SAE Aerospace
An SAE International Group

AEROSPACE RECOMMENDED PRACTICE

SAE ARP1395 REV. B

Issued 1978-02
Revised 1995-10
Cancelled 2003-03

Minimum Requirements for Future Wide-Body Aircraft Cargo Systems and Compartments (Intermodal)

CANCELLATION NOTICE

This document has been declared "CANCELLED" as of March 2003. By this action, this document will remain listed in the Numerical Section of the Aerospace Standards Index.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
SAE WEB ADDRESS: http://www.sae.org

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/ARP1395B

1. SCOPE:

The dedicated aircraft addressed herein is to be an uncompromised all-freighter aircraft developed primarily for use in the civil transport industry.

The requirements of this document are applicable but not limited to airborne equipment which is subject to the airworthiness directives of FAR Part 25 and which is designed to accommodate unitized cargo in the form of intermodal containers and other compatible unitized load devices. Intermodability in the context of this document encompasses the air-truck-rail-sea modes, and considers uncertificated as well as certificated unit load devices (ULDs). This document covers the fundamental prerequisites for the aircraft cargo compartment and the onboard cargo handling and restraining system. The cargo system and compartment considers primarily 96 in (2.44 m) wide, multiple bottom configuration ULDs. The cargo system and compartment should handle outsize cargo and should consider Civil Reserve Air Fleet (CRAF) requirement compatibility. The cargo system, compartment, and the cargo-related aircraft physical features should be sufficiently defined to establish specifications for ground interface mobile and/or fixed loading equipment and facilities with a goal of standardization thereof. This document is intended to assist air carriers in standardizing to the degree necessary to insure the smooth flow of cargo between ground and aircraft and between various aircraft in the future. This document is not intended to inhibit the development of new systems, but rather to establish a solid interface for the introduction of such systems.

1.1 Purpose:

This document specifies minimum performance, design, and test requirements for future civil wide-body dedicated freighter aircraft equipment identified as a main deck unitized cargo handling and restraint system. It further outlines the general design requirements for the cargo compartment and envelope.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this specification 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 specification and references cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP807	Flight Deck Interior Doors and Their Operation
ARP917	Stowage of Flight Crew's Survival Emergency, and Miscellaneous Equipment
ARP998	Crew Restraint System
ARP1150	Safety Considerations - Flight Deck Seats for Transport Aircraft
ARP1372	Minimum Requirements for Air Cargo Unit Load Device, Ground Handling and Transport Systems
ARP1409	Requirements for Aircraft On Board Weight and Balance System
ARP4101/9	Crew Safety Provisions for Cargo Aircraft

2.1.2 FAR Publications: Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591.

FAR Part 25

3. UNIT LOAD DEVICE (ULDs):

3.1 ULDs:

The following ULD specifications, standards, or applicable portions thereof, should be considered. Additional requirements may be obtained from equipment manufacturers' manuals, catalogs, and drawings.

3.1.1 CERTIFIED ULDs:

ANSI MH5.2-1976 Air Mode Containers

IATA 50/6 Main Deck 8 x 8 ft Container for High Capacity Aircraft

ISO 1496 Series 1 Freight Containers Part VII Air Mode Containers

NAS 3610-2F1, 2G1, 2H1, 2J1, 2M1, and 2R1 Cargo Unit Load Devices, Specification for (TSO/C90 and FAR Part 37.199)

SAE AS832 Air Land Demountable Cargo Containers

3.1.1 (Continued):

SAE AS1130 Air Land Demountable Cargo Pallets

SAE AS1131 Air Land Demountable Cargo Pallet Nets

SAE AS4041 Air Mode 8 x 8 ft Containers

TSO C90 FAA Technical Service Order for Certification of ULDs

3.1.2 UNCERTIFIED ULDs:

ANSI MH5.1-1975 Basic Requirements for Cargo Containers

ANSI MH5.4-1972 International (ISO) Freight Containers

ISO 1496 Series 1 Freight Containers

MIL-C-52661 Container, Cargo (MILVAN)

3.1.3 Optional ULDs: The following additional ULD specifications, or applicable portions thereof, may be considered for handling by optional system equipment:

MIL-P-27443 (USAF) Pallet, Cargo Aircraft (463L) (Type 1 Pallet Only)

MIL-N-27444 (USAF) Pallet Net, Cargo Aircraft (463L)

MIL-P-83037 (USAF) Platform, Cargo, Aerial Delivery (463L) (Considered for Logistic Purposes)

IATA 50/1B Interline Pallet for NAS 3610 Class II Restraint Systems

IATA 50/4 Certified Aircraft Container

IATA 50/8 Main Deck 3175 (125 in) Container for High Capacity Aircraft

3.2 General:

The following cargo-related airframe or aircraft equipment specifications, standards, handbooks, etc., or applicable portions thereof, should be considered. Additional applicable documents and/or requirements may be specified or forthcoming from customer and/or contracting agencies.

