CHANGES IN THE GENERAL SPECIFICATION FOR AIRCRAFT STRUCTURES - AIR FORCE GUIDE SPECIFICATION 87221A -

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This paper discusses the significant changes incorporated into the revision of the Air Force's Structures Mil-Prime Specification - AFGS-87221A.

EVOLUTION OF REQUIREMENTS

By 1975 there were some 47,000 DoD specifications & standards - of which 43,000 were procurement related:

- **A 1975 memo from the Deputy Secretary of Defense cited misuse of specs and standards as a major cost driver**
- **A 1977 Defense Science Board report concluded that this misuse represented a bottom-up rather than a top-down approach and dictated design solutions rather than specifying functional needs**

A NEW APPROACH WAS MANDATED

In the mid-1970s there was a growing realization that the approach then being used to develop new weapons systems was not yielding the desired results. In particular, it was found that the misuse of specifications and standards, particularly through the imposition of unneeded or incorrect "design solutions", was a major cost driver. It was decided that a new approach should be implemented - one that focused on designing the weapons system to achieve the desired system capabilities.

ACQUISITION OBJECTIVES THAT AFFECT ASIP

- **Emphasizing cost control by relating requirements to user needs**
- **Sharing of risk and responsibility between the contractor and the government**
- **Streamlining of RFPs and Source Selection process**
- **Encouraging contractor innovation through the tailoring of requirements**
- **Avoiding technical leveling by eliminating government mandated design solutions**

This new approach focused on these elements:

- First, to define the performance requirements necessary to enable the user's needs to be met.
- Second, to involve both the government and the contractor in sharing the risk & responsibility of designing a successful product.
- Third, to minimize the bureaucracy and time involved in selecting contractors.
- Fourth, to give the contractor flexibility in developing their preferred solution to meeting the user's needs.

MIL-PRIME PHILOSOPHY ESTABLISHED

Features:

- **Emphasis on performance requirements**
  - **Definitions of performance parameters**
  - **Leaves specific values blank**
- **One to one correlation of requirements to verification**
- **Allows innovative design solutions**
- **Retains "Lessons Learned" in a non-contractual appendix to assist in tailoring**

The resulting philosophy - which the Air Force refers to as the "Mil-Prime" philosophy - has these attributes:

- It emphasizes performance requirements, not design solutions.
- It allows contractors to propose the specific performance values that, in combination, produce the "best" or "preferred" concept.
- It insures that the user's needs are achieved by verifying the ability of the design to meet each performance requirement.
- And, finally, in the appendix, it captures "lessons-learned" - the advantages and disadvantages of different design approaches.

STATUS OF THE MIL-PRIMES

- **Over 50 of the Aeronautical Systems Division's major acquisition documents have been updated to conform to the Mil-Prime philosophy**
- **The Aircraft Structures MIL-A-87221 was initially released on 28 Feb 1985**
- **A revised version of this Mil-Prime, Version A, was released on 8 Jun 1990**
- **It is now referred to as an Air Force Guide Specification (AFGS) to enhance the understanding that the specific requirements and verification methods are to be tailored to the program requirements**

To date, over 50 of the major aircraft acquisition specifications have been rewritten to conform to the Mil-Prime philosophy. For aircraft structures, MIL-A-87221 consolidated all of the structures design, analysis and test requirements into one specification. This Mil-Prime, originally released in 1985, was updated and has been released as AFGS-87221A. The name was changed to "Air Force Guide Specification" to enhance the understanding that this specification serves as a starting point for the development of the final weapons system's structures specification.

SPECIFICATION SCOPE

This specification establishes the structural performance and verification requirements for an airframe. These requirements are derived from operational needs and apply to the airframe structure which is required to function and sustain loads during usage. This usage includes take-off, flight, landing, ground handling, maintenance, and **laboratory** tests. **This specification also establishes certain structural design criteria which, as a minimum, are necessary to enable the airframe to meet these structural performance requirements.**

The scope of the specification was expanded to include all test requirements, such as, proof and functional strength tests performed to verify airworthiness in preparation for flight test. The scope was also expanded to clarify that the tailored specification establishes the essential structural design criteria which are necessary to meet the structural performance requirements. This change clarifies the distinction between structural design requirements and structural design criteria - a distinction that was not clear in MIL-A-87221.

