Structures Bulletin

ASC/ENFS
Attn: Area B, Bldg 28
2145 Monahan Way
Wright-Patterson AFB, OH
45433-7017
Phone 937-255-5312

NAVAIR AIR-4.3.3
Attn: Bldg 2187, Suite 2340A
48110 Shaw Road, Unit 5
Patuxent River, MD
20670-1906
Phone 301-342-0283

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Subject: Revised Design Criteria for Pressurized Structure

References:

1. JSSG-2006, "Joint Service Specification Guide – Aircraft Structures," Department of Defense, 30 Oct 98.
2. JSSG-2009, "Joint Service Specification Guide – Air Vehicle Sub-systems," Department of Defense, 30 Oct 98.

Background:

Discussions concerning the design criteria contained in Joint Service Specification Guide (JSSG) 2006 "Aircraft Structures" (Reference 1) on pressurization proof test levels prompted ASC/ENFS and NAVAIR to review and revise recommended design for pressurized structure. Since pressurization criteria encompass multiple disciplines, this criteria revision has been coordinated with ASC/ENFA Air Vehicle Sub-systems Branch and NAVAIR 4.3.5.1 (Environmental Management System) and NAVAIR 4.3.5.3 (Fuel System) for use in update of JSSG-2009 (Reference 2). This Structures Bulletin supersedes the criteria in JSSG-2006 until the document is updated to incorporate the content of this bulletin.

Discussion:

Guidance on design pressures for pressurized compartments is contained in paragraph 3.4.1.12 of JSSG-2006. Guidance for pressurization proof test levels is contained in paragraph 4.10.5.4.

In its current version, Paragraphs 3.4.1.12 (Pressurization) and A.3.4.1.12 (associated guidance) have led to confusion concerning the applicability of system failures and design factors of safety. In addition, some of the text is inconsistent and sometimes inaccurate. Table 1 provides the revised design criteria for pressurized structure that considers applicable system failures for both flight and ground operations.

Table 1 – Design Criteria for Pressurized Structure

Applicable Load Conditions		Applicable System Failures	DLL	Reference
<u>Flight operations</u>	Normal Ops - level flight and pressurization loads	None	Acting separately: 1.33*P and in combination: 1.33*P + 1g flight loads + fuel inertia	JSSG-2006 Para. 3.4.1.12a, 3.2.22
		Undetectable or uncontrollable PRS failures which occur at a rate > 10^{-5} per flight	Acting separately: 1.33*P_F and in combination: 1.33*P_F + 1g flight loads + fuel inertia	
	Normal Ops - critical combination of flight and pressurization loads	None	Acting separately: 1.0*P and in combination: 1.0*P + flight loads + fuel inertia	JSSG-2006 Para. 3.4.1.12b, 3.2.22
		Undetectable or uncontrollable PRS failures which occur at a rate > 10^{-5} per flight	Acting separately: 1.0*P_F and in combination: 1.0*P_F + flight loads + fuel inertia	
<u>Ground operations</u>	Normal Ops	None	1.33*P	JSSG-2006 Para. 3.4.1.12c

<u>Table 1 Note</u>: Examples of undetected and uncontrollable fuel system and environmental system failures which occur more frequently than 10^{-5} per flight hour that may lead to maximum single failure operating pressure are as follows:

- Fuel high level shutoff valve failure: Failures of the fuel high level shutoff valve typically result in fuel exiting through the vent system at the same rate it is entering the tank resulting in the worst case positive pressure for the fuel tank. Typical fuel system design uses this as the worst case positive pressure condition, and the vent line is sized to maintain fuel tank pressure at or below tank proof pressure when this failure occurs.
- Cabin pressurization outflow valve failure: Failures of the cabin pressurization outflow valve typically are what result in the highest positive pressures within the fuselage, combined with max rate descent. There is typically a cabin safety valve to limit the pressurization in the event of outflow valve failure.

<u>Table 1 Definitions</u>:

DLL = Design limit loads which result from maximum attainable pressure differentials (multiplied by applicable factor) including component and system failures, internal loads due to maneuver, and fuel inertia (when applicable). Pressures shall be combined with other flight loads to obtain the most critical combination of flight and pressurization loads but internal stresses and strains arising from the pressurization loads shall not be assumed to be relieving from other flight loads.

PRS = Pressure regulation system (those components which through their operation or result of failure drive maximum compartment pressure, both positive and negative):

- For the fuel system this shall include the high-level shut off valve, and the primary and secondary vent valves. For an open fuel vent system there is no regulation of the pressure (i.e. no regulator, no relief valve, etc)
- For the cockpit/fuselage pressurization system this shall include the out flow valve and the emergency cabin safety valve.

P = Maximum attainable pressure differentials for normal operations of the pressure regulation system (PRS) including PRS tolerances.

P_F = Maximum attainable pressure differentials resulting from applicable PRS component failure(s) including PRS tolerances.