3.2.1 GOVERNMENT:

FAR Part 25 Airworthiness Standards: Transport Category Aircraft (or equivalent airworthiness regulations)

3.2.2 MILITARY (Optional):

AFSC DH1-11 Design Handbook - Air Transportability

AFSC DH2-1 Design Handbook - Airframe

MIL-A-8421 General Specification for Air Transportability

3.2.3 INDUSTRY:

ARP1372 Minimum Requirements for Air Cargo ULD Ground Handling and Transport Systems

ARP1409 Minimum Requirements for Aircraft Onboard Weight and Balance Systems

4. REQUIREMENTS:

4.1 Interface:

Cargo system and compartment compatibility with unitized cargo, other cargo, ground equipment, facilities, and pertinent cargo-related aircraft physical and environmental features, including capacities and limitations, should be clearly and completely defined herein and by reference to appropriate documentation.

4.1.1 Cargo: The ULD specifications and standards or applicable portions thereof as listed in 3.1, and the cargo types as described in 4.2.1, should be considered as the cargo for the future dedicated freighter aircraft.

4.1.2 Air Vehicle Cargo System: The air vehicle cargo system should provide for the handling and restraint of specified ULDs and outsized cargo in the aircraft.

4.1.2.1 Conveyance: The system should provide for the conveyance of the ULDs across the aircraft threshold and throughout the aircraft cargo compartment.

4.1.2.2 Support and Restraint: The system should provide for the structural support and restraint of the ULDs during flight and ground maneuver in a manner which will assure the cargo will not present a hazard to the aircraft or its crew, and shall be in accordance with the requirements of FAR Part 25.

4.1.2.3 Guidance: The guidance features of the air vehicle cargo systems should assure that positive control will be maintained over moving ULDs and that ULD excursions will remain within the aircraft cargo envelope. Compatibility at interface with ground loading equipment should be provided to assure guidance continuity.

4.1.2.4 Powered Movement: The system equipment should provide for powered movement and control of ULDs.

4.1.2.5 Stick Loading: The system should provide for both individual and multiple unit stick loading and unloading of ULDs.

4.1.2.6 Outsize Cargo: The system should provide for the handling and restraint of outsize cargo within the limits of the aircraft.

4.1.2.7 Uncertificated ULDs: The system should be capable of handling and restraining uncertificated ULDs, including standard containers which do not have continuous flat bottom surfaces. This capability may be provided directly by the cargo system or through the use of adapters installed in the cargo system or on/under the ULD.

4.1.2.8 Containers: The system should not impose unusual or peculiar requirements upon the ULDs which would be detrimental to the function of the ULDs in other transport modes.

4.1.2.9 Component Application: Some system components applicable to the loading/unloading function may be introduced into the aircraft for that function but remain with the ground equipment. Compatibility with military ground loading equipment for CRAF type missions should be considered.

4.1.2.10 Optional ULDs: Provisions may be incorporated for the handling of optional ULDs. Aircraft cargo system equipment pertinent only to optional ULDs or to outsize cargo may be provided either as optional onboard equipment or as quickly removable kit-installed equipment.

4.1.3 Aircraft Physical and Environmental Features: The aircraft cargo system and compartment should be thoroughly compatible and integrated with those aircraft physical, functional, and environmental features which impact the system and the compartment.

4.1.3.1 Physical and Functional Features: Example aircraft physical and functional features are: door opening size, shape and location, cargo envelope and clearances, cargo movement paths, sill height, cargo floor attitude and excursion, aircraft stabilization characteristics, crew location with respect to cargo compartment, cargo floor and fuselage structural characteristics. These features are further covered in this document.

4.1.3.2 Environmental Features: Example aircraft environmental features are: temperature, pressure, atmosphere, venting, vibration/shock, noise, and lighting. These features are further covered in this document.

4.1.4 Ground Equipment: The following specifications, standards, and recommendations should be considered. Additional requirements may be obtained from equipment manufacturers' manuals, catalogs, and drawings.

a. ARP1372

4.1.4.1 Compatibility: The ground equipment should be fully compatible with the aircraft cargo handling system.

4.1.4.2 Cargo Alignment: The combination of the aircraft cargo system, aircraft interfacing ground equipment, and aircraft physical features should minimize the criticality of cargo positioning and aligning during loading/unloading.

4.1.4.3 Facility: With respect to interface of the aircraft and/or unitized cargo to the facility, the facility and the ground equipment can be considered as synonymous when only the function of loading and unloading the aircraft is considered.

4.2 Loadability:

The chosen spectrum of cargo should be readily loadable if the aircraft is to perform efficiently. The cargo compartment should be sized to receive and contain the cargo utilizing most effectively the volume determined to meet the performance requirements. The cargo aperture and envelope should be located and sized, respectively, to meet the needs of the cargo and the handling system, which, in turn, should perform to meet the requirements of aircraft turn-around and unloading. There should be no constraints on methods to load or unload the cargo compartment of the aircraft.

4.2.1 Types of Cargo: The cargo compartment should accept various types of unitized and nonunitized cargo including cargo suitable to CRAF missions, when such is taken into consideration.

4.2.1.1 General Cargo: General cargo unitized in dry van containers or on suitable pallets will constitute the majority of the civil freighter domestic and international cargo in future air cargo operations. The ULDs listed in 3.1 will encompass the ULD spectrum which must be handled through the cargo aperture and in the cargo compartment.