ORGANIZATION OF THE AIRCRAFT STRUCTURES SPECIFICATION

- **SECTION 1 - SCOPE**
- SECTION 2 - APPLICABLE DOCUMENTS
- **SECTION 3 - REQUIREMENTS**
- **SECTION 4 - VERIFICATION**
- SECTION 6 - NOTES (DEFINITIONS)
- SECTION 10 - HANDBOOK

The changes incorporated into Sections 1, Scope, Section 3, Requirements, and Section 4, Verification, will be discussed in greater detail.

STRUCTURAL DESIGN REQUIREMENTS

3.1 Detailed structural design requirements. The requirements of this specification reflect operational and **maintenance requirements** and are stated in terms of parameter values, conditions and discipline (loads, flutter, et cetera) requirements. **The air vehicle structure (airframe) shall have sufficient structural integrity to meet these requirements, separately and in attainable combinations.**

- CLARIFIES THE DISTINCTION BETWEEN STRUCTURAL DESIGN REQUIREMENTS AND STRUCTURAL DESIGN CRITERIA

The basic structural design requirements statement was expanded to clarify that the airframe shall have sufficient structural integrity to meet the requirements of the tailored structures specification.

STRUCTURAL DESIGN CRITERIA

3.1.1 Structural design criteria. The **deterministic structural design criteria** stated in this specification are, as a minimum, those necessary to ensure that the airframe shall meet the detailed structural design requirements established in this specification. ... **Each individual criterion established herein has been selected based upon historical experience with adjustments made to account for new design approaches, new materials, new fabrication methods, unusual aircraft configurations, unusual usage, planned aircraft maintenance activities and ____________. The substantiation of the adequacy of these criteria in meeting the specified and inherent design requirements is documented in __________.**

A new requirements paragraph was added to address deterministic structural design criteria. This requirement states that the criteria selected must be tailored to the particular design concept, selected materials, fabrication methods, et cetera, used in the air vehicle. This change was made to prevent the repetitive use of inappropriate or historically-used criteria. The change was also made to add the requirement that the selected criteria must be substantiated and this substantiation must be documented. This change will help ensure that a sound set of criteria is selected based upon a good understanding of the circumstances involved in its application.

PROBABILITY OF DETRIMENTAL DEFORMATION & FAILURE

3.1.2 Probability of detrimental deformation and structural failure. (__). A combined load–strength probability analysis shall be conducted to predict the risk of detrimental structural deformation and structural failure. For the design requirements stated in this specification, the airframe shall not experience **detrimental structural deformations with a probability of occurrence equal to or greater than _____ per flight.** Also, for these design requirements, the airframe shall not experience the **loss of adequate structural rigidity or proper structural functioning** such that flight safety is affected **or suffer structural failure leading to the loss of the air vehicle with a probability of occurrence equal to or greater than _______ per flight.**

The specification now provides the option, at the government and contractor's discretion, to use a probabilistic load-strength failure analysis as an alternative to the use of deterministic design criteria for selected structural components. This is done by establishing two probability requirements. The first, similar to the typical strength design requirement at limit load, establishes an unacceptable frequency of occurrence of detrimental structural deformations. The second, similar to the typical ultimate load strength requirement, establishes an unacceptable frequency of structural failure.

WEIGHTS

3.2.5 Weights. The weights to be used in conducting the design, analysis, and test of the air vehicle are derived combinations of the operating weights, the defined payload, and the fuel configuration. **These weights shall be the expected weight at IOC.**

3.2.5.1 Operating weight. The operating weight is the weight empty (MIL-STD-1374) plus unusable fuel, oil, crew, and ____________.

3.2.5.2 Maximum zero fuel weight. The maximum zero fuel weight shall be the highest required weight of the loaded air vehicle without any usable fuel and is specified as the operating weight plus_______________.

The weight requirements have been revised to establish that the expected weights at the Initial Operational Capability (IOC) of the weapons system, not the weights at the beginning of Full Scale Development (FSD), as the weights to be used in the design and analysis process. This was included to address the reduction in mission capability associated with the increase in weight that normally occurs from the start of FSD to IOC.

The weight requirements have also been revised to define design weights in terms of vehicle configurations and not as specific numeric weight values. Again, this was done to prevent the use of out-of-date vehicle weights in the design and analysis process.

LIMIT LOADS

3.2.11 Limit loads. The limit loads, to be used in the design of elements of the airframe subject to a deterministic design criteria, shall be **the maximum and most critical combination of loads** which can result from authorized ground and flight use of the air vehicle, including maintenance activity, the system failures of 3.2.22 from which recovery is expected, a lifetime of usage of 3.2.14, **all loads whose frequency of occurrence is greater than or equal to ____ per flight**, and _____. All loads resulting from the requirements of this specification are limit loads unless otherwise specified.

