U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: AIRFRAME GUIDE FOR CERTIFICATION OF PART 23 AIRPLANES

Date: 4/30/07
Initiated by: ACE-100

AC No: 23-19A

FOREWORD

This Advisory Circular (AC) sets forth an acceptable means of showing compliance with Title 14 Code of Federal Regulations (14 CFR), part 23, for certification of the airframe (Subpart C and portions of Subpart D) of normal, utility, acrobatic, and commuter category airplanes and airships. The policy in this AC applies to airship projects; however, the certifying office should only use specific applicability and requirements if they are reasonable, applicable, and relevant to the airship project. This AC both consolidates existing policy documents, and certain ACs that cover specific paragraphs of the regulations, into a single document and adds new guidance.

This document provides guidance for the original issue of part 23 and the various amendments. This version of the AC covers policy available through January 1, 2007. Policy that became available after January 1, 2007, will be covered in future revisions to the AC.

s/

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Section **PAGE**

1. What is the purpose of this advisory circular (AC)? This advisory circular (AC) provides information and guidance on an acceptable means, but not the only means, to comply with Title 14 of the Code of Federal Regulations (14 CFR) part 23, Subpart C, and portions of Subpart D. However, if you use the means described in the AC, you must follow it in all important respects. This AC consolidates the substance of existing Civil Aeronautics Administration (CAA) and Federal Aviation Administration (FAA) letters into a single reference. It also presents information from certain existing AC's that cover general topics and specific airworthiness standards. This AC is not mandatory and does not constitute a regulation.

2. Who does this AC apply to?

a. This AC applies to any interested party that wants to certify an airplane to part 23 regulations.

b. This material has no legal status. However, to encourage standardization during the certification process, the FAA recommends that the applicant consider this guidance during each small airplane type certificate and supplemental type certificate project.

3. Does this AC cancel any previous AC's? Yes. The following AC is cancelled:

AC 23-19, Airframe Guide for Certification of Part 23 Airplanes.

4. What is the background of this guidance material? This AC is current with the airworthiness standards that appear in part 23 through Amendment 23-51, effective March 11, 1996, and policy issued through January 1, 2007. This information spans approximately 30 years of FAA and CAA letter-written aviation guidance. It includes some historical guidance that dates from Civil Air Regulations (CAR) 3 and the earlier CAR 04.

5. How is this advisory circular organized?

a. The paragraph headings are keyed to part 23. This AC includes all the regulatory topics found in part 23 Subpart C, and in Subpart D through CONTROL SURFACES.

b. Each AC paragraph matches with the applicable part 23 section for the corresponding amendment shown in the title.

c. Reference to AC information appears without the section "§" symbol, for example, "23.301."

d. Any reference to the like-numbered airworthiness standard is shown with a section symbol, for example, "§ 23.301."

e. When "Original" appears as the amendment number applicable to a specified section, it specifies that part 23 of the 14 CFR effective February 1, 1965, unchanged by any later amendment, applies to that section. As part 23 changes are introduced by new amendments, the FAA will make appropriate revisions to this AC.

6. Are there any related publications, and where can they be found?

a. Yes. You may get copies of current editions of the following publications free from:

U.S. Department of Transportation
Subsequent Distribution Office
Ardmore East Business Center
3341 Q 75th Avenue
Landover, MD 20785

b. Some of these publications are also available on the Internet at http://www.faa.gov. The related publications include:

(1) AC 20-33B, Technical Information Regarding Civil Aeronautics Manuals 1, 3, 4a, 4b, 5, 6, 7, 8, 9, 13, and 14;

(2) AC 20-44, Glass Fiber Fabric for Aircraft Covering;

(3) AC 20-71, Dual Locking Devices on Fasteners;

(4) AC 20-107A, Composite Aircraft Structure;

(5) AC 20-146, Methodology for Dynamic Seat Certification by Analysis for Use in Parts 23, 25, 27, and 29 Airplanes and Rotorcraft;

(6) AC 21.25-1, Issuance of Type Certificate: Restricted Category Agricultural Airplanes;

(7) AC 23-9, Evaluation of Flight Loads on Small Airplanes with T, V, +, or Y Empennage Configurations;

(8) AC 23-13, Fatigue and Fail-Safe Evaluation of Flight Structure and Pressurized Cabin for Part 23 Airplanes;

(9) AC 23-15A, Small Airplane Certification Compliance Program;

(10) Advisory Circular 23-20, Acceptance Guidance on Material Procurement and Process Specifications for Polymer Matrix Composite Systems;

(11) AC 23.562-1, Dynamic Testing of Part 23 Airplane Seat/Restraint Systems and Occupant Protection;

(12) AC 23.629-1A, Means of Compliance with Section 23.629, Flutter;

(13) AC 25.571-1C, Damage Tolerance and Fatigue Evaluation of Structure;

(14) AC 183.29-1 (latest revision), Designated Engineering Representatives Consultant Directory;

(15) Policy Statement PS-ACE100-2001-006, "Static Strength Substantiation of Composite Airplane Structure"

(16) Policy Statement PS-ACE100-2002-006, "Material Qualification and Equivalency for Polymer Matrix Composite Material Systems"

(17) Policy Statement PS-ACE100-2004-10030, "Substantiation of Secondary Composite Structures"

(18) Policy Statement PS-ACE100-2005-10038, "Bonded Joints and Structures – Technical Issues and Certification Considerations"

(19) FAA Order 8110.4C, Type Certification;

(20) FAA Order 8100.5A, Aircraft Certification Service Mission, Responsibilities, and Relationships, and Programs;

(21) TSO-C27, Twin Seaplane Floats.

(22) Civil Aeronautics Manual 04 (CAM 04) – Available on the Internet at: http://dotlibrary.specialcollection.net/

(23) Civil Aeronautics Manual 08 (CAM 08) – Available on the Internet at: http://dotlibrary.specialcollection.net/

c. In addition, copies of the following publications are available on request from:

Small Airplane Directorate Standards Office
Federal Aviation Administration DOT Building
901 Locust Street, Room 301
Kansas City, Missouri 64106

(1) ANC-1(1), Spanwise Air-Load Distribution, Army-Navy-Commerce Committee on Aircraft Requirements, 1938

(2) ANC-1(2), Chordwise Air-Load Distribution, Army-Navy-Civil Committee on Aircraft Design Criteria, Amendment –1 dated 3 January 1944

7. Where can I get engineering advice? See AC 183.29-1 for a list of engineers who are appointed by the FAA to do certain kinds of FAA approval work, and are familiar with the certification process.

8. Should I Confer with the FAA Aircraft Certification Office Project Engineer? Yes. An FAA project engineer can be an invaluable guide to the FAA Certification Process and the particular airworthiness standards for airplane design or modification.

Airframe Guidance for Certification of Part 23 Airplanes

SUBPART C—STRUCTURE

GENERAL

23.301 Loads	(Amendment 23-48)

9. Should references be included in the loads calculations? Yes. Each Basic Loads calculation should be annotated with the airworthiness standard section for which compliance is shown, for example, use part 23, § 23.301(a); they may also be shown in Design Criteria, Test Plans, Test Reports, and Software Documents.

10. What effect do cutouts have in structure? Doors, windows, access holes, etc., in aircraft structure causes redistribution of axial and shear loads, pressure loads, and stiffness changes. Fatigue capabilities may be affected. Damage tolerance capabilities may be affected. Account for all such design changes.

11. Do Biplane designs require any special aerodynamic load criteria?

a. Yes. A previously used typical approach includes:

(1) Developing an equivalent single wing (cellule), which aerodynamically represents the biplane wings. Civil Aeronautics Manual 04 (CAM 04), paragraph 217, provides an acceptable method unless the biplane has an unusual amount of stagger or decalage. Also, see CAM 04, Appendix III.

(2) Defining wing and tail loads from part 23 load conditions using the equivalent single wing.

(3) Distributing the equivalent single wing load between the upper and lower biplane wings. CAM 8, paragraph 212, provides an acceptable method for biplanes with no decalage.

(4) Distributing the individual wing-loads spanwise using a method such as Schrenk or ANC-1. (See Figure 1.)

b. Other acceptable methods for obtaining aerodynamic parameters for biplanes and other unique configurations include computational fluid dynamic (CFD) codes, including VS-Aero, MG-Aero, and TRANAIR. Applicants should validate the suitability of these codes for their particular configuration. Wind tunnel and flight tests are also acceptable methods of measuring load intensities.

12. What is the effect of increased engine power? An increase in engine power causes larger loads on, and in, several aircraft structures. A different engine, with different weight, center of gravity (c.g.) and horsepower, will change the inertial, gyroscopic, and aerodynamic loads from those of the previous engine. A changed propeller imparts similar effects on inertial, aerodynamic and gyroscopic loads, which are imposed on airplane structures.

13. Can ultimate load flight tests be used?

a. The FAA discourages attempting ultimate load flight tests unless the applicant understands fully the risks involved, and then the FAA advises caution.

b. See "Note" in 23.305, paragraph 22b, of this AC concerning flight tests.

14. Can I use wind tunnel data?

a. Wind tunnel tests may be used to measure several parameters used in determining airplane loads. Force models can be used to measure the tail-off and tail-on airplane lift, pitching moment and drag curves, downwash at the tail, and stability and control parameters. Pressure models can be used to obtain the wingspan loading and the pressure distributions on airplane components. Measured pressure distributions are particularly useful in determining loads on secondary structure, including nacelles, canopies, and fairings.

b. Lower performance conventional airplanes are commonly designed without the benefit of wind tunnel testing. Conventional, as used here, means an airplane having a main wing at or near the c.g. and an empennage aft of the airplane c.g. Wind tunnel tests are more likely to be useful for airplanes with unconventional configurations, unusual aerodynamic features, or high performance airplanes where compressibility effects cannot be neglected.

c. Scaling of test results to full-scale airplane values requires similarity of geometry, Mach Number and Reynolds Number. Similarity of Reynolds Number is the most difficult of these to achieve. Test data acquired at Reynolds Numbers significantly lower than flight may be of little use for certification purposes due to the large corrections that must be applied to the test data. Reynolds Number similarity can be achieved by using large-scale models or pressurized wind tunnels. Boundary layer transition strips or dots are frequently used to model flight scale Reynolds Number effects on a model tested at lower Reynolds Numbers.