4.2.1.2 Special Cargo: Special cargo is generally defined as cargo which may not be environmentally or physically compatible with the containers used for general cargo (4.2.1.1) but will be handled on suitable pallets within the dimensions and weights defined for general cargo. This cargo may include refrigerated or frozen items, liquids, autos, live animals, etc. Preservation of compatibility with ground transportation should be considered a requirement.

4.2.1.3 Outsize Cargo: Outsize cargo are those items incapable of being contained or restrained by the various ULDs listed (3.1), but that will fit with adequate clearance, the cargo envelope of the aircraft being developed. Bulk loading, special pallets or containers, dollies, or other means of entry and tie-down may be used depending upon the capability of the airframe and/or the design features desired by the buyer/user.

4.2.1.4 Military Cargo: Military (CRAF mission) cargo, when taken into consideration, may have considerable impact on the cargo compartment depending on the type, size, range, and payload under consideration for the aircraft being developed. Future development of the CRAF requirements for ULD types and sizes, for wheeled and tracked vehicles, and for outsize military cargo should be monitored and considered in the basic design and/or add-on capability of the aircraft.

4.2.2 Cargo Envelope: The size and shape of the cargo compartment and access thereto should have no constraints for receiving and restraining the specified spectrum of cargo. Criteria for applicable existing and proposed ULDs and for applicable military cargo proposed/negotiated for the future cargo aircraft should constitute the items used to determine the cargo envelope and, in turn, the fuselage contour. An efficient use of the volume should be achievable under maximum payload operations.

4.2.2.1 Loading Method Effects: Cargo compartment envelope sizing may be affected by loading methods. Proper positioning of the cargo within the compartment may also require design consideration for both the compartment and the loading equipment.

4.2.2.2 Sizing Factors: Figure 1 shows the various cargo envelope development sizing factors. A space allowance should be provided for guidance and restraint equipment. This space may or may not fall within the clearance space provided between the payload and structure. If required for outsize or other cargo, an additional space may be required for access to floor tie-downs. A space allowance should be provided for personnel ingress along the inboard or outboard sides of the cargo sticks. In addition to the basic clearance dimension of 2.00 in (50.8 mm) between payload and structure during both the loading/unloading and restraint modes, there may be an additional localized clearance dimension requirement in threshold areas for the gyration (i.e., teetering, valleying, articulating) of the load in transit at the interface. A space allowance should be made for the loading (conveyance) system equipment whether it be below or above the payload. Load separation in multistick arrangements should be not less than 4.00 in (101.6 mm) in a mechanical or automated system but could be much greater in a manual (floor tie-down) system. The largest factor in envelope development is the payload cross section. The composite payload cross section, which forms the basis onto which the above clearances and space allowance are additive, should be carefully considered. Where growth is probable in ULD gauge or height during the life of the aircraft, the growth dimensions should also be considered.

4.2.2.3 Crew Location: The flight station should be located in a manner to both facilitate the movement of cargo in/out of the aircraft and to maximize usable volume of the cargo compartment. Additionally, advantage should be taken of applicable reduced restraint criteria accorded aircraft whose cargo is not projected to pass through the flight station during an emergency/crash landing condition.

4.2.3 Cargo Compartment: The cargo compartment accommodates the cargo during loading/unloading modes and contains and restrains it during ground maneuver and flight. The number of cargo sticks and the stick length determinations go beyond the scope of this document. However, the sizing of the compartment with respect to a selected aircraft gross payload in pounds (kilograms) is basically determined by the value set for the onboard unitized cargo design density. Sufficient trade-offs should be evaluated utilizing cargo envelopes, payloads, ULD volumes, and tare weights to achieve the needed cargo compartment dimensional sizing.