Fuel inertia (fuel slosh) is the motion of the fuel in the tank as a result of maneuvers and gusts encountered by the air vehicle.

1g flight loads encompasses aerodynamic loading incurred under these conditions, therefore the pressure differential should be added or subtracted as appropriate. 1-g maneuvers include the full range of speeds, weight, inertial distribution, center of gravity and balancing tail loads. These factors should all be taken into account to determine critical aircraft loads due to 1-g flight.

Recommendations:

1. Pressurized compartments should be designed per the guidance contained in this Structures Bulletin.

2. JSSG-2006 Paragraphs 3.4.1.12 and A.3.4.1.12 Pressurization should be modified to the following (Note: New or modified language is in **blue** font. The factors in paragraphs 3.4.1.12 and A.3.4.1.12 are noted in the blanks below for readability of this Bulletin, but they should remain listed only in the REQUIREMENT GUIDANCE of JSSG-2006):

Proposed:

3.4.1.12 Pressurization.
The pressure differentials to be used in the design of pressurized portions of the airframe, including fuel tanks, shall be the maximum pressure differentials attainable during flight within the design flight envelope, during ground maintenance, and during ground storage or transportation of the air vehicle. These maximum pressure differentials shall include both positive (inside-to-outside) and negative (outside-to-inside) pressure differentials, as well as pressure differentials across pressure boundaries separating adjacent internal compartments. Where appropriate, these pressures shall be combined with other flight loads to obtain the most critical combination of flight and pressurization loads. The internal stresses and strains arising from the pressurization loads shall not be assumed to be relieving from other flight loads unless the probability of a loss of pressurization is less than the rate specified in 3.2.11. Similarly, structural stabilization derived from pressurization shall not be used to achieve required structural performance capabilities unless the probability of the loss of pressurization is less than the rate specified in 3.2.11.

These maximum pressure differentials shall be the maximum attainable with the normal operation of the pressure regulation system nominal settings plus manufacturing tolerance or the maximum pressure differentials attainable during or following the system failures of 3.2.22 which occur at a rate greater than or equal to that specified in 3.2.11. The following factors shall be applied:

a. For normal operations (level flight) the maximum pressure differentials attainable shall be increased by a factor not less than _[1.33]_ when acting separately and when in combination with 1g level flight loads and fuel inertia. The maximum pressure differentials attainable shall include effects of undetectable and uncontrollable PRS failures occurring >10^{-5} per flight.

b. For normal operations (maneuver and gust) the maximum pressure differentials attainable shall be increased by a factor not less than _[1.00]_ when acting separately or in combination with maximum and minimum flight loads and fuel inertia. The maximum pressure differentials attainable shall include effects of undetectable and uncontrollable PRS failures occurring >10^{-5} per flight.

c. For normal ground operations including maintenance, the maximum pressure differentials attainable shall be increased by a factor not less than _[1.33]_.

REQUIREMENT RATIONALE (A.3.4.1.12)

This requirement defines the methods to be used in determining the pressure differentials to be used in the design of the airframe.

REQUIREMENT GUIDANCE (A.3.4.1.12)

In subparagraphs a) and c), the recommended factor is 1.33. This value is typically greater than 1.00 so compartments are not routinely pressurized to design limit load which could shorten the fatigue life of the structure. A value larger than 1.33 should be used if the analytical model has not been validated with test data. A value less than 1.33 is not recommended. The 1.33 factor is not put on the inertia component of fuel resulting from a flight condition.

In subparagraph b), the recommended factor is 1.00 for each blank. This value should be increased if the analytical model has not been validated with test data. A value less than 1.00 is not recommended.

Special consideration should be given to the selection of the pressurization design requirements for cryogenic fuel tanks. Such tanks may require elaborate temperature and pressure control systems. The behavior of these systems during abrupt maneuvers or emergency conditions may be difficult to predict accurately.

It is also necessary to define negative pressure differential requirements. Negative pressure differentials may develop during rapid changes in altitude or with failures in the pressure control system. Negative pressure differentials may also occur during maintenance and ground storage. In cryogenically fueled vehicles, rapid internal temperature and pressure changes, associated with fuel loading and fuel sloshing, may develop high negative pressure differentials.

Prepared by:

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

Approved by:

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

Approved by:

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

Approved by:

BARRY K. STURGIS
Structures Division Head
AIR-4.3.3, Patuxent River, MD

Approved by:

DONALD POLAKOVICS
AUAV Senior Engineer
AIR-4.3E, Patuxent River, MD

Coordination

Name	*Function*	*Email*	*Initials*
Rob Hay	NAVAIR Loads and Dynamics	Robert.Hay@navy.mil	RFH
Mark DeFazio	Chief, Structures Branch	Mark.DeFazio@wpafb.af.mil	MSD
Howard Garcia	Tech Expert, Strength	Howard.Garcia@wpafb.af.mil	HFG
Tom Condron	Technical Advisor, Vehicle Subsystems Branch	Thomas.Condron@wpafb.af.mil	TJC