15. How can I determine the span-wise lift distribution? The span-wise distribution of lift on the wing may be obtained from wind tunnel test, flight test, analysis, or a combination of analysis and test. Figure 1 lists some commonly used span-wise lift distribution analysis methods. In addition to the methods listed in Figure 1, there are various computer codes available that use computation fluid dynamics (CFD), such as, VS-Aero, MG-Aero, and TRANAIR.

a. The National Advisory Committee for Aeronautics (NACA) Technical Report 572 reports on the Anderson method. The wings under consideration covered a complete range of taper ratios and aspect ratios from 2 to 20. It does not say that 20 is a limit.

b. Reference 1 (page 228) states that NACA Technical Report 585 contains an exact method.

c. The "Fourier Series Method" is described in Reference 1 on pages 233 to 242. This is the method in ANC-1 (which has tabular forms for ease of calculation). This method uses lifting line theory, which is good for conventional unswept wings with aspect ratios greater than 5 or 6 (see Reference 1, page 247).

d. Weissenger's "Method" (Reference 2) is applicable to straight or swept wings of low or high aspect ratio. This is a modified lifting theory method.

e. Schrenk's "Approximation" basically averages the lift forces obtained from an elliptical lift distribution with those obtained from a planform lift distribution. This approximation is accurate for wings that approach an elliptical planform (Reference 1, page 224). This method is contained in Civil Aeronautics Manual (CAM) 04, Appendix IV. The Limitations, in Section 6, state that it applies to the normal range of aspect ratios (from 5 to 12).

f. Reference 3 (page 14) lists NACA Technical Reports 572, 585, and 606. The first two of these technical reports are discussed in Items a and b above. Technical Report 606 is titled "Empirical Corrections to the Span Load Distribution at the Tip." Correction is only necessary if the wing is tapered less than 2:1 and has a blunt tip.

g. Reference 4 lists several references: 3.5 through 3.12 (see Enclosure 3).

h. In the paper titled "Application of Microcomputer Software to the Aerodynamic Design of a Motorglider" *Technical Soaring*, October 1993, the lifting line theory FORTRAN program in Reference 5 (pages 159-164) was used (on an Apple Macintosh Plus computer) to calculate the lift distribution of a 17-meter (55.76 foot) wing (aspect ratio unstated). A comparison was made of the lift distribution calculated by Schrenk's approximation.

i. Reference 6 contains a vortex lattice FORTRAN program.

j. Reference 7 is an aeroelastic supplement for the NASTRAN finite element program.

k. NACA TN 3030 titled, "A Method for Calculating the Subsonic Steady-state Loading on an Airplane with a Wing of Arbitrary Planform and Stiffness" includes both the aeroelastic effects and the ability to base the span loading on linearized wind tunnel wing section data. It also allows for correcting wind tunnel model elastics and jig twist.

FIGURE 1
SPANWISE WING-LOADING METHODOLOGIES

METHOD	APPROACH TO SOLUTION	LIMITATIONS ON APPLICATION	COMMENTS
ANC-1	Fourier Solution. Based on lifting line theory. Basic and additional lift.	Conventional unswept wings with aspect ratios greater than 5 to 6.	Exact Solution despite limitations of lifting line theory. Similar Methods: **LOTZ** **GLAUERT** (Elements of Aerofoil and Airscrew Theory) **ANDERSON** (Theory of Wing Sections)
SHRENK'S NACA TM-948	Approximate Solution. Based on lifting line theory. Basic and additional lift.	Conventional unswept wings with aspect ratios greater than 5 to 6.	Accuracy approaches **ANC-1**. Small inaccuracies overshadowed by original assumptions. Much easier to apply.
SHERMAN'S NACA TN-732	Successive approximations to match chord distribution. Each angle of attack requires separate calculation.	Applicable to any straight wing without high lift devices.	Accuracy compares with **ANC-1** but unsatisfactory due to separate calculation for each angle of attack.
PLANFORM (Often used for horizontal tail)	Air load distribution directly proportional to chord variation.	Untwisted high taper ratio wings.	Unconservative for Taper Ratios < 0.25. Conservative for Taper Ratios > 0.35.
WEISSINGER NACA TM 1120	Iteration process based on modified lifting line theory. Basic and additional lift.	Applicable to straight or swept wings of low or high aspect ratio.	Lifting surface method also presented as applicable to straight wings.
DeYOUNG & HARPER NACA TR 921	Based on simplified lifting surface theory. Basic and additional lift.	Applicable to straight or swept wings of low or high taper ratio.	Extension of **Weissinger Method**. Can account for compressibility M > 0.5 @ S.L.
DIEDERICH NACA TR 1000	Matrix Iteration process utilizing aero-elastic matrix determined from aerodynamic and structural properties of wing.	No planform limitations.	Considers loading and divergence speed.

NOTE: See NACA TN 606 for Empirical Tip Corrections, and RM L53B18 for Tip Tank Effects on Load Distribution.

REFERENCES

1. D. J. Peery, *Aircraft Structures*, McGraw-Hill, (1950).

2. J. Weissinger, *The Lift Distribution of Swept-Back Wings*, NACA Technical Note 1120, (1947).

3. Anonymous, *Basic Glider Criteria Handbook*, Federal Aviation Agency, (1962).

4. Niu, M. C. Y., *Airframe Structural Design*, Conmilit Press, LTD., (1988).

5. Kuthe, A. M. & Chow, C. Y., *Foundations of Aerodynamics*, Fourth Edition, John Wiley & Sons, New York, (1986).

6. Margason, R. J. and Lamar, J. E., "Vortex Lattice FORTRAN Program for Estimating Subsonic Aerodynamic Characteristics of Complex Planforms," *NASA Technical Note D-6142*, (February 1971).

7. *MSC/NASTRAN Aeroelastic Supplement*, MacNeal-Schwendler Corporation, 815 Colorado Boulevard, Los Angeles, CA 90041-1777.

8. DeYoung, J. and Harper, C. W., "Theoretical Symmetric Span Loading at Subsonic Speeds for Wings Having Arbitrary Planform." *NACA Report No. 921*, (1948).

9. Sivells, J. C., "An Improved Approximate Method for Calculating Lift Distributions Due to Twist." *NACA Technical Note 2282*, (1951).

10. DeYoung, J., "Theoretical Anti-symmetric Span Loading for Wings of Arbitrary Plan Form at Subsonic Speeds." *NACA Report No. 1056*, (1951).

11. DeYoung, J., "Theoretical Symmetric Span Loading Due to Flap Deflection for Wings of Arbitrary Plan Form at Subsonic Speeds." *NACA Report No. 1071*, (1952).

12. Falkner, V. M., "The Calculation of Aerodynamic Loading on Surfaces of any Shape." *ARC Report R&M No. 1910*, (1943).

13. Multhopp, H., "Methods for Calculating the Lift Distribution of Wings (Subsonic lifting-surface theory)." *ARC Report R&M No. 2884*, (1955).

14. Watkins, C. E., Woolston, D. S., and Cummingham, H. J., "A Systematic Kernel Function Procedure for Determining Aerodynamic Forces on Oscillating or Steady Finite Wings at Subsonic Speeds." *NASA Technical Report R*-48, (1959).

23.302 Canard or tandem wing configurations (Amendment 23-42)

16. Is there any policy available on this section as of January 1, 2007? No.

23.303 Factor of safety (Original)

17. Is there any policy available on paragraph (a) of this section as of January 1, 2007? The prescribed factor of safety of 1.5 is the **minimum** acceptable factor of safety. Also see section 23.619.

23.305 Strength and deformation (Amendment 23-45)

18. Is it possible to return an article to service after experiencing ultimate loads from a test? Certain FAA Order 8110.4 practices, about returning articles to service that have experienced ultimate load tests, may be relaxed without compromising safety. [Order 8110.4C, currently in effect, was issued several years after this example situation from Order 8110.4.] For instance, an engine mount assembly can be readily and completely inspected to determine that there is no structural damage (deformation, permanent set, material yielding). The previous FAA Order 8110.4 permits similar practice for limit load tested articles. Exercise judgment to determine the structures that can properly be inspected for damage.

19. How should I show that a part can withstand ultimate load without failure, and what is considered a failure on a static test specimen?

a. The interpretation of a structural failure of a static test specimen has varied greatly on past type certification programs. In the strictest interpretation, if one part fails beyond limit load but below ultimate load, the test is stopped—the part repaired—and the test rerun. The repair, in this case, becomes part of the type design. In a more liberal vein, a local failure up to ultimate load was accepted as long as the entire structure being tested was able to carry the ultimate load for 3 seconds. The applicant was not required to redesign or structurally “beef up” the locally failed part. In a third instance, the specimen was loaded to destruction with a continuously increasing load at a constant rate and with a continuous recording of the test results. The ultimate load was established as the load attained 3 seconds before the maximum load was recorded.

b. If the applicant chooses to demonstrate strength capability by tests of structural components, the applicant should substantiate that the strength of the tested component conservatively represents the strength of subsequent production components. Substantiating data might include quality control data, material and process specifications, material certifications, coupon sampling tests, or other appropriate information.

c. An applicant may also apply material correction factors to the applied test loads to account for material variability. Applicants should use material correction factors for ultimate load tests of single load path critical flight structure and for fail-safe tests of dual load path critical flight structure with one load path failed. Applicants do not need to use material correction factors for limit load tests or for ultimate load tests of fail-safe designs where loads from one failed component are distributed to and carried by two or more remaining components.

