



# **Structures Bulletin**

**ASC/EN**

**Bldg 28, 2145 Monahan Way**

**WPAFB, OH 45433-7017**

**Phone 937-255-5312**

**Number:** EN-SB-10-002 Rev-A

**Date:** 21 November 2011

**Subject:** Air Force Crash Load and Cargo Restraint Requirements for Fixed Wing Aircraft

**References:**

1. Joint Service Specification Guide 2006, Aircraft Structures, Department of Defense, 30 October 1998.
2. Joint Service Specification Guide 2010, Crew Systems, Department of Defense, 30 October 1998.
3. MIL-A-8865 (ASG) "Airplane Strength and Rigidity Miscellaneous Loads," 18 May 1960.
4. MIL-HDBK-1791, "Designing for Internal Aerial Delivery in Fixed Wing Aircraft," 14 February 1997.
5. MIL-A-008865A "Airplane Strength and Rigidity Miscellaneous Loads," 31 March 1971.
6. MIL-A-008865A Amendment 2 "Airplane Strength and Rigidity Miscellaneous Loads," 7 November 1973.
7. MIL-A-008865A Amendment 3 "Airplane Strength and Rigidity Miscellaneous Loads," 17 February 1977.
8. NACA TR-1133 "Mechanism of Start and Development of Aircraft Crash Fires," NASA Glenn Research Center, 1952.
9. "The Relationship of Injuries to Structures in Survivable Aircraft Accidents," Committee of Medical Research and the Committee on Aviation Medicine of the National Research Council, 1943.

DISTRIBUTION A. Approved for public release; distribution unlimited.

10. Civil Air Regulations, Part 4a Airplane Airworthiness, April 7, 1950.
11. Civil Air Regulations, Part 4b Airplane Airworthiness Transport Category, December 31, 1953.
12. MIL-S-5705 "Structural Criteria, Piloted Airplanes, Fuselage, Booms, Engine Mounts, and Nacelles," December 1954.
13. MIL-A-8865 "Airplane Strength and Rigidity Miscellaneous Loads," 18 May 1960.
14. MIL-A-8629 "Airplane Strength and Rigidity," 28 August 1953.
15. Weingarten, Joseph L., et al. Air Cargo Restraint Criteria, AFFDL-TR-71-139. January 1972.
16. Weingarten, Joseph L., et al. Final Report – Air Cargo Restrain Criteria, ASD-TR-73-17. April 1973.
17. Weingarten, Joseph L. Cargo Aircraft and Spacecraft Forward Restraint Criteria, ASD-TR-76-30. Dec. 1977.
18. MIL-A-8421 "General Specifications for Air Transportability Requirements," 25 October 1974.
19. FAR Part 25 "Airworthiness Standards: Transport Category Airplanes," 29 October 2008.
20. FAR Part 23 "Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes," 25 February 2009.
21. MIL-STD-810G "Department of Defense Test Method Standard: Environmental Engineering Considerations and Laboratory Tests," 31 October 2008.

**Purpose:**

This bulletin defines crash load requirements for passenger transport modules and palletized seats. A discussion on seat nomenclature (including seat types and orientation) is also covered in addition to revisions to facilitate cargo collocated with passengers. The criteria contained in this Structures Bulletin are intended to serve as an update and revision to the current crash load criteria of the JSSG-2006.

**Background:**

Several program offices have expressed interest in the airworthiness certification of passenger transport modules for use on cargo aircraft. Current crash load requirements do not address passenger transport modules. ASC/EN and the Program Offices held discussions pertaining to current United States Air Force

DISTRIBUTION A. Approved for public release; distribution unlimited.

crash load criteria applicable to the individual components of these modules. These discussions led to the compilation of specification history and lessons learned, detailed in Appendix A and B of this Structures Bulletin.

### **Discussion:**

The Joint Service Specification Guide 2006 (JSSG-2006) (Reference 1) covers design criteria for airframe primary structure and applies to metallic and nonmetallic air vehicle structures. The airframe primary structure includes the fuselage, wing, empennage, landing gear, structural elements of the control systems, control surfaces, radomes, antennas, engine mounts, nacelles, pylons, in-flight refueling mechanism, carrier related apparatus/devices, structural operating mechanisms and structural provisions for equipment, payload, cargo (if applicable), personnel, and other items (where applicable). Aircraft seats are included in this specification to ensure adequate strength for the seats and supporting structure during a crash event.