The limit load requirement was updated to ensure that limit loads are the maximum and most critical combination of loads to be experienced during mission use and maintenance activities. The definition of limit loads now includes a requirement to establish a lower bound on the frequency of occurrence of random loads to act as a cutoff for excluding severe but very infrequent loads from the design process. This cutoff frequency is referred to in later sections involving probabilistic loads. These limit loads are to be used in the design of elements of the airframe subject to a deterministic design criteria.

ULTIMATE LOADS

3.2.12 Ultimate loads. Ultimate loads not derived directly from ultimate load requirements of this specification shall be obtained by multiplying the limit loads by **appropriate factors of uncertainty**. These ultimate loads shall be used in the **design of elements of the airframe subject to a deterministic design criteria. These factors of uncertainty and the circumstances where they are to be used are** __________.

There are two changes in the ultimate loads requirements. First, the terminology "Factor of Safety" has been changed to "Factor of Uncertainty." This change was made to better define how this factor is used in the structural design process. The second change states the requirement that the factors of uncertainty and the circumstances where they are to be used are to be incorporated into the tailored specification. This change acknowledges that different factors of uncertainty may be appropriate for different structural concepts in the same vehicle. It also helps to ensure that consideration of the appropriateness of historically-used factors are reviewed before they are incorporated into the tailored specification.

REPEATED LOADS SOURCES

3.2.14.2 Repeated loads sources. All significant sources of repeated loads shall be considered and included in the development of the service loads spectra. The following operational and maintenance conditions shall be included as significant sources of repeated loads.

g. Heat flux. The repeated heat flux time histories are __________.

Heat flux was added to the list of repeated load sources to be considered in the determination of the tailored requirements.

POWER OR THRUST LOADS

3.2.17 Power or thrust loads. The power or thrust of the installed propulsion system shall be commensurate with the ground and flight conditions of intended use, including system failures of 3.2.22, and the capabilities of the propulsion system and crew. **The thrust loads attainable shall include all thrust loads up to the maximum. These loads shall include engine transients due to both normal engine operation as well as the engine system failures of 3.2.22 and** __________.

The Power or thrust loads requirements were expanded to specify that the thrust loads to be used in the determination of the limit loads shall be all thrust loads up to the maximum. Also, the selection of the critical thrust design loads shall include engine transients due to both normal engine operation as well as engine system failures.

FLIGHT CONTROL & STABILITY AUGMENTATION DEVICES

3.2.18 Flight control and stability augmentation devices. In the generation of loads, flight control and automatic control devices, including load alleviation and ride control devices, shall be in those operative, inoperative and transient modes for which use is required or likely or **due to the system failure conditions of 3.2.22 and** __________.

The requirement was added that system failures of the flight control system and stability augmentation devices must be considered in the selection of the critical design loads.

MATERIALS & PROCESSES

3.2.19 Materials and processes. Materials and processes shall be **selected in consonance with MIL-STD-1587, MIL-STD-1568** and the following requirements so that the airframe meets the operational and maintenance performance requirements.

- This and subparagraphs now incorporate all the material and process requirements formerly found in Section 3.10 Strength
- Castings, Forgings, Grain Direction, Environmental Effects, Nonmetallic Materials

MATERIALS

3.2.19.1 Materials. The **materials used in the airframe shall be commensurate with the operational and maintenance capability** required of the airframe. Whenever materials are proposed for which **only a limited amount of data is available, the acquisition activity shall be provided with sufficient background data so that a determination of the suitability of the material can be made.** The **allowable structural properties shall include all applicable environmental effects, such as exposure to climatic conditions of moisture and temperature; airborne or spilled chemical warfare agents; and maintenance induced environments commensurate with the usage of the airframe.** Specific material requirements are:

a. ________________

PROCESSES

3.2.19.2 Processes. The processes used to prepare and form the materials for use in the airframe as well as joining methods shall be commensurate with the material application. Further, **the processes and joining methods shall not contribute to the degradation of the properties of the materials when the airframe is exposed to operational usage and maintenance environments.** Specific material processing requirements are:

a. ________________

b. ________________

The materials and processes requirements previously found in several different sections of the specification are now consolidate into one section.

