type B devices. The pocket size shall be a minimum of 12.50 in (317.5 mm) wide and 4.50 in (114.3 mm) high. Pocket spacing shall be a function of geometric parameters of the engine and pockets should be equidistant from the center of gravity.

4.7.9 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.

4.8 Pallet Base

The unit base may be rigidly attached to the pallet base.

The pallet base may or may not 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 per NAS 3610 (TSO C90)/AS36100A or the applicable supplementary type certificate (STC).

Allowable pallet maximum gross weight and load factors shall apply.

5. RESTRAINT PROVISIONS

5.1 Aircraft Restraint Provisions

Pallet base restraint shall be per NAS 3610/AS36100A Class II restraint systems for Type A and B devices. Those pallet sizes adopted, which are not covered in NAS 3610/AS36100A, an example of which is the pallet shown in Figure 1, shall meet minimum restraint configurations set by the STC.

5.1.1 Aircraft restraint provisions of the pallet being used shall be retained. Attach fittings shall not negate access required by aircraft restraints and/or the ability for one man, without the use of tools, to set the required aircraft restraints.

5.1.2 The load path of the unit restraint system shall be compatible with aircraft restraint systems designed for NAS 3610/AS36100A type 2 ULDs. The restraint load path should be held to a minimum where possible.

5.1.3 The airframe manufacturer may define operational requirements for positioning of complete aircraft engine packs and/or compressible loads in front of them, so as to ensure for aircraft restrain systems designed for NAS 3610/AS36100A type 2 ULDs, the safety barrier net integrity and function, as required for a emergency landing.

5.2 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.

6. LOADS - AIRCRAFT AND GROUND TRANSPORT

See also 5.1.

6.1 Gross Weights of Engine Plus Transport Device

Where feasible, maximum load capacities of NAS 3610/AS36100A may apply. However, the following load capacities will be applicable as a design guide reflecting existing engine transport design weights and actual aircraft capability.

6.1.1 Type A (Lower Deck)

60.4 in x 125 in (1534 mm x 3175 mm) : 7000 lb (3174 kg)
88 in x 125 in (2235 mm x 3175 mm) : 10,200 lb (4626 kg)
96 in x 125 in (2438 mm x 3175 mm) : 11,100 lb (5035 kg)

6.1.2 Type B (Main Deck)

88 in x 125 in (2235 mm x 3175 mm) : 15,000 lb (6804 kg)
96 in x 125 in (2438 mm x 3175 mm) : 15,000 lb (6804 kg)
96 in x 196 in (2438 mm x 4978.4 mm) : 25,000 lb (11,340 kg) across the fuselage
96 in x 196 in (2438 mm x 4978.4 mm) : 25,000 lb (11,340 kg) lengthwise
96 in x 238.5 in (2438 mm x 6057.9 mm) : 30,000 lb (13,608kg)

6.2 Ultimate Load Criteria

The aircraft values stated below may be taken as a design guide for maximum ultimate load criteria in line with NAS 3610/AS36100A; for individual aircraft types and defined positions, these values may differ.

6.2.1 Type A

TABLE 1

	Forward	Aft	Side	Up	Down
Aircraft	1.5 g	1.5 g	1.5 g	3.0 g	6.0 g
Airport Groundhandling	3.0 g	3.0 g	0.5 g	0.75 g	2.5 g

6.2.2 Type B

TABLE 2

	Forward	Aft	Side	Up	Down
Aircraft	1.5 g	1.5 g	1.5 g	3.0 g	6.0 g
Airport Groundhandling	3.0 g	3.0 g	0.5 g	0.75 g	2.5 g

6.3 Ground Transportation

6.3.1 Ground transportation requirements shall meet or exceed those outlined in the Department of Transportation Motor Carriers Safety Regulation. Reference current issue, Part 393.100, Subpart I, "Protection Against Falling or Shifting Cargo" - and/or national safety regulations as applicable.

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

7. ASSEMBLY AND DISASSEMBLY

7.1 Attach Fittings

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

7.1.2 No special tool or equipment shall be required to secure fittings.

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

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

7.1.5 Handles, straps and fittings shall withstand a minimum of 5000 lbf (2225 daN) pull in any direction.

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

7.2 Preparation for Shipment and Loading

Assembly/disassembly personnel for preparation of transport device equipment and time required before loading into the A/C should be held to a minimum. Following shall be minimum objectives:

7.2.1 Type A (Lower Deck)

a. maximum personnel - one (1) person

b. maximum assembly/disassembly time - 5 minutes

c. maximum equipment - one 11,000 lbf @ 48 in (4893 daN @ 1219 mm) load center forklift or equivalent

7.2.2 Type B (Main Deck)

a. maximum personnel - two (2) persons

b. maximum assembly/disassembly time - 10 minutes

c. maximum equipment - one 26,640 lbf @ 48 in (11,850 daN @ 1219 mm) load center forklift or equivalent

7.3 Provision for Return Haul

See 7.1.6 and 10.4.1.4.

8. ENVIRONMENTAL CRITERIA

8.1 Operation Conditions

Equipment should be capable of operating under the following conditions:

8.1.1 Temperature range of -54 to +71 °C (-65 to +160 °F).

8.1.2 Relative humidity of 100%.

8.1.3 Exposure to salt sea atmosphere.

8.1.4 Sand and dust particles, wind velocity of 60 mph (97 kmh).

8.1.5 Exposure to rain, snow and sleet.

8.1.6 All fluids normally contained on engines and on aircraft.

8.2 Materials and Processes

8.2.1 Materials and process selected should give consideration to extremely hard usage to which the unit will be subjected to provide for a maximum service life.

8.2.2 All metal parts should be protected against corrosion.

8.2.3 All non metallic parts and/or joints which are liquid absorbent should be sealed and/or treated.

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

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

9. 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 insure good readability. Markings should include the following items:

1. Manufacturer, Part No. and Serial No.
2. Engine(s) that can be transported on the stand.
3. Applicable pallet base by NAS 3610/AS36100A Code No. or manufacturer's name and part No. if STC item.
4. The weight of the stand to the nearest pound and kilogram.
5. Maximum allowable gross weight of engine transport device.
6. Aircraft type to which the loadability of the total engine transport package is limited, if applicable; also aircraft configuration/load position, as per approved document.
7. Type of approval for the unit and issuing airworthiness authority.

10. TESTING

10.1 Scope

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

10.1.1 It is intended that tests shall be non-destructive in nature and not result in damage unless ultimate load conditions are employed.

10.1.2 Test equipment and methods of testing described are not meant to be restrictive. Alternate equivalent methods to accomplish the desired results may be employed.

10.1.3 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 may not be used in service until all component parts are inspected and those that exhibit permanent deformation are replaced.

10.2 Test Criteria

10.2.1 All deflections must be measured during testing.

10.2.2 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.

10.3 Recommended Test Equipment

10.3.1.1 When restraint or movement on conveyor systems is evaluated, the test system shall be in accordance with the following.

- Rows of rollers on approximately 20 in (508 mm) centers with each row composed of 1.5 in (38 mm) diameter rollers 3 in (76.2 mm) long uncrowned with edge radius of 0.06 in (1.5 mm) spaced on 10 in (254 mm) centers, 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 1 in (25.4 mm) diameter balls located on a 5 in x 5 in (127 mm x 127 mm) grid pattern. Pallet travel is in all directions across the grid.

- Swivel casters with 1 in (25.4 mm) diameter wheels having a contact length of 2 in (50.8 mm) located on a 12 in x 12 in (305 mm x 305 mm) grid pattern. Pallet travel is in all directions across the grid.

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