20. What is the definition of "acceptable local failures" in static structural tests?

a. Regulatory History

(1) Amendment 23-45, 14 CFR § 23.305(b) read as follows:

> ”The structure must be able to support ultimate loads without failure for at least three seconds.”

(2) Amendment 23-45, effective August 6, 1993, changed § 23.305(b) to read as follows:

> ”The structure must be able to support ultimate loads without failure for at least three seconds, except local failures or structural instabilities between limit and ultimate load are acceptable only if the structure can sustain the required ultimate load for at least three seconds.”

(3) The Notice of Proposed Rule Making (NPRM, Notice 90-18, Small Airplane Airworthiness Review Program Notice No. 4) for Amendment 23-45, provided the following information supporting the revision to § 23.305(b).

> ”This proposal clarifies the FAA’s interpretation of failure during static ultimate load test. Using existing Section 23.305, the test is a failure if a part or component fails (e.g., a rivet) beyond limit load but below ultimate load during a static ultimate load test. Using a more liberal interpretation, a failure or structural instability between limit and ultimate load is acceptable as long as the entire structure demonstrates the capability to carry ultimate load for three seconds. This proposal clarifies this disparity, but is not intended to relieve the requirement for deflection shown in Section

> 23.301(c) or Section 23.305(a). The intent of this proposal was unopposed at the conference."

(4) The "conference" referred to in the NPRM is the Part 23 Regulatory Review Program public meeting held in St. Louis, Missouri, in October 1984. The minutes from the meeting (pg. 191, Regulatory Review Program, Committee II, Airframe, October 22, 1984) provide further insight into the intent of the revision to § 23.305(b).

> "The idea, here, is to allow the test to continue between limit and ultimate. In the event you had a rather minor local failure, such as a sheared rivet or two, the idea is, if the major component, assuming you are testing a wing, for example and you shear or rivet or two, there have been cases in which FAA personnel had discontinued the test and have told the applicant or the manufacturer that the test did not pass, because there was a failure. Now, this proposed change would permit the test to continue to ultimate and would consider to be an acceptable test, provided there were no major structural failures."(Sic)

b. Policy

(1) The intent of § 23.305(b) is that the structure must support ultimate loads without failure. The revision at Amendment 23-45, clarified that minor, local failures, and instabilities may be acceptable. The intent of the revision was to provide relief in those instances where minor, insignificant failures might otherwise result in the test being declared a failure.

(2) The revision was not intended to make any failures acceptable as long as some part of the structure was able to sustain the required loads. The original intent of the regulation remains the same; any failures before or at ultimate load are not desirable. The revision simply allows for the use of good engineering judgment, so that relatively minor local failures and structural instabilities may be discounted.

(3) Acceptable local failures or structural instabilities might include:

- A limited number of sheared rivets.
- Short cracks not extending a significant distance through the part or component.
- Localized panel buckling.
- Delaminations or disbonds over a small percentage of the part or joint area.

(4) The following types of failures are not acceptable even if some part of the structure is able to support the required load. If the structure develops these types of damage before or at ultimate load, the test should be considered a failure.

- Any failure that causes significant load shedding or redistribution of loads. Significant load shedding is indicative that a major load path or component has failed. Load versus deflection data and strain gage data can be observed during the test to verify that the design load paths are maintained.
- Large number of sheared fasteners.
- Widespread cracking.
- Extensive buckling
- Large areas of delaminations or disbonds.

21. Can I use structural analysis to show compliance to part 23, § 23.305? Yes. Often, an engineer can perform structural analyses that will substantiate airplane designs and design changes. Contact an engineer who is familiar with the FAA certification process and the particular airworthiness standards. Among others, a Designated Engineering Representative (DER) can sometimes help in this endeavor. This is another way that allows a designer or a modifier to gain FAA approval for changes to the type design. See AC 183.29-1, Designated Engineering Representatives, current edition.

22. Can I employ static tests to show compliance to part 23, § 23.305?

a. Yes. The assessment of a structure at limit load is a visual check. Deformations may be observed at limit load. However, those deformations should disappear when the load is removed. Also, any deformation that may occur at any load up to limit load should not interfere with safe operation. For example, when static testing a complete wing structure that includes installed control systems, ailerons, flaps, etc., the control systems and surfaces should perform their intended function during any deformation that may occur up to and including limit load.

b. The FAA CAUTIONS airplane designers and certifiers to watch out for the SPECIAL EXCEPTION to FAA LIMIT and ULTIMATE load regulatory failure conditions (Euler Column Buckling). COLUMN STRUCTURES, when they are used in a (primary structure) single-load-path design application, cannot be allowed to buckle under either FAA LIMIT or FAA ULTIMATE load conditions. Two common applications of column structures are wing struts and control system pushrods.

c. Settlement of structure due to the effects of riveting, fasteners, etc., does take place during limit load tests. When testing a pressurized fuselage, the pressure differential required by § 23.365 will introduce some settlement in the rivets and fasteners. The differential pressure required is 1.33 times the maximum relief valve setting. For altitudes that exceed 45,000 feet, previously issued part 23 special conditions required a differential pressure of 1.67 times the maximum relief valve setting. Under limit load, if it can be accomplished safely, visually inspect the test specimen. Accept sounds associated with the working of rivets, fasteners, and panels as the applied load increases to limit load. See 04.201, Civil Aeronautics Manual (CAM) 04, Deformations, revised July 1, 1944. (See 23.365 guidance about pressure tests.)

d. For metallic structures only, the FAA Small Airplane Directorate allows tested structure to be used as part of an airplane in operational service. However, the structure must have been thoroughly examined, following static tests to any loads, and the structural deformations must have remained elastic. That is, the structure should be shown, by proper measurements, not to have experienced material stresses beyond the material yield-point stresses under the applied loads. Any deviations to the type design that are created due to structural tests should be dispositioned before the article is subjected to operational flights. If, during any static tests, portions of the structure become visibly damaged, the damaged items should be replaced before the structure is released for operational flight tests. On the other hand, any static test structure that has been tested and has yielded is not a candidate structure for later operational flight tests.

23. Can I conduct flight tests as the sole means to show compliance to part 23, § 23.305 for secondary structures?

a. No. In the past, there have been instances where flight tests to dive speed have been accepted as the only means of substantiating secondary structures.

> **Definition:** Secondary structure is not a primary load-carrying member. Failure of secondary structure neither reduces the airframe structural integrity nor prevents the airplane from continued safe flight and landing.

b. A dive-speed approval does not satisfy the requirement that structure should support ultimate load.

c. In other instances, dive-speed flight tests have not been accepted as the sole means of showing compliance with the airworthiness standards. In those cases, an applicant presents additional data. Some secondary structure modifications, or alterations, have been approved by structural analyses and tests without dive-speed tests; these modifications include structures like windshields, windows, and radomes.

d. Sometimes, the FAA has accepted flight tests to design dive speed (not just to the never-exceed-speed, V_{NE}) as the only means of "substantiating" secondary structures. This substantiation does not satisfy the requirement for the structure to support ultimate load, nor does it apply the load factors of the V-n diagram to the structure. Flight tests to design dive speed should not be accepted as the sole means of substantiation; the applicant must present additional data to complete the "show compliance with Airworthiness Standards" requirements. Certain secondary structure modifications or alterations, which do not change the original external contour, have been FAA approved by structural substantiation alone. Examples of these types of secondary structures include windshields, windows, and radomes.

> **Caution:** Compliance to flight tests should be prudently limited to an 80 percent design flight envelope (V-n diagram; limit loads) until structural tests to all ultimate load conditions are satisfactorily completed (or until all structural analyses to ultimate load conditions are satisfactorily completed).

Caution: Structural flight tests do not necessarily demonstrate ultimate load conditions for secondary structures. Limit dynamic pressure, limit maneuver load factor (and load), and limit landing impact load factor (and load) may be easily achieved during flight tests. Limit gust load factor may be difficult to achieve during flight tests. It can be dangerous to attempt ultimate load factor (and load) flight tests. Ultimate load flight tests are discouraged.

Caution: In rare instances, some secondary structures can be flight tested safely to ultimate load conditions well within the airplane flight envelope (V-n diagram), and well below the airplane design dive speed (V_D). Landing gear doors are an example of this special case. The landing gear operational speeds, landing gear extended, V_{LE}, and landing gear operating, V_{LO}, can be considerably lower than the airplane design dive speed. Consequently, it is sometimes possible to flight test to an ultimate dynamic pressure for the landing gear that is safely below the limit dynamic pressure for the airplane design dive speed. Angle of attack may be a negligible factor in this case, and maximum airplane yaw angles may be accommodated within the airplane limit flight conditions.

24. What is your interpretation of "detrimental, permanent deformation," as used in paragraph (a) of this section, on limit load testing?

a. Current policy does not specify a numeric value for "allowable permanent deformation".

b. As stated previously, metallic structure should not be used in service if it has exceeded the deformation obtained by the 0.2 percent offset method, which is the common engineering practice for defining the yield point of metals. Yielded material is not airworthy. This addresses the airworthiness of materials, but it does not define what is considered "detrimental, permanent deformation."

c. The definition of "detrimental, permanent deformation" is more qualitative in nature, but we can define a set of pass/fail criteria for the limit load tests. Therefore, every item on the following list of criteria must be met for any *permanent deformations present after the removal of limit load*, to meet the criteria that there is no "detrimental, permanent deformation."

(1) It must not require <u>repair</u>.

(2) It must not be <u>noticeable</u> during routine maintenance and inspections.