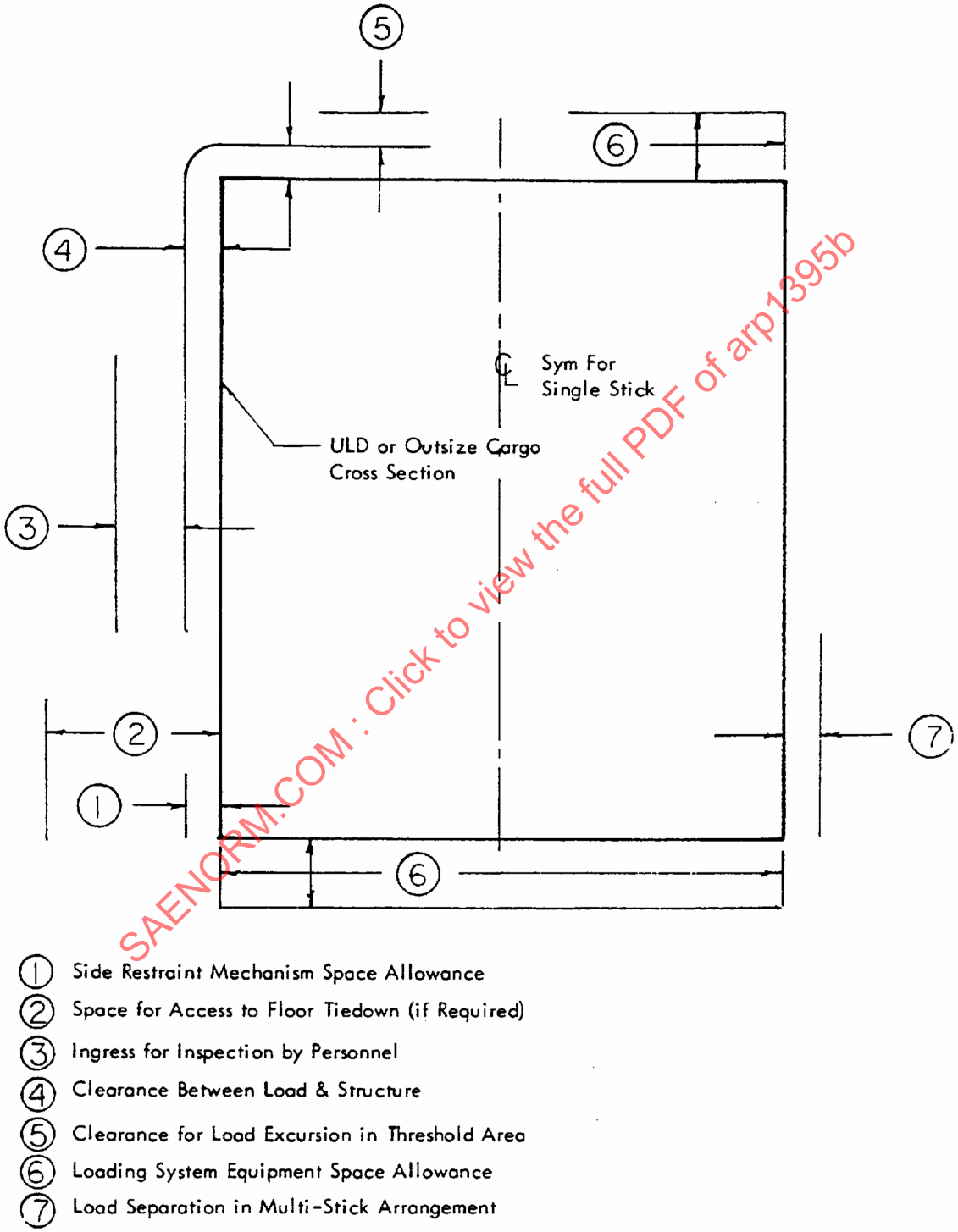

FIGURE 1 - Cargo Envelope Development Factors

4.2.4 Cargo Aperture: Cargo doors have the basic function of closing the loading access opening of the cargo compartment. No constraints should be placed on the operation of the cargo doors. The aperture should consider external cargo handling operations such as winching or hoisting of outsized cargo. Hinging, latching, actuation, and sealing of the door should not interfere with the basic function or loadability of the cargo compartment.

4.2.4.1 Door Location: Cargo door locations may be considered to be at the discretion of the aircraft designers. However, the location should be selected and the path of cargo movement (i.e., straight-in, Y, 90° turn) should be directed by the ability of the system to meet such performance parameters as turn-around times and the handling of all ULD sizes. Consideration should be given to a location which will enable suitable ground loading equipment to maneuver easily into position. The door opening should be such that it provides maximum clearance with the cargo envelope, and the full open position should be the maximum allowed by the aircraft structure.

4.2.4.2 Ground Equipment Clearances: Cargo door (including visors) opening criteria should be compatible with the requirements for clearance of ground interface loading equipment at the aircraft loading interface.

4.2.4.3 Operating Times: Cargo door opening and closing times should be as short as possible commensurate with safety and the unlocking, actuation, and locking operations. These times, however, should not exceed 90 s.

4.2.5 Cargo Floor Height: This document does not purport to specify a discrete cargo floor height. However, a range of cargo floor heights is desirable to provide the ground system equipment designers some finite parameters. The most important decision in this process is the determination of whether the cargo floor is above or below the aircraft wing (unless the aircraft is to be a distributed-load aircraft). This decision, when made, dictates whether the aircraft is high wing or low wing. In making this determination, it is important to evaluate the time effect of lift height on cyclic lift devices. It is also important to determine the effect on the system of the ground loading of vehicles should the CRAF vehicular requirements prevail. There is no way to kit or add-on a capability to effect a substantial floor height change. Integral and/or removable kit loading ramps may be provided as requirements dictate for special ground loading operations. The cargo floor height of the aircraft to be developed should fall between a minimum of 4.5 ft (1.37 m) and a maximum of 18 ft (5.49 m).

4.2.6 Aircraft Stabilization: The cargo floor of the future all-freighter aircraft can be expected, under changing cargo and fuel loads during the loading/unloading operation, to incur (unless restrained) a substantial change in height and deck angle. This floor height/angle excursion is detrimental to the loading process, especially at the threshold floor sill location. Also, during the loading and discharge of cargo, tip-over of the aircraft must be prevented. The aircraft should be capable of being stabilized to provide a relatively constant floor height and deck angle during cargo handling. The degree to which change in height and attitude should be controlled is a function of the specifics of the cargo handling system and the tolerances to which it can accept cargo in transit at and across the threshold interface.