Seat nomenclature has evolved over the years and is sometimes confusing with respect to crash requirements for design. Seats and their occupant restraint devices (lap-belts, etc.) which consider human survivability for various accelerations are covered by Crew Systems engineering (ASC/ENFC) in JSSG-2010 (Reference 2), but are also addressed in JSSG-2006 to assure the backup structure is properly sized for reacting the loads imparted during use. The final seat design must incorporate structural crash requirements with those of the crew restraint to provide a "crashworthy" seat - where an occupant will have the best chance for survival. Understanding the basics of seat crash protection, as described in this bulletin, will allow the reader to gain a firm grasp of how to deal with various seat nomenclatures. Note that the crash load factors specified in this bulletin shall be applied regardless of the seat orientation and are applied separately for each of the aircraft axes for a 245 pound nude weight occupant plus flight equipment/clothing. Axes directions noted apply to inertia loads.

The air transport of cargo and use of cargo restraint devices is covered by Air Force Instruction, the Aircraft Technical Order, and the crew loadmaster. Engineering assistance from the Air Transportability Test Loading Activity (ATTLA) is required for uncertified cargo items. The air transportability certification process is outlined in Appendix C.

### **Seat Nomenclature Clarification:**

Prior to the advent of MIL-A-8865 (ASG) in 1960 (Reference 3), military aircraft seats were commonly procured separately from the aircraft development program using specifications that cited minimum performance and safety standards for seats installed in certificated aircraft. These specifications were created for seats that were to either be furnished as GFE (Government

Furnished Equipment) to the aircraft Original Equipment Manufacturer (OEM) or purchased by the Major Command (MAJCOM) for use in the field (i.e. to reconfigure the aircraft for a given mission).

These legacy seat specifications contained design criteria information on materials, construction, strength, dimensions, workmanship, including acceptance tests (etc.) necessary to produce a seat for an aircraft. All seat configurations (folding, swivel, "side facing", etc.) were certified to the same crash load requirements. It should be noted that crash load requirements for structures, such as side-facing seats, are based on loading magnitudes and directions associated with crash conditions (i.e. 9g forward restraint criteria). Crew Systems provides requirements relative to seat orientation based on physiological evaluation to maximize the probability of occupant survival and to minimize the probability of injury (i.e. 20g forward restraint criteria).

Current design requirements for seat crash load factors cover cargo and non-cargo seats criteria separately. For cargo aircraft there are two primary seat types (all seats should fall into one of these two categories): first are seats in the cockpit (for the pilot, copilot, observer, etc.) and second are seats in the remainder of the aircraft (passenger seats, stowable troop seats, etc.). Stowable troop seats are reconfigurable, temporary-use seats positioned in or alongside the cargo bay originally meant for paratroopers to use while waiting for the aircraft to arrive at the drop zone. These stowable troop seats are commonly used as general seating and for longer duration missions than originally intended. In order to provide the same protection as passenger seats, the previous stowable troop seat crash requirements have been revised and are equal to passenger seat crash load criteria (Fwd/Aft 20/10, Right/Left 10/10, and Down/Up 20/10). Also, note that the side facing seat designation has been removed because crash load factors are oriented with respect to the aircraft coordinates. All cargo aircraft seats must meet the following crash load criteria: Fwd/Aft 20/10, Right/Left 10/10, and Down/Up 20/10.

The crash restraint requirements presented for cargo pilot seats, crew seats, troop seats, passenger seats and any other seat installed in the aircraft for any purpose shall be those listed in the Table 1 (Fwd/Aft 20/10; Right/Left 10/10; Down/Up 20/10). Stowable troop seats (i.e. paratroop seats) are not exempt, but the MAJCOMs must be aware of the increased risk associated with these types of seats. Each MAJCOM makes a choice on how it will utilize its aircraft and what seating orientations will be used for maximum utility, but should consider that a fore/aft facing occupant is safer than the side-facing occupant in a crash.

For all non-cargo aircraft, pilot seats (including ejection seats in the cockpit for the pilot, copilot, crew, etc.) shall be designed to the following crash loads factors: Fwd/Aft 40/20, Right/Left 14/14, and Down/Up 20/10. For a personnel

capsule, the design crash load factors applied shall be as follows: Fwd/Aft 9/1.5, Right/Left 1.5/1.5, and Down/Up 4.5/2 as shown in Table 2.

The Federal Aviation Regulation (FAR) Part-25 covers crash criteria for transport category aircraft seating in which crash loads are referred to as “emergency landing” loads. These criteria (paraphrasing) require design and test for a (forward) 9g static load case and a 16g dynamic load case. For airworthiness certification purposes, the USAF accepts the FAR Part-25 certified seats as equivalent based on the static and dynamic load requirements.