(3) It must not prevent proper <u>fit</u> and <u>function</u> of primary structure, secondary structure, and flight controls. Removable primary structure, removable wings on gliders for example, must align properly when reinstalled. Doors, access panels and similar structure must fit properly, with correct fastener alignment. Control surfaces must function properly, with full range of travel and proper fairing.

(4) It must not have a noticeable effect on the <u>external airload distribution</u>. Areas of special attention include deformations that may change the local airflow or that may have altered the wing twist.

(5) It must not have a noticeable effect on the internal load distribution.

(6) It must not have a noticeable effect on handling, performance, or flutter characteristics. Areas of special attention include deformations that may have altered the wing twist or stiffness properties.

(7) It must not weaken or damage the primary structure. No other permanent set may occur with repeated applications of limit load.

(8) It must not prevent compliance to any regulation.

25. I have permanent set in the vertical deflection of my airplane wing, at the wing tip, after limit load testing. The permanent set is approximately 5 percent of the maximum vertical deflection measured at limit load. Is this considered "detrimental" permanent deformation?

a. Not necessarily. Permanent set in wing tip deflection can result from permanent deformation or joint slippage. It is not necessarily true that a large permanent set implies that the structure has yielded. For example, a small deformation that occurs near the wing centerline can translate into a large deformation at the wing tip.

b. You should identify the location and size of the deformation that caused the permanent set. Wing tip deflection caused by bolted joint slippage is not necessarily an example of detrimental, permanent deformation.

c. You must evaluate the wing tip deflection and its root cause, joint slippage, or material deformation, by the qualitative criteria listed in the question above to determine its acceptability.

26. Is there any guidance available specifically for composite structures relative to strength and deformation?

Yes. See Policy Statement PS-ACE100-2001-006, "Static Strength Substantiation of Composite Airplane Structure".

23.307 Proof of structure (Original)

27. What should I consider for increases in maximum weight, in maximum landing weight, or in maximum zero fuel weight?

a. Due to changes in the operational requirements of an owner or operator, the need arises to modify and substantiate the structure for an increase in maximum weight, in maximum landing weight, or in maximum zero fuel weight. **Any one of these changes affects the airplane basic loads and structural integrity and may affect the limitations and performance.** Two examples follow:

(1) When increasing the original airplane maximum weight, special considerations are necessary. (See an acceptable method in paragraph 28.)

(2) When replacing a piston engine with a turbopropeller engine, one must consider that:

(a) Jet fuel weighs as much as 17 percent more than avgas, and

(b) Airplane total fuel quantity often must increase.

(c) Therefore, the maximum zero fuel weight changes. These kinds of modifications should be investigated to verify that either:

1 The critical loads have not increased, or

2 The loads that have increased are capable of being carried by the existing or modified structure.

28. What is one acceptable method for showing compliance for a weight increase?

a. Prepare a compliance checklist. It may be an advantage to the applicant to identify the airworthiness standards affected by the proposed weight increase. Both the applicant and the FAA Aircraft Certification Office personnel will have a better idea of what technical showings of compliance need to be made.

b. Identify the critical flight, landing, and ground loads. The loads may either be obtained from the existing type certificate data (if they are made available to the applicant by the holder of the type certificate) or the applicant may derive them. Derived loads should be verified to produce essentially the same results as those used for the original type certification work.

c. The airplane structural design airspeeds (see part 23, § 23.335) should be re-evaluated to determine if the selected airspeeds are adequate at the increased design weights. Lateral gust conditions (see § 23.443) should reflect any changes in yaw moment-of-inertia resulting from revised mass distributions. An increase in airplane weight often causes an increase in wing loading. When pitch and roll inertia affect the airplane loads, due to increasing or redistributed mass, examine these also.

d. Confirm the support of all structures affected by load increases, however small. This may be accomplished after the critical loads are identified. Stress analyses, static tests, or a combination of both proof-of-strength methods may be used to prove the structures capable of sustaining ultimate loads (see §§ 23.307 and 23.641). The FAA encourages, but does not require, the applicant to conduct proof-of-strength tests to both limit and ultimate load conditions—and beyond (for the additional knowledge gained and growth capability). If static tests are used as the proof-of-strength method, the structure should be inspected for detrimental permanent set following the removal of the limit load(s). Any structure that shows detrimental permanent set requires some redesign and retest. When using analyses as the proof-of-strength method, the material yield-point stress should not be exceeded when a limit load is analytically applied.

e. If an airplane was initially certified with maximum landing weight equal to maximum weight, and if an increase in the maximum weight is applied for, the applicant may take advantage of the five percent difference between landing weight and maximum weight permitted by § 23.473(b). In that case, resubstantiation of the landing gear is not required for the first five percent of the weight increase as long as the airplane center of gravity (c.g.) remains within the original type certificate limits. (See subparagraph "k" below).

f. Until Amendment 23-48, part 23 did not require that a maximum zero fuel weight be established (see § 23.343, Design fuel loads). However, for airplane designs with wing fuel tanks, the minimum fuel condition may produce the highest wing-bending moment; it also affects the wing torsional moment. Evaluate these conditions during the compliance phase of the project (see § 23.301).

g. Verify weight distribution and c.g. design changes. Weight increases or relocated mass items, which change the overall mass distribution, also change the airplane c.g. at empty weight, maximum weight, and weights in between the two extremes. These kinds of design changes should be carefully investigated for their affects on the original weight versus the c.g. envelope. The designer should consider the effects of depletable payload items, like fuel; account for c.g. shifts; and calculate the influence these may have on the whole airplane.

h. Examine the effects of design changes to the airplane structural damping and speeds. Changes to the maximum weight, maximum zero fuel weight, airplane structural stiffness and the distribution of mass need to be examined with the effects of flutter in mind. Ground vibration survey tests permit the identification of airplane structure nodes, modes, and corresponding frequencies. From these, the airplane flutter characteristics can be analytically estimated. AC 23.629-1A, Means of Compliance with Section 23.629, “Flutter,” thoroughly discusses this subject.

i. Re-evaluate the fatigue strength or fail-safe strength estimates. A fatigue or fail-safe evaluation should be accomplished if the certification basis airworthiness standards include §§ 23.571 or 23.572, and they should be prudently considered in every design. This evaluation may indicate that cyclic tests should be run on a fatigue test specimen with the modifications incorporated.

j. The certifier should revise the Airplane Flight Manual and the Instructions for Continued Airworthiness. The revisions or supplements to these manuals should reflect any pertinent changes in weight and balance data, performance, flight procedures, maintenance procedures or practices, life-limited parts, etc. Note that the Maintenance Manual and the Instructions for Continued Airworthiness may also be affected.

k. Identify the critical flight, landing, and ground loads. The loads may be obtained from the existing type certificate data if the holder of the type certificate makes them available to the applicant. The designer (or modifier) can calculate the loads. Verify calculated loads—the olderCARs often show acceptable methods to calculate loads that an airplane designer may use.

l. A decision about whether the maximum weight increase is “small” or “substantial” does not affect the application of guidance in this AC.

29. Is there any information available on wood airplane structures?

a. When designing aircraft that contain wooden structures, refer to “Design of Wood Aircraft Structures,” Army-Navy-Civil ANC-18 Bulletin. This bulletin was prepared by the Forest Products Laboratory, Forest Service, United States Department of Agriculture, and ANC-23 Panel on Sandwich Construction for Aircraft, Subcommittee on Army-Navy-Civil Aircraft Design Criteria (Aircraft Committee Munitions Board). The following are general interest information items:

(1) In the continental United States, ANC-18 Bulletin, Section 2.1, indicates that 15 percent moisture is considered acceptable for wood used in airplane design. The moisture content expected in service would obviously depend on the geographic region of the earth where the aircraft is operated. However, where the relative humidity is expected to be greater than 90 percent for an extended time (the Tropics), 20 percent moisture content should be assumed.

NOTE: As moisture content increases, wood strength decreases.

(2) The FAA knows of no protective coating that will prevent wood from reaching an equilibrium condition in moisture content in ambient conditions.

(3) The FAA recommends that tests be conducted whenever the design is in question.

(4) Specific test requirements for strength due to moisture content, when proof of strength is shown by tests of Civil Air Regulations (CAR) 3.174-1(b), are not outlined and much is left to the FAA certification engineer. Test conditions should be reasonable and, without other data, the recommendations of ANC-18 Bulletin should be used (see Section 3.0111). Certification records of four previous successful airplane designs show that the moisture content of the test articles was not documented during tests.

(5) The FAA has no published methods or procedures about the effects of moisture content on the strength of wooden structures. Refer to “Design of Wood Aircraft Structures” (ANC-18 Bulletin) for methods and procedures that are acceptable to the procuring or certificating agency (see Section 1.0).

30. Are there any precautions I should take when placing tension pads for static tests? Yes. There was a fatal accident involving an airplane that suffered a wing upper-skin failure in buckling. When tension pads are used to apply loads during static tests, they may stiffen thin-skinned structure and bias test results non-conservatively. The following factors should be observed and documented in the test report regarding tension pad use:

a. Type: Round rubber pad with metal back, square rubber pad with metal back, round canvas pad, square canvas pad, etc.

b. Size and number: Percentage of lifting surface covered (outboard or inboard, fore or aft).

c. Location: Upper or lower lifting surface (the surface is a main tension or compression field); tension pad nearness to a spar, rib, or stringer structural element; effects of fuel pressure loads.

31. Do you have any information about alternate means of compliance for seat structural requirements on agricultural airplanes? Yes. See 23.562, Emergency landing dynamic conditions (paragraph 174), for information and guidance about dynamic seat requirements.