4.2.7 Cargo Handling: The cargo handling system provides the interface between the cargo and the airframe. It also provides an interface with the ground interface loading equipment. Although certain types of cargo may be loaded manually, the basic cargo handling system should be mechanical with powered drive for movement of cargo. The system should have growth potential for operation by automated means. Aircraft systems design should allow for simultaneous cargo handling and refueling, or line maintenance operations. Specific system recommendations are covered elsewhere in this document.

4.2.8 Ground System/Facility: The ground system should interface both the aircraft onboard cargo transportation system and the intended ULD's. The ground system should have the capability to load/unload the aircraft within the minimum load/unload times of the aircraft cargo handling system. This interface provides the intermodal aspect for the air-truck link of the air-sea-truck-rail overall intermodal transportation system. The facility should provide the necessary ramp, equipment, and building spaces to accommodate the ULD staging/storage requirements and the cargo loading/unloading and aircraft servicing operations.

4.2.9 Loading Access/Inspection/Verification: Loading access/inspection/verification to the exterior of all ULDs should be provided to assure the security and integrity of the cargo when restrained in the cargo compartment. This may include a combination of direct and/or remote means such as direct access, compartment lighting, fiber and/or reflective optics, microswitches, or other applicable means to make such determinations. Consideration should be given for access to cargo handling equipment in case of malfunction with cargo in place. Considerations may be extended to in-flight cargo monitoring functions.

4.3 System Performance:

The system should be designed with total consideration for all functions performed. The cargo system and compartment should provide a capability for a maximum payload of unitized cargo with minimum loss of loadable volume.

4.3.1 Performance Standards: The aircraft onboard cargo system should be designed to provide the capability for minimal turnaround times with high reliability, minimal cargo handling costs, and the damage-free handling of cargo.

4.3.1.1 Load/Unload Cycles: With appropriate aircraft/ground interface equipment available, the cargo handling system should be capable of discharging a full unitized cargo load in 15 min and completely reloading the aircraft in 15 min. Five additional minutes should be allowed for a changeover from unloading to loading. Aircraft positioning and door opening/closing times are not to be charged to the load/unload cycle times.

4.3.1.2 Manloading: Onboard manloading requirements should not exceed 1 man per stick of cargo during normal ULD loading/unloading operations. This requirement is not necessarily applicable to optional ULDs or outsize cargo.

4.3.1.3 Force: If an onboard power system is provided, the frictional rolling or other force requirements should not exceed 3% of the gross load weight when moving the load on a level surface, and the system should further be capable of moving the load on the inclined surfaces of 4.3.1.4.

4.3.1.4 Loading System Alignments: The system at the interface between the aircraft and the ground loader/dock equipment should function properly if the aircraft moves through a range from 2° nose down to 2° nose up and ±2° in roll attitude during loading/unloading operations unless the aircraft is positioned and restrained. Relative crest or valley angle during load/off-load should not exceed 2°. A step of 0.38 in (9.3 mm) up and 0.50 in (12.7 mm) down should be traversable by ULDs in transit.

4.3.2 Functional Characteristics: The system should consist of a low-friction load-bearing surface or device for conveyance of ULDs to and from their loaded position within the aircraft, powered ULD movement equipment, directional control equipment, and restraint devices.

4.3.2.1 All-Seasons Operation: All loading/unloading, power, and restraint operations should be capable of being accomplished by personnel encumbered with special clothing such as winter gloves.

4.3.2.2 Special Tools: System equipment should be designed to accommodate ULDs of one standard width and varying lengths, heights, and configurations. Optional capabilities may be provided to accommodate ULDs of varying width. When this capability is provided, the adjustment should be accomplished without special tools and should be operable by personnel wearing winter clothing.

4.3.2.3 System Capabilities: The system should be capable of accommodating the maximum load for which each ULD is designed. The system should also accommodate heavier than specification ULD loads to the extent that the airframe can accept heavier local loadings. Aircraft structural capabilities may limit the final positioning locations of maximum weight loads within the aircraft.

4.3.2.4 System Growth: This document system should consider growth to full automation with respect to the movement and restraint of ULDs.

4.3.3 Structural Compatibility: The cargo compartment envelope basically defines the inside of its surrounding structural airframe shell. Because of inherently different flexure characteristics existent between airframe and ULDs, it is necessary to consider the level of structural compatibility and possible limiting conditions.

4.3.3.1 Loads: The airframe shall and cargo support structure should be capable, through the cargo restraint system, of adequately restraining the cargo for both ground maneuver and flight loads as defined in FAR Part 25. This should be accomplished without damage to the aircraft or the cargo. Also, loads introduced during cargo loading/unloading should be accommodated without damage. Consideration should be given to zone loading restrictions normally associated with airframe structures. Load capabilities should be provided in the distributed (force/area) and running (force/unit of length) manner. Additional capabilities (such as concentrated, puncture, axle) may also be specified.