### **Palletized Seating/Passenger Transport Modules on USAF Cargo Aircraft:**

Special consideration needs to be given to palletized seating and passenger transport modules designed for carriage on cargo aircraft. Palletized seating and passenger transport modules are user requested modifications that accommodate new mission requirements. Military and civilian specifications have never considered palletized seating or passenger transport modules, and thus never incorporated criteria to cover these requirements. With the advent of senior leaders traveling on military transports, the idea of palletized seating has been extended to include semi-luxurious accommodations that can be rolled on to any transport aircraft. In the past, senior leaders have shared the same accommodations as crew/passengers.

Passenger transport modules are designed to provide seating and amenities that do not normally exist on transport aircraft. They are also designed to integrate with the cargo handling systems on USAF transports. In order to be shipped as cargo, these pallets must meet the requirements of MIL-HDBK-1791 (Reference 4). However, MIL-HDBK-1791 was written solely for cargo and as such, does not address requirements for the safety of passengers or mission-related aircrew.

Currently, there are no design criteria specifically for palletized seats and passenger transport modules. The design criteria used for these seats and modules should be established using the air vehicle specification of the aircraft on which it is intended to be carried. The correct criteria are dependent on the intended use. If the seat or module is not occupied during taxi, takeoff, and landing, then it may be designed using the criteria for cargo, provided it is placarded properly. If it is intended to be occupied during these flight segments, then the entire seat or module must be designed per the updated criteria provided in Table 1.

Most palletized seats and passenger transport modules are designed using standard cargo pallets such as the 463L pallet. The attachments between the pallet and the cargo floor are capable of carrying the pallet design weight and withstanding the crash load factors intended for cargo. When the pallets are used as support structure for seats or modules, these attachments must be

analyzed to determine if they can withstand the load requirements associated with them. If the module contains a seat and is occupied during taxi, takeoff, and landing, the attachments between the pallet and cargo floor must be able to withstand the updated criteria provided in Table 1.

Palletized seats and passenger transport modules must offer equivalent protection to occupants seated in the palletized seating/modules and the passengers seated around the palletized seating/modules. To provide this equivalent protection, the seats of a palletized seating system shall afford the same restraint capability as a typical cargo aircraft passenger seat for a 245 pound nude weight occupant plus flight equipment/clothing (Fwd/Aft 20/10; Right/Left 10/10; Down/Up 20/10), and the pallet shall be restrained to the fixed and removable equipment criteria (Fwd/Aft 9/1.5; Right/Left 1.5/1.5; Down/Up 4.5/2). These two requirements appear to be conflicting, however, one must remember the surrounding structure is always designed to the 9g forward criteria, the same as all fixed and removable equipment. The rationale for the 20g forward seat requirement is to accommodate the response of the human body to the crash deceleration. The passenger transport module will be treated the same as fixed and removable equipment as well (Fwd/Aft 9/1.5; Right/Left 1.5/1.5; Down/Up 4.5/2). This includes module structure, tie-down/restraint system, and any miscellaneous items attached to or contained within the module. All seats contained in a passenger transport module shall afford the same restraint capability as a typical cargo aircraft passenger seat for a 245 pound nude weight occupant plus flight equipment/clothing (Fwd/Aft 20/10; Right/Left 10/10; Down/Up 20/10).

#### **Passengers collocated with cargo:**

Current operations allow passengers and cargo to be transported on the same flight without regard to separation. This manner of operation has greater inherent risk over passengers seated separately from cargo. Every effort should be made to separate cargo and passengers to ensure the highest level of safety is provided. Two options to assure passenger safety during a crash are available. The first option (preferred approach) is to separate the passengers from the cargo by placing them on separate decks of the aircraft. The second option is if the passengers and cargo must be located in the same bay, passengers should be placed aft of the cargo; alternatively, passengers seated forward of cargo must be afforded the additional protection of a cargo net system installed between them and the cargo. It should be recognized that this option may entail additional risk. This risk has to be accepted at the appropriate level and the loadmaster's instructions be updated. Any cargo collocated with passengers shall be restrained to the 9g forward criteria (Fwd/Aft 9/1.5; Right/Left 1.5/1.5; Down/Up 4.5/2) to reduce risk during a crash.

## **Additional Updates to the JSSG-2006 Crash Load Requirements:**

During the development of crash load criteria for passenger transport modules and palletized seating, additional criteria and notes were incorporated into the crash load factors Tables 1 and 2. This was the result of an effort to clarify crash requirements for cargo, litter, and fuel tanks that lost essential detail when they were paraphrased from MIL-A-008865A (Reference 5) and documented in JSSG-2006.