32. Can I conduct flight tests as a substantiation method for secondary structure? See question number 22.

33. What are the failure criteria for secondary structure? When secondary structure experiences forces that vary with angle of attack, or yaw conditions, demonstrate these structures to the same failure criteria as a primary structure by:

a. A support limit load without detrimental permanent deformation, and

b. A support ultimate load without failure for 3 seconds.

This can often be accomplished using a simple conservative analysis.

34. What are some of the methods? Structural analyses or static tests, or a combination of these, may be used to show compliance with both the limit and ultimate load conditions. The critical points on the flight envelope (V-n diagram) should be examined. The basic loads may be obtained from flight tests, wind tunnel tests, derived data from similar airplane designs, or by conservative analyses. Engineering judgment is involved. Some pertinent considerations include the following:

a. *Wind tunnel basic loads:* It may be necessary to apply a conservative factor to ensure the confidence of the FAA project engineer in the full-scale loads. Factors to consider include Reynolds numbers, flow similarities between the tunnel-model and the full-scale airplane, and load measuring methods.

b. *Three methods to obtain flight-test loads:*

(1) When either compressibility or elasticity are negligible (or both), the first method is 1g flight-test data taken over the range of angle of attack that correspond to the airspeed critical points on the flight envelope (V-n diagram). This first method is also known as “scaling by dynamic pressure.” These data may then be corrected to the flight conditions on the V-n diagram (i.e., corrected for dynamic and static pressure).

(2) When compressibility effects are significant—and even if they are not, the second method is to repeat the first method at several higher load factors (within the limit load capabilities of the particular airplane design). One can measure loads in 1g level flight, and steady turning flight, at a series of constant airspeeds. This technique produces a family of load curves that can be extrapolated to limit load conditions. Obtain the desired Mach number by prudently choosing the airspeed and altitude.

(3) A third method is to fly roller coaster maneuvers (pull-ups and pushovers) to produce load factors above and below 1g conditions. This method demands accurate measuring techniques for loads and flight conditions during transient flight conditions. The transitory nature of the data sometimes gives more data problems than value.

c. *When static pressure influences structural loads:* The structure experiences a load increase due to the external air load when the external static pressure is different from the internal static pressure. This often happens on secondary structures like engine cowls, windshields, and windows.

d. Also see the question regarding the use of wind tunnel data under section 23.301.

35. What proof-of-strength factors should be considered for airplane design changes that may affect structure? (Also see 23.321, General (flight loads).)

a. When loads increase, the strength of structure is affected by shear, bending, and torsion—not just one of these conditions.

b. In some aircraft certifications, the structure was proven by tests only. Any modifications to these aircraft that alter the loads—or the load paths—must be assessed to determine if the change is significant enough to require retests. It is inappropriate to assume that additional strength resides in the structures beyond the values proven by tests.

c. For stressed-skin wings, if analyses are used to justify the strength between limit and ultimate load conditions, strain-gauge data coupled with panel-buckling stress data may be used to show that the strength extrapolation is reasonable and correct.

d. Consider the effects of stress concentration factors.

e. A small increase in design maximum weight may cause a severe reduction of fatigue life (see 23.572, Metallic wing, empennage, and associated structures).

f. Any load increase on the wing, tail, or landing gear structures, or passenger, cargo or equipment areas affects the fuselage.

g. Identify specific materials, dimensions, and processes used in the design (see part 21, § 21.31, and part 23, § 23.603).

h. A previously certificated airplane requires structural proof-of-strength substantiation to the Certification Basis regulations when:

(1) Someone puts a turbine engine on a previously certificated reciprocating-engine airplane; or when

(2) A turbine engine substitutes as a single-power-source for two or more reciprocating engines.

36. I want to get an STC for a gross weight increase, but I am not the Original Equipment Manufacturer (OEM), so I do not have access to the original Type Certificate data. Do I have to assume that the margin of safety of all structural components is zero? Yes. Assume that the margin is zero unless you can confirm two things. First, you corroborate that the proof of strength was demonstrated by a combination of analysis and tests. Second, you confirm that these tests showed a margin of safety greater than zero in an "as delivered" condition.

37. Is there any guidance available specifically for composite relative to proof of structure?

Yes. See Policy Statement PS-ACE100-2001-006, "Static Strength Substantiation of Composite Airplane Structure".

FLIGHT LOADS

23.321 General	(Amendment 23-45)

38. Is there any policy available on paragraph (a) of this section as of January 1, 2007? No.

39. Is there any policy available on paragraph (b) of this section as of January 1, 2007? No. However, you can see 23.307 for guidance about airplane weight increases. See 23.471 for guidance about ramp weight and take-off weight.

40. Is there any policy available on paragraph (c) of this section as of January 1, 2007? No. However, for information about canard and tandem wing airplane configurations, see 23.421, balancing loads for horizontal stabilizing and balancing surfaces. Also, laminar flow aerodynamics information may be found in 23.21, proof of compliance.

41. Can you show a graphical relational image of the airworthiness standards that concern airplane loads? Yes. See Figure 2 and Figure 3 on the next two pages.