One additional change in the area of materials is that "B" basis allowables are now accepted for the design of structures whose strength will be verified by static test. Where appropriate, environmental induced material property degradation must be included.

NON-STRUCTURAL COATINGS, FILMS & LAYERS

3.2.21 Non-structural coatings, films and layers. Coatings, films and layers applied ... **Further, methods of nondestructive inspection shall be provided for inspecting the structure behind or beneath the coatings, films and layers for cracks, failures, damage, corrosion and other structural integrity anomalies. In particular, if the inspections of 4.11.1.2.2.d and 4.12.1 are applicable to the structure behind or beneath the coatings, films and layers, the coatings, films and layers shall not preclude or impede the performance of the durability and damage tolerance inspections.** If the coatings, films, or layers are attached by adhesive bonding ...

The requirements relating to the non-destructive inspection of non-structural coatings, films and layers were expanded to ensure that such coatings do not unacceptably degrade the ability to maintain the structural integrity of the underlying structure.

SYSTEM FAILURES

3.2.22 System failures. All loads resulting from or following the single or multiple system failures defined below whose frequency of occurrence is greater than or equal to the rate specified in 3.2.11 shall be limit loads. Subsequent to a detectable failure, the air vehicle shall be operated with the flight limits of 3.2.5, 3.2.7.10 and 3.2.9.5.

- **Tire failures**
- **Radome failures**
- **Hydraulic failures**
- **Transparency failures**
- **Propulsion system failures**
- **Mechanical failures**
- **Flight control system failures**
- **Other failures**

The specification requirements for establishing the limit loads resulting from single or multiple aircraft system failures has been renamed from "Probable Failures" to "System Failures." The cut-off frequency of occurrence established in the limit loads section is also used here to define which loads resulting from an aircraft system failure - for example, an uncommanded control surface deflection - are to be included in the selection of the limit loads. Other possible system failures to be considered are listed.

FOREIGN OBJECT DAMAGE

3.2.24 Foreign object damage (FOD). (__) The airframe shall be designed to withstand the FOD environments listed below. These FOD environments shall not result in the loss of the air vehicle or shall not incapacitate the pilot or crew with a frequency equal to or greater than ______ per flight. These FOD environments shall not cause unacceptable damage to the airframe with a frequency equal to or greater than __________ per flight.

PRESSURIZATION

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 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. ...**

BIRD FOD

3.2.24.1 Bird FOD. (_). The airframe shall be designed to withstand the impact of __ ______ pound birds with the corresponding air vehicle speeds of _______ KTAS in a manner consistent with the normal flight without loss of the air vehicle or the incapacitation of the pilot or crew. The airframe shall be designed to withstand the impact of _____ pound birds with the corresponding air vehicle speeds of _____ KTAS with no unacceptable damage. Unacceptable damage is __________.

•Also applies to HAIL FOD and RUNWAY, TAXIWAY, AND RAMP DEBRIS FOD

PRESSURIZATION (CONT'D)

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.**

The foreign object damage (FOD) requirements have been rewritten to establish these requirements on a probabilistic basis. Two cut-off frequencies of occurrence, similar to the approach used for random loads in the limit loads section, were defined. The first establishes an unacceptable frequency of occurrence for the loss of the aircraft or the incapacitation of the pilot or crew due to FOD. The second establishes an unacceptable frequency for the occurrence of unacceptable damage to the airframe.

The specific damage mechanism, such as the size of an impacting bird and the corresponding air vehicle speed, relating to each cut-off frequency as well as the specific definition of what constitutes unacceptable damage is defined in the subparagraphs.

The requirements for pressurization have been rewritten to expand the range of flight and ground operations to be included in the selection of pressurization design loads. The loads resulting from random pressurization system failures are addressed consistent with the previously discussed system failures and the cut-off frequency defined in the limit loads section. Also, the circumstances for the use of pressurization induced stresses and strains to reduce the severity of other flight and ground operations' induced internal loads or for the use of the increased structural stiffness resulting from internal pressurization in achieving limit or ultimate load structural requirements are defined.

FAIL - SAFE STABILITY

3.7.4 Fail-safe stability. For the system failures of 3.2.22, the air vehicle shall be free from flutter, divergence or other aeroelastic or aeroservoelastic instabilities after each failure. In addition, this **fail-safe criteria shall include air vehicle augmentation system failures that occur at a rate equal to or more frequent than the rate specified in 3.2.11.**

The requirement that the air vehicle be free of aeroelastic or aeroservoelastic instabilities following the defined system failures of 3.2.22 was expanded in ensure that potential augmentation system failures are included in meeting this fail-safe criteria.

