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AEROSPACE RECOMMENDED PRACTICE

SAE ARP1840 REV. A

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Superseding ARP1840

Aircraft Engine Transport Devices

FOREWORD

Changes in this revision are format/editorial only.

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 by a Class II NAS 3610 restraint system as provided.

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 upper 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 x 125 inches (1534 x 3175 mm)
88 x 125 inches (2235 x 3175 mm)
96 x 125 inches (2438 x 3175 mm)

The transport device shall be compatible with NAS 3610 Class II restraint systems.

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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 x 125 inches (2235 x 3175 mm)
96 x 125 inches (2438 x 3175 mm)
96 x 160 inches (2438 x 4064 mm)*
96 x 196 inches (2438 x 4978.4 mm)*
96 x 238.5 inches (2438 x 6057.9 mm)

and compatible with NAS 3610 Class II restraint requirements.

*Note: These sizes are not currently included in NAS 3610. See Figures 1, 2, and 3 for restraint requirements.

The restraint of the engine transport device onto the pallet shall use mechanical links providing load paths which are compatible with NAS 3610, 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.

2. REFERENCE DOCUMENTS:

The following Specifications, Recommended Practices, Standards or applicable portions thereof should be considered.

2.1 NAS 3610 - Cargo Unit Load Devices - Specification for.

2.2 ARP1334 - Ground Equipment Requirements for Compatibility with Aircraft ULD's.

2.3 ARP1757 - Symbology for Standardization of ULD Handling Devices.

2.4 AS1130 - Air and Air/Surface (Platform) Cargo Pallet.

2.5 AS1491 - Interline Air Cargo Pallets.

2.6 IATA 50/0 - Condition Requirements for Interlining of ULD's.

2.7 IATA 50/1 - Pallets for NAS 3610 Class II Restraint Systems.

2.8 IATA 50/9 - 20' Pallet for NAS 3610 Class II Restraint Systems.

2.9 United States Department of Transportation Motor Carriers Safety Regulations Part 393.100 Subpart I, "Protection Against Falling or Shifting Cargo" may be obtained from the U.S. Government Printing Office, Washington, DC 20402, Stock No. 5004-00010.

Note: NAS 3610 may be obtained from the Aerospace Industries Association of America, Inc., 1725 De Sales St. N.W., Washington, DC 20036. IATA 50/0, 50/1 and 50/9 may be obtained from the International Air Transport Association, 200 Peel St., Montreal, Quebec, Canada H3A 2R4.

3. DESIGN OBJECTIVES:

3.1 General:

This ARP 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 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. Further requirements to be met for engine change are included in relevant documentation.

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

and require the cooperation of the parties involved.

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 inches (3175 mm) and a width of 60.4 inches (1534 mm), 88 inches (2235 mm) or 96 inches (2438 mm).

Type B: Shall adapt to pallet length of 125 inches (3175 mm) and a width of 88 inches (2235 mm) or adapt to pallet lengths of 125 inches (3175 mm), 160 inches (4064 mm), 196 inches (4978.4 mm) and 238.5 inches (6057.9 mm) and a width of 96 inches (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 inches (50 mm). A minimum clearance of 2 inches (50 mm) in the cargo doorways is also recommended.

4.3 Grossweight/Weight Distribution:

The design of the transport device must 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 must be considered when compared to the maximum gross weight capability of the aircraft.

4.3.1 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 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 paragraph 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 paragraphs 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 is 2.5 times the operating load defined in paragraph 4.7.3.1.

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 paragraph 8.

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

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 paragraph 6.2 for ultimate load.

4.7.3.3 With the engine transport device configured for truck transport, a shock mount system having a natural frequency in the 7-10 Hertz range is recommended, and must 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 paragraph 4.7.3.1 to a flight load level as per paragraphs 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 inches wide and $4.50\ ^{(+0)}_{(-0.25)}$ inches high. Pocket spacing shall be a function of geometric parameters of the engine and pockets should be equidistant from the centre 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 shall 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 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 Class II restraint systems for Type A & B devices. Those pallet sizes adopted, which are not covered in NAS 3610, such as 96 x 160 inches (2438 x 4064 mm) and 96 x 196 inches (2438 x 4978 mm), shall meet minimum restraint configurations shown in Figures 1, 2, and 3.

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 conform to the NAS 3610 Class II restraint system. 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 the latter, so as to ensure for NAS 3610 Class II aircraft restraint systems, the safety barrier net integrity and function, as required for a crash condition.

5.2 Engine Restraint Provisions:

5.2.1 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 paragraph 5.1.

6.1 Gross Weights of Engine Plus Transport Device:

Where feasible, maximum load capacities of NAS 3610 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 inches x 125 inches : 7,000 lb (3174 kg)
88 inches x 125 inches : 10,200 lb (4626 kg)
96 inches x 125 inches : 11,100 lb (5035 kg)

Type B (Upper Deck):

88 inches x 125 inches : 13,300 lb (6032 kg)
96 inches x 125 inches : 15,000 lb (6804 kg)
96 inches x 160 inches : 15,000 lb (6804 kg)
96 inches x 196 inches : 23,040 lb (10,451 kg) across the fuselage
96 inches x 196 inches : 23,500 lb (10,658 kg) lengthwise
96 inches x 238.5 inches : 25,000 lb (11,340 kg)

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; for individual aircraft types and defined positions, these values are in most cases lower, rarely higher.

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
				(3.1 g	6.1 g* for DC10)

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 5,000 lb (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 manning 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 manning - one (1) man
b. maximum assembly/disassembly time - 5 minutes
c. maximum equipment - one 11,000 lb/48 inch (5035 daN/1219 mm) load center forklift or equivalent

7.2.2 Type B (Upper Deck):

a. maximum manning - two (2) men
b. maximum assembly/disassembly time - 10 minutes
c. maximum equipment - one 26,640 lb/48 inch (12084 daN/1219 mm) load center forklift or equivalent

7.3 Provision for Return Haul:

See paragraphs 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 °C to +71 °C (-65 °F 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 retardent 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 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; no permanent deflection is acceptable.

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 When restraint or movement on conveyor systems is evaluated, the test system shall be in accordance with AS1130.

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

- Swivel casters with 1 inch (25.4 mm) diameter wheels having a contact length of 2 inch (50.8 mm) located on a 12 x 12 inch (305 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.

10.4 Testing Requirements:

10.4.1 Demonstration (at full capacity loads).

10.4.1.1 Assembly: Demonstrate time elapsed, manning, and equipment required.

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

10.4.1.3 Lifting: Demonstrate top lifting, bootstrap, and forklifting requirements and ability to control the load during:

a. assembly,
b. placement of loaded units with pallet attached on conveyorized ramp equipment.

10.4.1.4 Disassembly and preparation for return haul. Demonstrate ability to disassemble.