FIGURE 2
FLIGHT LOADS

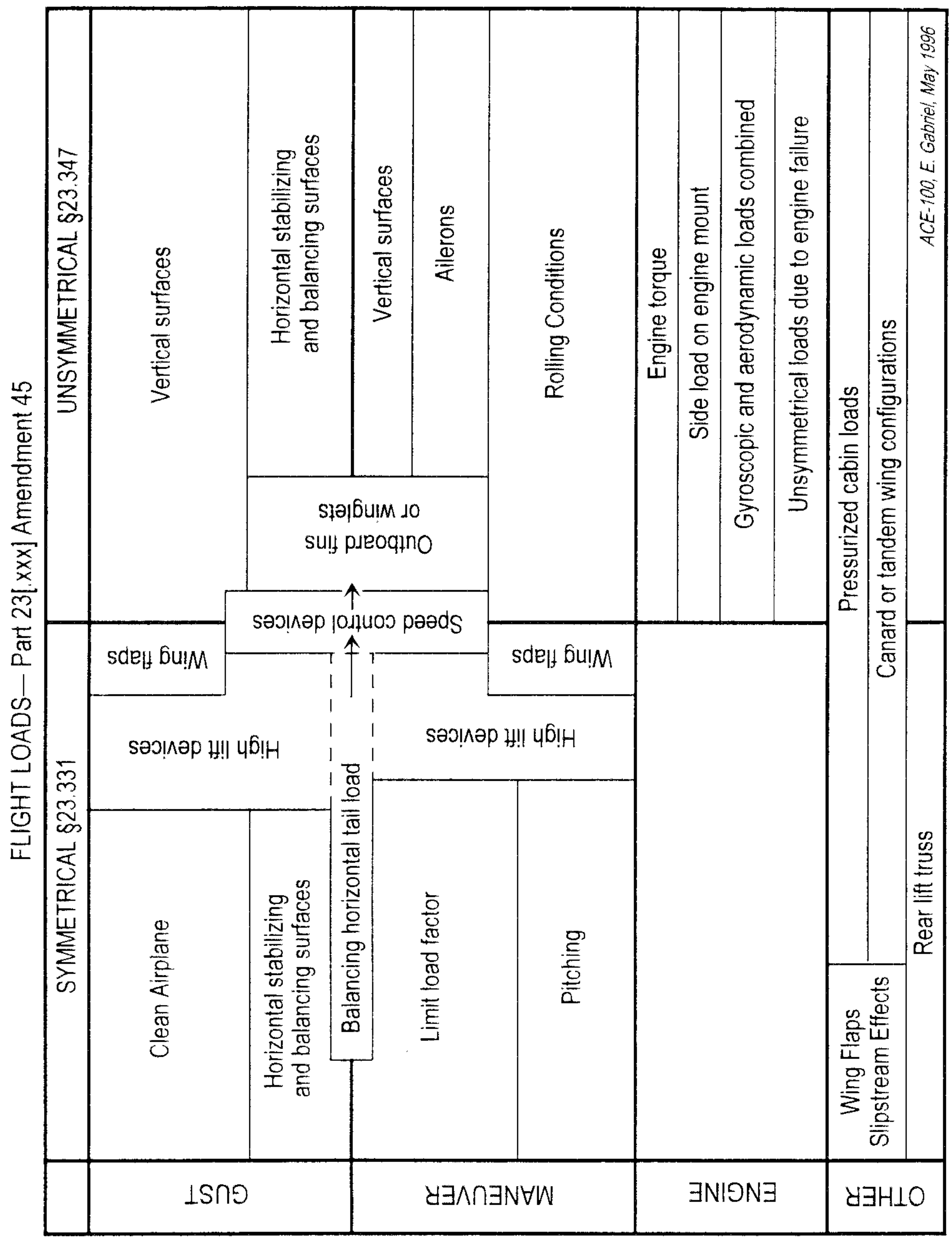


FIGURE 3
FLIGHT LOADS

Flight Loads – Part 23 Amendment 45

	SYMMETRICAL § 23.331		UNSYMMETRICAL § 23.347	
GUST	**Clean Airplane** Discrete Vertical Gusts [§ 23.333(c), § 23.341] ± 50 fps @ V_C and ± 25 fps @ V_D ± 66 fps @ V_B (commuter category only)	**High Lift Devices** [§ 23.345] ± 25 ft/sec vertical 25 ft/sec head-on **Wing Flaps** [§ 23.457(a)]	**Vertical Surfaces** Lateral gust: ± 50 fps @ V_C [§ 23.443(a)] Commuter category [§ 23.443(b)] Gusts normal to plane of symmetry @ V_B, V_C, V_D clean airplane @V_F high lift devices	
GUST	**Horizontal Stabilizing and Balancing Surfaces** [§ 23.425] Clean airplane and with high lift devices	[§ 23.373] **Speed Control Devices**	[§ 23.445] [§ 23.445(d)] **Outboard Fins or Winglets**	**Horizontal Stabilizing and Balancing Surfaces** [§ 23.427] Loads from gusts combined with yawing and slipstream effects, clean airplane and with high lift devices
MANEUVER	**Balancing Horizontal Tail Load** [§§ 23.331, 23.421] **Limit Load Factor** [§ 23.337] Normal or Commuter Category n = 3.8* Utility Category n = 4.4 Acrobatic Category n = 6.0 *May reduce for W > 4,118 lbs.			**Vertical Surfaces** [§ 23.441] - @ V_A Yaw, sideslip, and rudder deflection **Ailerons** [§ 23.445] Abrupt maximum control movement @V_A. Control deflection requirements @V_C and V_D
MANEUVER	**Pitching:** Checked and Unchecked Applies to horizontal stabilizing and balancing surfaces [§ 23.423] Abrupt maximum control input @ V_A	**High Lift Devices** [§ 23.345] n = 2.0 g **Wing Flaps** [§ 23.457(a)]	**Rolling Conditions** [§ 23.349] – Wing and wing bracing Category / Condition (See § 23.333) / Airload Distribution Normal, Utility, Commuter / A / 100%/70% to 75% Acrobatic / A and F / 100%/60% Wing loads due to aileron deflections § 23.445	
ENGINE			**Engine Torque** [§ 23.361] – Combined with symmetrical limit loads @ V_A	
ENGINE			**Side Load on Engine Mount** [§ 23.363]	
ENGINE			**Gyroscopic and Aerodynamic Loads** [§ 23.371] – Pitching and yawing, applies only to turbine installations	
ENGINE			**Unsymmetrical Loads Due to Engine Failure** [§ 23.367] – Turboprops only	
OTHER	**Wing Flaps Slipstream Effects**, n = 1.0 [§ 23.457(b)]		**Pressurized Cabin Loads**, combined with flight loads [§ 23.365]	
OTHER	**Rear Lift Truss**, reverse air flow [§ 23.369]		**Canard or Tandem Wing Configurations** [§ 23.302]	

23.331 Symmetrical flight controls (Amendment 23-42)

42. Is there any policy available on this section as of January 1, 2007? No.

23.333 Flight envelope (Amendment 23-34)

43. Do I have to revise the velocity-load factor (V-n) diagram for Supplemental Type Certificates (STC) involving engine changes or modifications? It is not an automatic requirement. This question usually arises because some foreign certifying agencies require the development of a new V-n diagram if the original minimum design cruising speed (V_C) was defined by the wing loading (W/S) [reference: part 23, § 23.335(a)(1) and (2)], instead of the maximum level flight speed (V_H) [reference: part 23, § 23.335(a)(3)]. However, we do not require a new V-n diagram unless the applicant wishes to increase V_C.

44. Is there any policy available on paragraph (b) or (c) of this section as of January 1, 2007? No.

23.335 Design airspeeds (Amendment 23-48)

45. When applying design airspeed criteria, how may the designer establish a minimum design cruising speed?

a. The designer may establish the minimum design cruising speed, $V_{C\,min}$, according to the following:

$$33\sqrt{\frac{W}{S}} \le V_{C\min} \le 0.9V_H$$, for normal, utility and commuter category

and

$$36\sqrt{\frac{W}{S}} \le V_{C\min} \le 0.9V_H$$, for acrobatic category

b. Both minimum and maximum design cruise speed values, $V_{C\ min}$ and $V_{C\ max}$, may be chosen with the following understanding:

$$V_C \leq 0.9V_H$$

46. Why would I want to define V_C as equal to 0.9 V_H? Use this definition if you are designing an airplane that is capable of a sustained speed (V_C) higher than that obtained by using the wing loading (W/S) formula.

47. Is there any policy available on paragraph (b) of this section as of January 1, 2007? No.

48. What is the design maneuvering speed V_A?

a. The design maneuvering speed is a value chosen by the applicant. It may not be less than $V_s\sqrt{n}$ and need not be greater than V_c, but it could be greater if the applicant chose the higher value. The loads resulting from full control surface deflections at V_A are used to design the empennage and ailerons in part 23, §§ 23.423, 23.441, and 23.455.

b. V_A should not be interpreted as a speed that would permit the pilot unrestricted flight-control movement without exceeding airplane structural limits, nor should it be interpreted as a gust penetration speed. Only if $V_A = V_s \sqrt{n}$ will the airplane stall in a nose-up pitching maneuver at, or near, limit load factor. For airplanes where $V_A > V_S\sqrt{n}$, the pilot would have to check the maneuver; otherwise the airplane would exceed the limit load factor.

c. Amendment 23-45 added the operating maneuvering speed, V_O, in § 23.1507. V_O is established not greater than $V_S\sqrt{n}$, and it is a speed where the airplane will stall in a nose-up pitching maneuver before exceeding the airplane structural limits.

49. Is there any policy available on paragraph (d) of this section as of January 1, 2007? No.

23.337 Limit maneuvering load factors (Amendment 23-48)

50. Is there any policy available on this section as of January 1, 2007? No.

51. Are there any related sections? Yes. See Section 23.423, Maneuvering loads.

23.341 Gust load factors (Amendment 23-48)

52. Is there any policy available on this section as of January 1, 2007? No.

23.343 Design fuel loads	(Amendment 23-48)

53. Is there any policy available on this section as of January 1, 2007? No.

23.345 High lift devices	(Amendment 23-48)

54. Is there any policy available on this section as of January 1, 2007? No.

23.347 Unsymmetrical flight conditions	(Amendment 23-48)

55. Is there any policy available on this section as of January 1, 2007? No.

23.349 Rolling conditions	(Amendment 23-48)

56. Is there any policy available on this section as of January 1, 2007? No.

23.351 Yawing conditions	(Amendment 23-42)

57. Is there any policy available on this section as of January 1, 2007? No.

23.361 Engine torque	(Amendment 23-45)

58. Is there any policy available on paragraph (a) of this section as of January 1, 2007? No.

59. How do I determine the limit engine torque load imposed by sudden engine stoppage due to malfunction or structural failure (such as compressor jamming) for turbine engines to satisfy the requirements of paragraph (b)(1)? Title 14 Code of Federal Regulations (CFR) part 33, § 33.23 requires the specification of the maximum allowable limit and ultimate loads for engine mounting attachments and related engine structure. Therefore, the maximum engine structure loading information, as specified in the engine Manufacturers Installation Manual, satisfies the limit engine torque load imposed by sudden engine stoppage due to malfunction or structural failure (such as compressor jamming).

60. Is there any policy available on paragraph (c) of this section as of January 1, 2007?

a. This rule requires the design of engine mounts and supporting structure to sustain limit torque at takeoff power and at maximum continuous power, with corresponding propeller revolutions per minute (r.p.m.), for two specified flight conditions. The rule defines limit torque equal to mean torque multiplied by a factor that is a function of the number of cylinders of a reciprocating engine (see Figure 4).

FIGURE 4
LIMIT ENGINE TORQUE DEFINITION

$$T_{\lim} = F_{cyl} T_{mean}$$

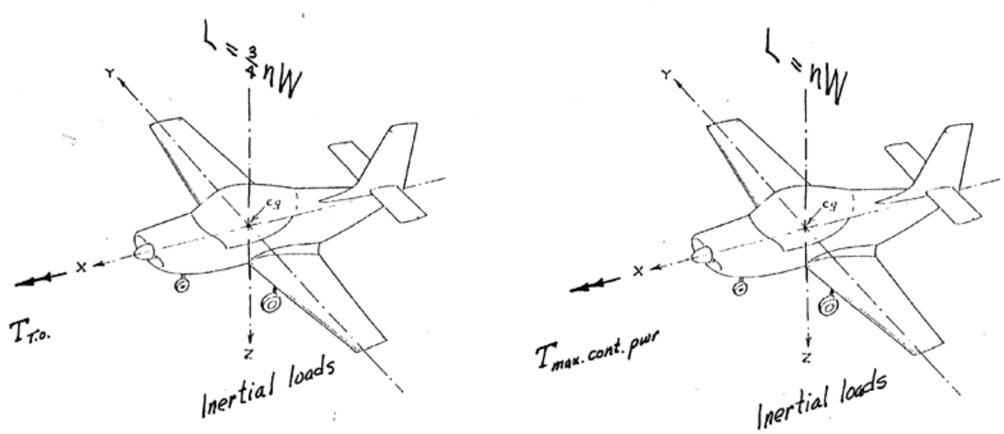
Engine type	Turbo-propeller	Five or more cylinders	Four cylinders	Three cylinders	Two cylinders
F_{cyl}	1.25	1.33	2	3	4

b. **NOTE:** The limit engine torque, T_{lim}, is not an engine limit in the sense of part 33, § 33.7. For structural installation loads purposes, treat it as simply a limit load arrived at by the equation and figure shown. Engine mean torque is available from the engine manufacturer. The engine type multiplying factor, F_{cyl}, is a constant for a given engine without regard to the speed or power at which the engine is operating.

c. The FAA published engine torque requirements incorrectly in Amendment 23-26. Part 23, § 23.361 was corrected with Amendment 23-45. The incorrectly written rule failed to require the multiplying factor for the torque load. The applied (incorrectly written) rule can result in lower structural loads than previously required from torque loads. These loads affect the engine mount, and either the fuselage or nacelle and wing designs.

d. **Policy:** Apply the mean torque factors in the manner that existed in part 23 before Amendment 23-26 and corrected in Amendment 23-45. Determine airplane design loads for two engine limit torques and for two flight-load-conditions. These airworthiness standards for engine torque loads constitute the minimum level of safety required by the FAA for the engine mount, and either the fuselage or the nacelle and wing designs. For airplane designs that have a part 23 certification basis that encompasses Amendments 23-26 through 23-44, apply the intent of the regulation depicted by the amendments before or after these amendments. Figure 5 presents a view of torque, aerodynamic, and inertial loads airworthiness standards.