STRESSES & STRAINS

3.10.4 Stresses and strains. Stresses **and strains** in airframe structural members shall be controlled through proper sizing, detail design, and material selections to satisfactorily react all limit and ultimate loads. **In laminated composites, the stresses and ply orientation are to be compatible and residual stresses of manufacturing are to be accounted for, particularly if the stacking sequence is not symmetrical.**

3.10.4.1 Fitting factor. ...

3.10.4.2 Bearing factor. ...

The general strength requirement relating to stresses was expanded to include strains since strain is the controlling design parameter in some structural materials. These general requirements were also expanded to specifically address laminated composites.

STATIC STRENGTH

3.10.5 Static strength. Sufficient static strength shall be provided in the airframe structure for reacting all loading conditions loads without degrading the structural performance capability of the airframe. Sufficient strength shall be provided for operations, maintenance functions, and **any tests that simulate load conditions**, such that:

a. Detrimental deformations, **including delaminations**, shall not occur at or below limit loads, or **during the tests required in 4.10.5.3 and 4.10.5.4.** The deformation requirements of 3.2.13 apply.

b. Rupture or collapsing failures shall not occur at or below ultimate loads.

The static strength section was modified to include the requirement that the airframe shall have sufficient strength to withstand the loads and load distributions applied to the airframe during ground tests. Specifically, the airframe must have sufficient strength to withstand the functional, strength, and pressurization proof tests. Also, the requirement that no detrimental deformations shall occur at or below limit loads was expanded to include delaminations.

INITIAL & INTERIM STRENGTH FLIGHT RELEASES

3.10.6 Initial and interim strength flight releases. Initial and, as needed, interim **strength flight restrictions** shall be established to maintain safe flight conditions **until all structural validation testing has been successfully completed. The loads resulting from overshoots, upsets and the recovery from overshoots and upsets, and the loads during and following the system failures of 3.2.22 shall be included in the establishment of the flight restrictions.**

a. For the initial strength flight release, flight restrictions shall be defined to restrict the air vehicles from experiencing loads greater than ______ percent of limit loads.

b. Prior to the completion of all structural validation testing, interim strength flight releases shall be defined to permit flight up to limit loads or the strength envelope cleared through the strength proof testing of 4.10.5.4, whichever is less.

INITIAL & INTERIM STRENGTH FLIGHT RELEASES (CONT'D)

4.10.6 Initial and interim strength flight releases.

a. Prior to the initial flight release, the **airframe shall be satisfactorily strength analyzed** for reacting all predicted limit and ultimate loads and this **analysis shall be approved by the procuring activity.** Also, **prior to the initial flight release, the functional *proof test requirements of* 4.10.5.3 shall be successfully met. Prior to first pressurized flight of all air vehicles, the pressurization proof test requirements of 4.10.5.4 shall be successfully met.**

INITIAL & INTERIM STRENGTH FLIGHT RELEASES (CONT'D)

b. **Prior to flight beyond the initial strength flight release, the accuracy of the loads predictive methods shall be validated by using an instrumented and calibrated flight test air vehicle to measure actual loads and load distributions during flight within the initial strength flight release envelope.** Also, prior to flight beyond the initial strength flight release, the **strength proof test requirements of 4.10.5.4 shall be successfully met.** Extrapolations of the measured data beyond the initial flight limits shall be used to establish the expected conservatism of the predictive methods for flight up to limit loads. This procedure of loads measurement and data extrapolation shall be used to validate the conservatism of the strength analysis and strength proof tests ...

FINAL STRENGTH FLIGHT RELEASE

3.10.7 Final strength flight release. Prior to final strength flight release for operation up to 100 percent of limit strength **for either production air vehicles or flight test air vehicles not proof tested per 4.10.5.4**, the airframe shall have **exhibited ultimate load static test strength for ultimate loads which reflect verified external limit loads.**

The sections defining the initial, interim and final strength flight releases have been reorganized to clarify the limitations to be imposed on the air vehicle as a function of the analyses and tests satisfactorily completed.