4.3.3.2 Deflections: The cargo support structure working with the cargo restraint system should accommodate the range of deflections imposed by ground maneuvers and flight loads as defined in FAR Part 25. This should be accomplished without damage to the aircraft or the cargo. Since aircraft structures in the interest of weight saving are relatively flexible, and since many container types of ULDs are relatively rigid, the introduction of highly concentrated loads of a crippling nature must always be of prime consideration. Thus, cargo support structures should be designed for such concentrated loads or alternative methods employed for distributing the loads.

4.3.3.3 Restraint: Cargo restraint should be provided through the interface system such that the ground maneuver and flight loads as defined in FAR Part 25 will not damage the aircraft or the cargo. The restraint interface is a function of the cargo interface and is further described in 3.2, 4.1.2, 4.2.2, and 4.7.4.

4.3.3.4 Weight and Balance: Cargo placement (location) in the cargo compartment is dictated by a combination of factors including foremost, the proper distribution of ULDs or other cargo of widely divergent gross weights to effect a proper aircraft center-of-gravity. Secondarily, zone loading capabilities must not be exceeded, and thirdly, placement for off-loading at enroute stops must be considered.

4.3.4 Crash Conditions: The structural provisions and other features peculiar to the containment or control of cargo and the protection of crew and personnel during emergency landing operations shall be designed to meet the requirements of FAR Part 25.

4.3.4.1 Barriers: Cargo compartment bulkheads or barrier nets designed, when required, for crew and personnel protection during emergency landing operations shall incorporate means for access between compartments. Such access provisions during normal operations shall be operable by one man and the time for opening or closing shall not exceed 1 min. If bulkheads, barrier nets, or other restraint barriers are employed in conjunction with the restraint of uncertificated ULDs similar ingress/egress features should be provided. This requirement may not apply to fixed structural bulkheads.

4.3.4.2 Structural Fuses: If structural fuses are employed, the fuse support structure should be designed for 1.5 more than the fuse.

4.3.4.3 Crew Safety: Careful consideration for all aspects of regulatory requirements for crew safety shall be made. For SAE publications relative to this subject, ARP807, ARP4101/7, ARP917, ARP998, ARP4101/9, and ARP1150 should be referred to.

4.3.4.4 Hazardous Cargo: Provisions should be made for the carriage of hazardous cargo in compliance with Title 49 CFR (Code of Federal Regulations) parts 171-177. Positive provisions shall be made for in-flight inspection and/or monitoring.

4.3.5 Environmental Compatibility: The cargo compartment should provide an environment compatible with the requirements of the cargo for the time the cargo is aboard the aircraft. Additionally, the cargo compartment should provide an environment compatible with the needs of personnel whether they are loading and/or maintenance personnel or flight personnel. Most functional equipment provided environmental requirements apply only to the cargo compartment when the aircraft is closed up and prepared for flight or in flight.

4.3.5.1 Temperature: The aircraft environmental system should provide a cargo compartment temperature above freezing (32 °F, 0 °C) when measured in any part of the loadable volume.

4.3.5.2 Pressure: The aircraft and its environmental system should be capable of providing a pressure altitude for the cargo compartment of 18 000 ft (5486 m) when the aircraft is at maximum cruise altitude. Customer requirements may, however, specify a lower cargo compartment pressure altitude suitable to the carriage of a greater spectrum of cargo/commodity types.

4.3.5.3 Venting and Circulation: Ventilation and circulation requirements should be determined by the spectrum of cargo to be carried; for instance, inert cargo requires no ventilation whereas live animal cargo (if a customer requirement) requires a ventilation rate of up to one air change every 3 min. The circulation capability should assure that there are no static air pockets in the cargo compartment.

4.3.5.4 Vibration/Shock: The cargo compartment and equipment should be designed to withstand vibration levels of 0.15 in (3.8 mm) from 5 to 1000 Hz with a maximum acceleration of 2.0 g.

4.3.5.5 Noise: The cargo compartment should have sufficient soundproofing to provide adequate noise protection for the types of cargo to be transported for a given length of flight time.

4.4 Reliability/Maintainability:

System reliability and maintainability should provide for high equipment availability.

4.4.1 Replacement Times: When a failure occurs, the replacement time for repetitive high usage items including components per 4.1.2.9 should not be more than 10 min. Major low usage items should be capable of replacement in 30 min.

4.4.2 Service Life: The major onboard components of the system, based on expected operational usage, should have a service life equivalent to the aircraft airframe service life. Service components including components per 4.1.2.9 having a high frequency of use and exposure to fatiguing impacts, such as latching devices, restraint fittings, guide rails, etc., should have a design life expectancy of 5 years.

4.4.3 Maintenance Tools: Assembly, disassembly, and maintenance (including servicing) should be accomplished with general purpose tools and equipment normally and commercially available.

4.5 Convertibility:

Equipment provided to handle and restrain option ULDs and/or outsize cargo should be capable of quick erection/installation. Where applicable, this equipment may be kit installed. Auxiliary equipment in place should not limit handling and restraint of basic ULD sizes. If a nonstandard gauge option is exercised, the system should be able to accommodate a stick composed of a mixture of basic and optional ULD sizes.