FIGURE 5
VIEW OF TORQUE, AERODYNAMIC, AND INERTIAL LOADS



23.363 Side load on engine mount (Original)

61. Is there any policy available on this section as of January 1, 2007? No.

23.365 Pressurized Cabin Loads (Original)

62. How do I determine the cabin pressure loads and what do I combine them with? Multiply the maximum differential pressure loads by the 1.5 factor of safety (see part 23, § 23.303). The maximum differential pressure loads should include the high side relief valve tolerance pressure. Combine them with the ultimate loads of both the normal flight inertia and the local external aerodynamic pressure distribution conditions.

63. Is the aerodynamic pressure a constant? The airloads will vary over the length of the fuselage.

64. Is there any policy available on paragraph (c) of this section as of January 1, 2007? No.

65. What pressure should be used as limit load (omitting other loads)? For the limit (pressure only) load condition, airplane fuselage structure should be designed to withstand:

$$P_{\mathrm{lim}} = (1.33)P_{\max.relief.valve}$$

66. What pressure should be used as ultimate load (omitting other loads)?

a. For the ultimate (pressure only) load condition, combine the 1.5 factor of safety with the 1.33 burst pressure factor to get an ultimate load case for the pressure vessel structural design**.** Part 23 special conditions have imposed a 1.67 burst pressure factor for airplanes with design altitudes that exceed 45,000 feet. This practice is consistent with part 25. Aerodynamic and landing impact loads may be ignored for this load case.

$$P_{ult} = 1.5(1.33)P_{\max.relief.valve}$$

For altitudes that exceed 45,000 feet,

$$P_{\mathrm{lim}} = (1.67)P_{\max.relief.valve}$$

$$P_{ult} = 1.5(1.67)P_{\max.relief.valve}$$

b. Note that the regulation for pressurization tests requires a strength test on a fuselage designed for pressure to the ultimate load condition given by the above equation (see § 23.843).

67. What is meant by "external door"? External door means an opening, a doorway, in the external surface of the airplane. Evaluate door failure effects regardless of whether the door is inward or outward opening. For this rule, an emergency exit is a door. Also see 23.305, Strength and deformation, paragraph 22, for guidance about conducting static tests for pressure vessels.

23.367 Unsymmetrical loads due to engine failure (Amendment 23-7)

68. What is meant by "critical engine"? Traditionally, the term "critical engine" is used to describe the engine whose failure to operate results in the largest yawing moment, compared to that caused by failure of the other engine. However, in a more general sense, and for this regulation, the term "critical engine" means the engine that, when failed, results in the highest structural loads on the airplane.

69. Is there any policy available on paragraph (b) of this section as of January 1, 2007? No.

23.369 Rear lift truss (Amendment 23-48)

70. What is the purpose of this regulation? Civil Air Regulation (CAR) 3.194 is considered a special supplementary reversed airflow condition for design of the rear lift truss, which has no direct relationship to any of the points on the V-n envelope. It has been historically considered as a downwind taxi for a "tail-wheel" type airplane. The lift truss is the brace (frequently a "V," sometimes "parallel" struts—one to each existing spar) running from the bottom of the fuselage to the lower spar cap(s) of the wing. These lift truss struts usually attach to the wing at midspan. "Wing struts" are usually loaded in tension (for positive load factor conditions)—except during negative "g" maneuvers or gusts, inverted flight conditions (aerobatic maneuvers), landing, and taxi. In these latter cases, the struts can be loaded in compression; therefore, they are subject to Euler column buckling phenomena. Even when on the ground, the airplane rear lift truss (or strut) can experience significant compression loads if the airplane has a tail wheel. This is especially true when the airplane is tied down or is taxiing downwind.

71. Is there any policy available on paragraph (b) of this section as of January 1, 2007? No.

23.371 Gyroscopic and aerodynamic loads (Amendment 23-48)

72. Is there any policy available on this section as of January 1, 2007? No.

23.373 Speed control devices (Amendment 23-7)

73. Is there any policy available on paragraph (a) of this section as of January 1, 2007? No.

74. Is there any policy available on paragraph (b) of this section as of January 1, 2007? No.

CONTROL SURFACE AND SYSTEM LOADS

23.391 Control surface loads	(Amendment 23-48)

75. What is the background on this regulation? The control surface load criteria that previously appeared in Appendix B of part 23 were removed from part 23 at Amendment 23-42. The Appendix B criteria were shown to give inappropriate surface loadings for certain airplane configurations, including:

a. High-performance part 23 aircraft;

b. Aircraft that have spar configurations located aft of the 25 percent chord length; and

c. Aircraft that have horizontal stabilizer leading edges that are not attached at the fuselage.

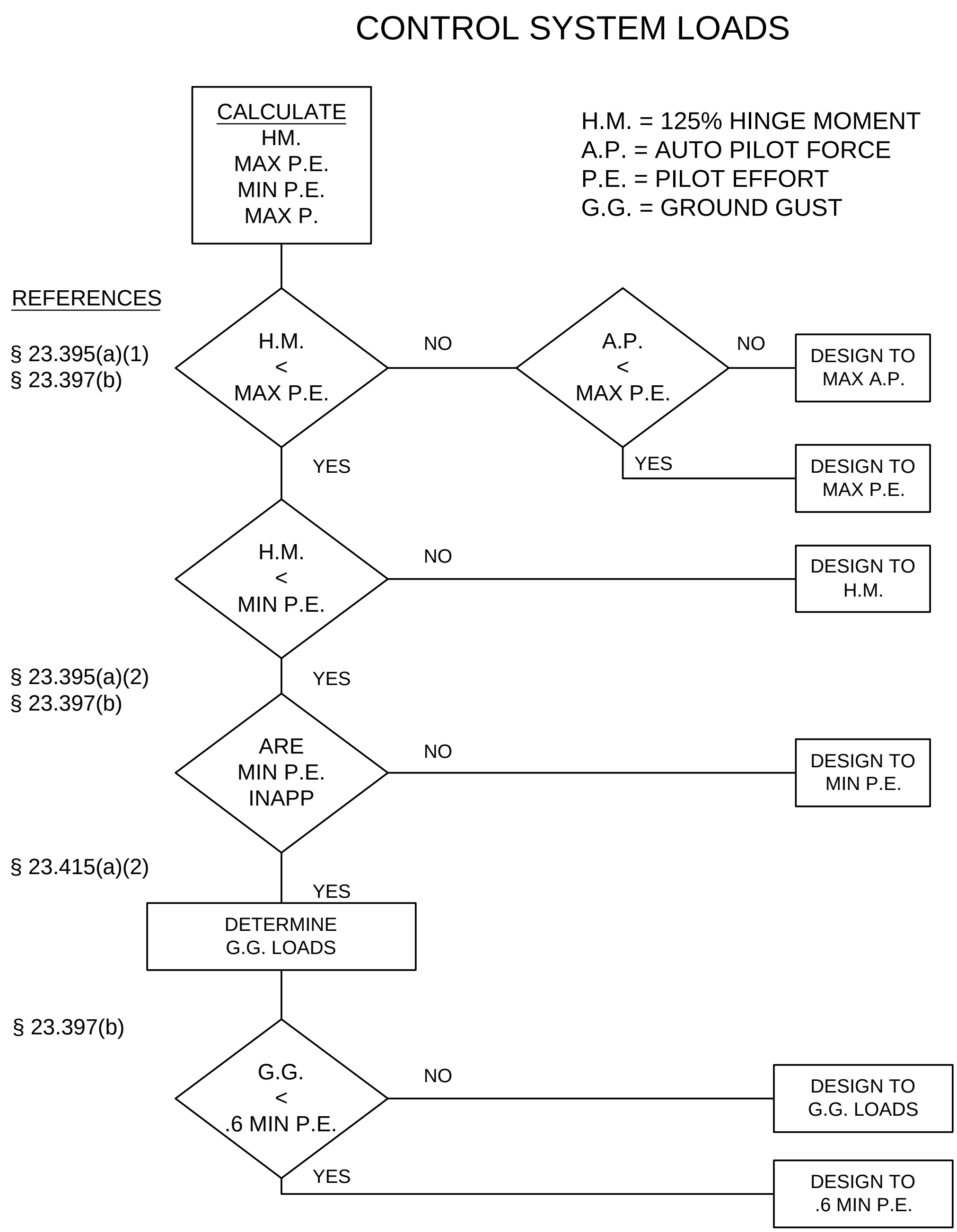
23.393 Loads parallel to hinge line	(Amendment 23-48)

76. Is there any policy available on this section as of January 1, 2007? No.

23.395 Control system loads	(Amendment 23-7)

77. Can you explain this regulation schematically? Yes. Figure 6 presents an overall relational view of control system loads airworthiness standards. Also see “Control Systems” requirements that are contained in part 23, §§ 23.671 through 23.701.

FIGURE 6
CONTROL SYSTEM LOADS



78. Is there anything else I can review to get more information? Yes. See 23.423, Maneuvering loads, for more guidance about control system loads.

79. Is there any guidance for unconventional multipath control systems? The control system loads, and limit control forces, and torque airworthiness standards require that pilot loads be opposed at the attachment of the control system to the control surface horn. For an unconventional multipath control system, which involves control of separate surfaces (each with its own horn), it would be appropriate to expect the pilot forces to be restrained at the control surface horns. If this allows a portion of the system to be designed for less than the minimum pilot-effort forces, special attention should be given to the design of this portion of the system to ensure the rugged system.

80. Does this regulation apply to wing flap control systems? No. The § 23.395 requirements are not applicable to wing flap systems.