DURABILITY

3.11 Durability. The durability of the airframe shall be adequate to resist fatigue cracking, corrosion, thermal degradation, delamination and wear during operational and maintenance use such that the operational and maintenance capability of the airframe is not degraded. **These requirements apply to metallic and nonmetallic structures, including composites, with appropriate distinctions and variations as indicated. Durability material properties shall be consistent and congruent with those properties of the same material, in the same component, used by the other structures disciplines. See 3.2.19.1.** The economic life of the airframe shall be sufficient to withstand the service life and usage of 3.2.14.

FATIGUE CRACKING / DELAMINATION DAMAGE

3.11.1 Fatigue cracking/delamination damage. Adverse cracking/**delamination** which would cause functional impairment or require costly maintenance action or both shall not occur within __________ lifetimes when the airframe is subjected to the environment and service usage of 3.2.14, except where it is desired to meet the limited life provisions of 3.11.5. Steady state level flight and ground loading conditions shall not result in sustained growth of cracks/delaminations in the airframe.

DAMAGE TOLERANCE

3.12 Damage tolerance. The damage tolerance capability of the airframe shall be adequate for the service life and usage of 3.2.14 as amplified below. **Particular requirements applicable to specific materials are so identified.** Safety of flight and other selected structural components of the airframe ... **These requirements apply to metallic and nonmetallic structures, including composites, with appropriate distinctions and variations as indicated. Damage tolerance material properties shall be consistent and congruent with those properties of the same material, in the same component, used by the other structure's disciplines. See 3.2.19.1.** Damage tolerance requirements shall also be applied to the following special structural components:

The durability and damage tolerance requirements were expanded to better address nonmetallic / composite structures.

FUNCTIONAL PROOF TESTS

4.10.5.3 Functional proof tests prior to first flight. Prior to the first flight of the first flight article, proof tests shall be conducted **to demonstrate the functioning of flight-critical structural systems, mechanisms and components whose correct operation is necessary for safe flight.** These tests shall **demonstrate that the deformation requirements of 3.2.13 have been met.** The functional proof tests that will be conducted, the articles on which they will be conducted, and the load level to which the systems, mechanisms and components will be loaded are: ______________. Where these **tests are not performed on every flight air vehicle**, the substantiation that the planned test program is adequate to demonstrate the flight safety of all flight air vehicles is **documented in** __________.

The functional proof test requirements were rewritten to better clarify the intent of this testing.

STRENGTH & PRESSURIZATION PROOF TESTS

4.10.5.4 **Strength and pressurization proof tests.** Strength proof tests shall be successfully performed ... **Pressurization proof tests shall be successfully performed on every airframe prior to pressurized flight.** These **proof tests shall demonstrate that the deformation requirements of 3.2.13 have been met at all load levels up to the maximum loads expected to be encountered during flight for flight anywhere within the released flight envelope including the effects of recovery from upsets and the system failures of 3.2.22.** These **proof tests shall also validate the accuracy of the strength predictive methods through comparisons of measured critical internal loads, strains, stresses, temperatures, and deflections with predicted values.** Re-proof tests shall be conducted ...

STRENGTH & PRESSURIZATION PROOF TESTS (CONT'D)

a. Strength proof test load levels shall be equal to or greater than ________ percent of limit mechanical loads or the maximum mechanical loads to be encountered during flight, whichever is less, and _______ percent of limit thermal loads or the maximum thermal loads to be encountered in flight, whichever is less. The proof load distributions shall be equal to or more severe than the predicted load distributions.

STRENGTH & PRESSURIZATION PROOF TESTS (CONT'D)

b. Prior to **the first flight with pressurized compartments,** each pressurized compartment of each pressurized flight air vehicle **shall be pressure proof tested to _______ percent of the maximum pressure limit loads of 3.4.1.12.** Subsequent to the **successful completion of ultimate pressurization tests** on the static test article, **each air vehicle shall be pressure** proof tested **to the maximum operating pressure differential attainable with normal pressure control system operation multiplied by a factor of ________. Where necessary to demonstrate combined external load and internal pressurization strength, the pressure proof tests shall be combined with the strength proof tests of subparagraph a. above.**

The strength and pressurization proof test requirements were combined and rewritten to clarify when these tests are required and what these tests are expected to accomplish.

Conclusion

These changes in the Structures Mil-Prime reflect the experience gained in applying the requirements contained in this Mil-Prime to ASD programs currently in or entering Full Scale Development.

The author, in behalf of the entire Structures Division, extends our appreciation to the Aerospace Industries Association (AIA) for their assistance in developing the Mil-Prime specification's requirements in general and, particularly, the damage tolerance requirements for composites.