4.6 Safety:

Safety of personnel, the aircraft, and the cargo must be given prime consideration in the layout, design, and operation of all cargo handling and cargo compartment features and equipment.

4.6.1 Personnel: Provisions for the safety of personnel should be incorporated with regard to anticipated operating conditions and the capabilities of the operating personnel. Special care should be exercised to make safe the performance of necessary tasks by personnel working at or across the threshold area(s) and at the interface with ground loading equipment. Applicable current OSHA and other regulatory standards shall be met.

4.6.2 Cargo Monitoring: The capability to monitor the security of cargo at all times when onboard the aircraft should be a basic provision. Paragraph 4.2.9 covers the access, inspection, and verification of the integrity of the cargo with respect to its restraint and containment. The monitoring of the security of the cargo should also encompass, by direct or remote means, a surveillance of its well being with respect to environmental and other conditions.

4.7 Detail Design:

The following design guidance provisions further product definition to those areas where sufficient knowledge exists to offer same.

4.7.1 General Design Considerations: The following design parameters should apply to all onboard cargo handling equipment components.

4.7.1.1 System Components: The system components should be minimum weight, simple, rugged, and low cost.

4.7.1.2 Environment: The system should be capable of operating under the following conditions:

a. Temperature range from -25[1] to +140 °F (-32 to +60 °C)
b. Relative humidity up to 95%
c. Exposure to salt-sea atmosphere
d. Vibration incident to service use
e. Sand and dust particles as encountered in desert areas
f. Exposure to rain in cargo door area

4.7.1.3 Impact Loads: System components should be capable of withstanding impact loads resulting from rough handling. ULDs moving at speeds up to 60 ft (18.3 m) per minute should be considered unless speed limiting devices are used.

4.7.1.4 Loose Parts: There should be no loose parts which might be easily lost.

4.7.1.5 Component Weight and Size: The weight and size of any component installed on the aircraft should permit installation and removal by not more than two men.

4.7.1.6 Foolproofing: Where improper installation of a part could cause malfunction of the part or the equipment in which it is installed, an unsymmetrical mounting means should be provided. That mounting should permit the item to be installed only on its proper operating position.

4.7.2 Conveyance System: The conveyance system should consist of a device or devices suitable to the task of moving the ULDs in and out of the aircraft cargo compartment.

4.7.2.1 Options: The conveyance system may be a part of the aircraft or may be a part of the ground interface equipment, or it may be part of each.

4.7.2.2 Load Bearing: The conveyance device(s) may, but do not necessarily, form a load bearing surface capable of supporting the ULDs under the ground maneuver and flight load conditions.

4.7.2.3 ULD Separation: The minimum separation between ULDs in adjacent sticks should be 4.00 in (101.6 mm). In determining the minimum required separation, the aircraft floor deflection, ULD restraint deflection, and ULD deflection should be considered.

4.7.2.4 Forces: The horizontal force required for movement of ULDs on a level plane should be a minimum consistent with the conveyance device(s) employed, and consistent with the force limit set forth in 4.3.1.3 and 4.3.1.4 for both level and inclined surfaces.

4.7.2.5 Exposed Edges: All exposed edges of conveyance devices/parts which contact the ULD or the aircraft should be rounded to protect contact surfaces.

---

[1] Where application includes an arctic environment, this figure should be changed to -65 °F (-54 °C).

4.7.3 Guidance: Guidance system components should maintain positive low friction lateral directional control and should permit free longitudinal movement during loading operations.

4.7.3.1 Rail Location: Rails, tracks, or fittings designed for lateral and/or longitudinal guidance should be so spaced and located as to assure repeated final positioning of the ULDs for restraint under the ground maneuver and flight conditions while also meeting the clearance specified in 4.7.2.3. If also used for restraint, the total lateral clearance between the ULD edge and the rail, track, or fitting surface should be commensurate with the demands for lateral and/or longitudinal freedom during loading/unloading operations and for structural adequacy during the ground maneuver/flight regime. Specific ULD specifications should be consulted in establishing these clearances.

4.7.4 Restraint: Devices/fittings designed for vertical restraint should provide a maximum vertical clearance between the ULD surface and the restraint device surface commensurate with the overall restraint system concept needs. The interaction between the ULD and the restraint devices under the full spectrum of ground maneuver and flight load conditions should be examined to assure that no undue local loadings are created by the differential stiffness of the ULD and the aircraft. The requirements of the applicable ULD specifications should be consulted in establishing this detail design.

4.7.4.1 Longitudinal Freedom: Devices/fittings designed to provide forward and aft restraint should limit the longitudinal freedom to the maximum degree commensurate with the tolerances dictated by the ULD locating and positioning requirements and tolerances of the detail design engagement concept.

4.7.4.2 Multiple Functions: Restraint/devices/fittings should be designed to accomplish multiple restraint functions where possible.

4.7.4.3 Manloading: This restraint device should be capable of being operated by one man without accessory tools or equipment.

4.7.4.4 Performance: All restraint devices for any single ULD position should be capable of being operated by one man in less than 1/2 min without accessory tools or equipment.

4.7.4.5 Positive Indication: The latching mechanism should incorporate means, whether manual or automatic, to determine and provide positive indication of ULD restraint.