The criteria for cargo collocated with passengers were revised (Fwd/Aft 9/1.5; Right/Left 1.5/1.5; Down/Up 4.5/2). This is in response to the increase in instances where cargo is collocated with passengers. The new criteria also negate the need for the previously required trade studies. A note outlining the process for applying cargo crash load factors is located in Table 1, and closely resembles the verbiage found in MIL-A-008865A Amendment 2 (Reference 6). It offers additional guidance in the event that the aircraft cannot meet the revised restraint requirements.

The crash load factors for cargo intended for aerial delivery are an addition to the JSSG-2006 (Fwd/Aft 3/1.5; Right/Left 1.5; Down/Up 4.5/2). These criteria are derived from Amendment 3 of MIL-A-008865A (Reference 7) and can be found in Section 4.2.3.2 of MIL-HDBK-1791. Passenger positioning does not affect these crash load factors and is noted in Table 1 below.

The crash load criteria for litters have also been updated. Instead of requiring the use of trade study results, the crash load criteria reflect the factors outlined in MIL-A-008865A Amendment 3 for litters (Fwd/Aft 9/1.5; Right/Left 1.5/1.5; Down/Up 4.5/2). These crash load criteria are applicable for a 245 pound nude weight occupant plus flight equipment/clothing.

Fuel tank crash load requirements have not been changed. However, further guidance has been provided in the notes section of Tables 1 and 2 to help distinguish between integral fuel tanks and those classified as fixed and removable equipment.

Table 1 – Revised JSSG-2006 Crash Load Factors for Cargo Aircraft

DISTRIBUTION A. Approved for public release; distribution unlimited.

COMPONENT	DETAIL	Long		Lateral	Vertical	
		Fwd	Aft	Right/Left	Down	Up
Seats <sup>1</sup>	Pilots & flight deck	20	10	10	20	10
	Passengers	20	10	10	20	10
	Stowable troop seats	20	10	10	20	10
Palletized seats	Seats	20	10	10	20	10
	Pallet restraint/tie down	9	1.5	1.5	4.5	2
Passenger transport modules	Seats	20	10	10	20	10
	Fixed & removable miscellaneous equipment	9	1.5	1.5	4.5	2
	Module restraint/tie down	9	1.5	1.5	4.5	2
	Module structure	9	1.5	1.5	4.5	2
Litter installation	All	9	1.5	1.5	4.5	2
Cargo <sup>2</sup>	Collocated with passengers	9	1.5	1.5	4.5	2
	Located such as would not cause injury or impede egress	3	1.5	1.5	4.5	2
	Aerial Delivery <sup>3</sup>	3	1.5	1.5	4.5	2
Fixed & removable miscellaneous equipment	Located where they could cause injury or impede egress	9	1.5	1.5	4.5	2
	Located where they could not cause injury or impede egress	3	1.5	1.5	4.5	2
Fuel tanks <sup>4</sup>	Internal tanks at two-thirds fuel capacity	9	1.5	1.5	4.5	2

Notes:

Highlighted items are changes to the guidance of the current JSSG-2006.

- 1) The seat crash load factors are oriented with respect to the aircraft coordinates. Seat orientation has no effect on these crash load factors.
- 2) Where cargo is located in a manner wherein failure could not result in injury to passengers or prevent egress, the cargo restraint system and its respective airframe attachments and carry-through structure shall be designed to the following minimum load factors acting separately:

Longitudinal 3.0 forward, 1.5 aft  
 Lateral 1.5 right, 1.5 left  
 Vertical 4.5 down, 2.0 up

Where cargo and passengers can be collocated, and passengers are seated adjacent to or forward of the cargo (exclusive of cargo intended for aerial delivery), cargo shall be restrained to the provisions below or shall be restrained to the provisions above and be supplemented with a net-type restraint system, to be defined by the procuring activity, so that the overall

DISTRIBUTION A. Approved for public release; distribution unlimited.



restraint system, including the net and the respective airframe attachments and carry-through structure, provides the following minimum load factors acting separately:

Longitudinal 9.0 forward, 1.5 aft  
Lateral 1.5 right, 1.5 left  
Vertical 4.5 down, 2.0 up

Where the airplane cargo bay floor and back-up structure cannot react the 9g ultimate forward tie down load, the rationale for why this cannot be accommodated must be provided so that the procuring activity can disposition the discrepancy appropriately.

- 3) The crash load factors for cargo for aerial delivery are not dependent on the location of passenger occupancy.
- 4) JSSG-2006 separates fuel tanks in to two classifications: integral fuel tanks and installations and fixed and removable miscellaneous equipment (all tanks other than integral tanks). The fuel tanks and installation category includes typical integrated fuel tanks such as those in the wings and below the flight deck. Fuel tanks that are categorized as fixed and removable miscellaneous equipment are removable additions to the aircraft. These types of tanks include wing tip tanks, the C-130 "Benson" fuel tank, and the F-16 conformal fuel tanks among others.

Table 2 – Revised JSSG-2006 Crash Load Factors for Non-Cargo Aircraft

COMPONENT	DETAIL	Long		Lateral	Vertical	
		Fwd	Aft	Right/Left	Down	Up
Seats <sup>1</sup>	Pilot Seat (ejection seats)	40	20	14	20	10
	Personnel capsule	9	1.5	1.5	4.5	2
Fixed & removable miscellaneous equipment	Located where they could cause injury or impede egress	9	1.5	1.5	4.5	2
	Located where they could not cause injury or impede egress	3	1.5	1.5	4.5	2
Fuel tanks <sup>2</sup>	Internal tanks at two-thirds fuel capacity	9	1.5	1.5	4.5	2

Notes:

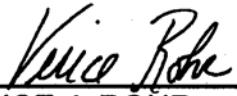
Highlighted items are changes to the guidance of the current JSSG-2006.

- 1) The seat crash load factors are oriented with respect to the aircraft coordinates.
- 2) JSSG-2006 separates fuel tanks in to two classifications: integral fuel tanks and installations and fixed and removable miscellaneous equipment (all tanks other than integral tanks). The fuel tanks and installation category includes typical integrated fuel tanks such as those in the wings and below the flight deck. Fuel tanks that are categorized as fixed and removable miscellaneous equipment are removable additions to the aircraft. These types of tanks include wing tip tanks, the C-130 "Benson" fuel tank, and the F-16 conformal fuel tanks among others.


**Summary:**

The current structural design criteria for aircraft crash loads contained in JSSG-2006 do not cover passenger transport modules and palletized seats, and are incomplete. The criteria contained in this Structures Bulletin are an update to the crash load criteria and should be used for all USAF fixed wing aircraft.

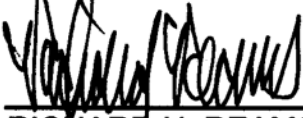
Prepared by:

  
VINCE J. ROHR  
Loads & Criteria Engineer  
ASC/ENFS  
WPAFB, Ohio

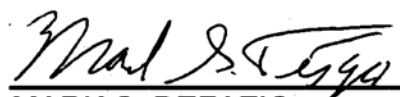
Prepared by:

  
WILLIAM F. BUCKEY, P.E.  
Loads & Criteria Technical Expert  
ASC/ENFS  
WPAFB, Ohio

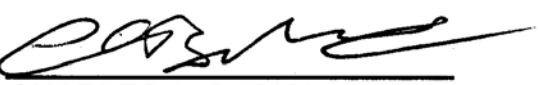
Approved by:

  
RICHARD H. REAMS  
Technical Advisor, Structures  
ASC/ENFS  
WPAFB, Ohio

Approved by:

  
MARK S. DEFAZIO  
Chief, Structures Branch  
ASC/ENFS  
WPAFB, Ohio

Approved by:

  
CHARLES A. BABISH IV  
Technical Advisor, ASIP  
ASC/EN  
WPAFB, Ohio

*Coordination*

Name	Function	Email	Initials
Tim Jennewine	ENF Tech Director	Timothy.Jennewine@wpafb.af.mil	TJ
Howard Garcia	ENFS Tech Expert	Howard.Garcia@wpafb.af.mil	HG
Sean Mortara	ENFS Tech Expert	Sean.Mortara@wpafb.af.mil	SM
Doug Hopkins	ENFC Branch Chief	Joseph.Hopkins@wpafb.af.mil	DH
John Hill	ENFC Tech Advisor	John.Hill@wpafb.af.mil	JH
Mel Santiago	ENFC Tech Expert	Melvin.Santiago@wpafb.af.mil	MS
Martin Andries	ENFC Tech Expert	Martin.Andries@wpafb.af.mil	MA
Teresa Metzger	ENFC Tech Expert	Teresa.Metzger@wpafb.af.mil	TM
Jim Wafzig	ENFA Branch Chief	James.Wafzig@wpafb.af.mil	JW
Tom Condron	ENFA Tech Advisor	Thomas.Condron@wpafb.af.mil	TC

*Acknowledgement for Significant Contribution:*  
Brian Boeke

DISTRIBUTION A. Approved for public release; distribution unlimited.