4.7.4.6 Load Complement: The restraint system should satisfactorily accommodate less than a full complement of ULDs for flight.

4.7.4.7 Uncertificated ULDs: The ULD restraint concept should include the capability to satisfy regulatory restraint criteria for uncertificated ULDs unencumbered by ancillary devices of special restraint equipment.

4.7.5 Power Equipment: Power drive equipment should provide the longitudinal and lateral (where necessary) force for movement of ULDs in the aircraft during loading/unloading operations per 4.3.1.3 and when the aircraft attitude is within limits shown in 4.3.1.4. Consideration should be given to providing positive traction under adverse environmental conditions.

4.7.5.1 Control: The equipment should provide for braking and positive fore-aft or lateral control of the loads under all aircraft attitudes discussed in 4.3.1.4. The power drive equipment and the guidance equipment should provide positive positioning of the ULDs for restraint.

4.7.5.2 Override: The power drive equipment should be capable of being manually overridden or retracted within 5 min in case of malfunction to permit movement of the cargo. The power drive system should provide for loading and off-loading ULDs with an inadvertent "power off" condition.

4.7.5.3 Equipment: Power equipment may be part of the aircraft cargo system, part of the ground interface equipment, or part of both.

4.7.5.4 Lift/Set-Down: The power equipment may also lift and set down ULDs during loading/unloading movement if this is necessitated by the cargo system concept.

4.7.5.5 Control Location: Power equipment controls should be located at the most advantageous location for the operator to safely control the loading process. This location may be in the threshold area inside and/or outside of the aircraft. Additional controls, if necessary, may be spaced incrementally down the length of the cargo compartment.

4.7.5.6 Inoperable: The powered cargo transfer system should be inoperable during flight.

4.7.6 Structural Considerations: The aircraft cargo floor and underfloor structure should be adequate to react through the cargo system, the ULD handling loads, and the ULD loads incident to ground maneuver and flight operations.

4.7.6.1 Floor Continuity: The extent and continuity of the cargo floor should be consistent with the needs of the specific cargo system employed.

4.7.6.2 Personnel Suitability: The cargo floor should be suitable for the needs of both cargo and aircraft maintenance personnel. Provision for the drainage of liquids should be included. Walkways should incorporate an anti-skid surface.

4.7.6.3 Floor Discontinuity: If the cargo floor is discontinuous, consideration must be given to the safety of cargo handling and maintenance personnel, to prevent damage to underfloor structure and fuselage shell, to prevent the collection of dirt, debris and liquids in the bilge area, to drainage and anti-skid requirements, and to the environmental control of the cargo compartment.

4.7.6.4 Normal Capability: Airframe structural characteristics should be compatible with the requirements of the ULDs and the aircraft cargo system. Airframe structural characteristics should be such that rigid ULDs up to 40 ft (12.2 m) in length and 45 000 lb (20 412 kg) gross weight may be routinely accommodated with no requirement for ULD flexible joints or flexible structure, and with no adverse effect on system serviceability.

4.7.6.5 Special Capability: Airframe structural provisions should also be such that ULDs of 44 800 lb (20 320 kg) gross weight for the 20 ft (6.1 m) length and 67 200 lb (30 480 kg) gross weight for the 40 ft (12.2 m) length may be handled and transported in selected cargo compartment locations.

4.7.6.6 Special Restraint: Structural provisions should be made for the special restraint requirements of outsize and overweight cargo within the basic airframe capability of the aircraft. Removable kit installations may be employed to meet this specialized requirement.

4.7.6.7 Containment: Structural containment configurations which can accept uncertificated ULDs should be a basic airframe feature.

4.7.7 Threshold Equipment: Cargo door sill equipment, designed to ease the transfer of ULDs into the aircraft, may be either a part of the system or it may be a part of the ground equipment or terminal facilities.

4.7.7.1 Door Sill: The cargo door sill or sill equipment should incorporate provisions for the attachment of a ground loading equipment bridge or other similar ground interface equipment. The door sill should be capable of supporting the maximum ULD local loading permissible in the aircraft.

4.7.7.2 Compatibility: Ground equipment utilized to perform the transfer function across the interface should be designed to be compatible with the associated aircraft physical and functional features affecting the transfer; i.e., floor height, floor excursion, roll and pitch angles, stabilization characteristics, cargo aperture, cargo envelope.

4.7.7.3 Complexity: Should weight, cost, and complexity be required in the equipment, these items of impact, where possible, should be in the ground or terminal facility equipment. This requirement does not preclude a greater degree of self-sufficiency in aircraft systems where significant off-line operational usage is planned.

4.7.7.4 Misalignment Tolerances: The transfer system at the threshold should be conceived and designed to be generously tolerant in the amount of ULD misalignment acceptable.

4.7.7.5 Control Across Threshold: Lateral and longitudinal guidance devices should be of a configuration to assure directional control of ULD loads during “teetering” or “bridging” conditions. See 4.3.1.4.

4.7.7.6 Drive Force Continuity: Power drive force and control should be continuous across the threshold area including the duration of “teetering” or “bridging” conditions. See 4.3.1.4.