23.397 Limit control forces and torques	(Amendment 23-45)

81. Is there any policy available on paragraph (a) of this section as of January 1, 2007? No.

82. For paragraph (b) of this section, where should the loads be applied?

a. Apply the 100-pound load on a single fore-and-aft control wheel anywhere along the periphery or at the tip of the grip-handle on U-type wheels, and in both fore-and-aft directions.

b. Part 23, § 23.397(b) presents both a symmetric and asymmetric 100-pound wheel load for elevator control. You should also see the Figure 6, which presents an overall relational view of control system loads airworthiness standards.

23.399 Dual control system	(Amendment 23-48)

83. Is there any policy available on this section as of January 1, 2007? No.

23.405 Secondary control system	(Original)

84. Is there any policy available on this section as of January 1, 2007? No.

23.407 Trim tab effects (Original)

85. What is the maximum out-of-trim condition one should consider when determining control surface loads?

a. This rule only applies when maximum pilot-effort forces are imposed on the control system (refer to part 23, § 23.397). Then, the trim tab deflection is limited to the maximum out-of-trim condition that can exist under prolonged pilot-effort forces (refer to § 23.143).

b. This interpretation only applies to a trim tab that is attached to a movable control surface that is further attached to a fixed main-aerodynamic surface (i.e., it excludes a trim tab that is attached to a stabilator).

c. See 23.423, Maneuvering loads, for more guidance about trim tabs.

23.409 Tabs (Original)

86. Is there any policy available on this section as of January 1, 2007? No.

23.415 Ground gust conditions (Amendment 23-48)

87. How do the ground gust loads in paragraph (a) fit in with the other control system loads in the design requirements? Refer to the accompanying graphic to 23.395, Control System Loads (Figure 6), which presents an overall view of control system loads airworthiness standards.

88. Is there any policy available on paragraph (b) or (c) of this section as of January 1, 2007? No.

HORIZONTAL STABILIZING AND BALANCING SURFACES

23.421 Balancing loads	(Amendment 23-42)

89. Is there any guidance for stabilator design?

a. Yes. You may find stabilator chordwise air-load distributions in the *Basic Glider Criteria Handbook* for both the balancing conditions and the maneuvering and gust conditions. Also, stabilators have historically developed flutter problems; therefore, carefully consider the flutter effects of a stabilator design.

b. The *Basic Glider Criteria Handbook*, 1962 Revision, Federal Aviation Agency, Flight Standards Service, Washington, D.C., is now available by mail from: Manager, Standards Office (ACE-110), Federal Aviation Administration, Small Airplane Directorate, DOT Building, 901 Locust, Room 301, Kansas City, MO 64106.

c. Also, see 23.321, General (flight loads), for more guidance about balancing tail loads.

90. Is there any policy available on paragraph (b) of this section as of January 1, 2007? No.

23.423 Maneuvering loads	(Amendment 23-42)

91. The condition described in paragraph (a) of the regulations does not appear to be realistic. What is the reason for this?

a. Part 23, § 23.423(a) addresses an artificial load condition intended to provide adequate tail strength for abrupt, unchecked pitch maneuvers up to the design maneuver speed, V_A . The condition is artificial because the airplane will pitch, and the load factor will no longer be 1g, before the elevator reaches full deflection.

b. A 6g maneuver involves significant airplane pitch velocity, which relieves pilot input and results in a lower stick force per unit elevator deflection. One may correlate tail angle of attack and airplane pitch velocity with measured and calculated hinge moments to gain confidence in the load calculations.

c. A flight in which the pilot pulls full-back-stick at design maneuver speed, V_A, and 1g, initially, would probably result in higher elevator angles than would be calculated at 1g because of airplane response characteristics. However, the tail loads resulting from an analysis accounting for airplane response characteristics would not likely exceed those calculated from an analysis that assumes 1g conditions.

d. The analytical approach is acceptable with the following suggestions:

(1) For elevator deflection, divide calculated hinge moment by 1.25 (reference § 23.395(b)).

(2) For an elevator tab configuration, deflect the tab to assist the pilot, per § 23.407, Trim tab effects.

e. See the guidance in 23.421, Balancing loads, for stabilator loads distributions.

23.425 Gust loads (Amendment 23-42)

92. What gust loads should be used for stabilator-type aerodynamic surfaces? For stabilator-type aerodynamic surfaces, use *the Basic Glider Criteria Handbook* as the information source for air-load distributions.

93. Is there any policy available on paragraph (b), (c) or (d) of this section as of January 1, 2007? No.

23.427 Unsymmetrical loads (Amendment 23-42)

94. What unsymmetrical loads should I use for trim systems? For guidance related to non-aerodynamic trim system designs, see 23.677(b), "Trim systems."

95. What is meant by "conventional" in paragraph (b) of this section? Conventional means the airplane's center of gravity (c.g.) is located within the boundaries of the wing mean aerodynamic chord with the empennage aft and the engine(s) forward.

96. Do the conventional requirements for unsymmetrical loads apply to V-Tail configuration designs? No. A V-tail configuration is considered unconventional; therefore, the conventional requirements for unsymmetrical loads do not apply.

97. For a T-tail design, is a maneuver at maximum elevator deflection required in combination with a maneuver at maximum rudder deflection at the design maneuver speed, V_A?

a. Simultaneous maximum deflection of both the elevator and rudder control surfaces is not required by the regulations, although an airplane designer may choose to design for the combined loads for other reasons. The horizontal and vertical stabilizer maneuver loads regulations require structural substantiation for sudden maximum displacement of elevator and rudder, at the design maneuver speed, V_A, as separate conditions (see part 23, § 23.423(a) and § 23.441(a)(1)). However, the airworthiness standard for unsymmetrical tail loads, in § 23.427(a), requires that horizontal stabilizer surfaces and their supporting structure withstand unsymmetrical loads arising from maneuver and gust loads, and yaw and slipstream effects.

b. If maximum simultaneous rudder and elevator deflection at the design maneuver speed, V_A, is a proposed maneuver, then this should be a design load condition.

98. For T-tail designs, should a symmetrical load on the horizontal stabilizer be combined with a vertical stabilizer load? This combined load condition is not required by part 23. Horizontal stabilizer design maneuver and gust loads are normally combined with zero load on the vertical stabilizer. However, the yaw maneuver loads and the lateral gust loads are combined with the horizontal stabilizer balancing load for 1g level flight (see § 23.441 and § 23.443).

99. For T-tail designs, should a 50 feet per second (fps) gust load applied on the horizontal stabilizer be combined with a 50 fps gust load applied to the vertical stabilizer?

a. You are not required to apply a 50 fps gust load to both the horizontal and vertical-tail surfaces simultaneously. The horizontal-tail gust loads regulation requires that 50 fps vertical up and down gusts be applied to the horizontal stabilizer at design cruise speed, V_C (see § 23.425(a)(1)). Also, the airworthiness standard for the vertical-tail gust loads requires that a 50 fps lateral gust be applied to the vertical stabilizer at design cruise speed, V_C, as a separate condition (see § 23.443(a)).

b. For a T-tail, determine the induced unsymmetrical loads on the horizontal stabilizer when the lateral gust and 1g balance tail loads occur. Examine the resulting combined design load condition to determine if it is critical for the empennage and its supporting structure. Use rational methods to calculate the unsymmetrical loading condition.

c. Combining the horizontal and vertical gust loads is not a mandated FAA requirement that is contained within the regulations; it is a suggestion for a designer to consider.

d. The maneuvers and safe entry speeds proposed for certification should be carefully considered for higher combined loads on the empennage and aft fuselage than would be determined by applying part 23 requirements. If higher loads are likely to occur, the applicant should perform more investigations.

e. You may not determine the horizontal stabilizer unsymmetrical load from § 23.427(b)(1) and (2) for a T-tail airplane. This formula first appeared in Civil Air Regulations (CAR) 03.2214, effective November 13, 1945, long before the T-tail configuration came into use.

f. AC 23-9, Evaluation of Flight Loads on Small Airplanes with T, V, +, or Y Empennage Configurations, provides guidance about this topic.

> **NOTE**: If the diagrams are to be reproduced, or the AC revised, the "roll axis and moment reference" and the "moment reference" points should be removed.

g. In summary, the part 23 regulations do not require the designer to combine the symmetric pitch maneuver loads with the yaw maneuver loads (see § 23.423 and § 23.441). However, lateral gust and yaw maneuver loads should be combined with 1g level flight loads.

100. What guidance is available for other tail designs such as V-tail and Y-tail? AC 23-9, paragraph f, provides guidance about control surface and system loads for airplanes with control surfaces that receive simultaneous inputs from more than one control axis.

101. Do acrobatic category airplanes require any special considerations?

a. Yes. For acrobatic category airplanes, which are intended to perform “flick” or “snap” rolls, the unsymmetrical loading on the horizontal stabilizer should be calculated using conservative assumptions.

b. Instrumented flight-test results may be used instead of conservative assumptions.

VERTICAL SURFACES

23.441 Maneuvering loads	(Amendment 23-48)

102. Is there any policy available on paragraph (a), (b) or (c) of this section as of January 1, 2007? No.

103. May I use Appendix B of part 23 to determine the control surface loads?
No. Do not use Appendix B of part 23 to determine control surface loads. See 23.391 Control surface loads, for more guidance about Appendix B of part 23. Also, avoid misusing information that appears in Civil Air Regulations (CAR) 3.219; a tail torsional moment that is satisfactory for a stabilizer with a main spar at the quarter-chord may be inadequate if the main spar is located nearer mid-span. Part 23, Appendix A, as amended by Amendment 23-48, provides helpful guidance.

23.443 Gust loads	(Amendment 23-48)

104. Is there any policy available on this section as of January 1, 2007? No.

105. May I use Appendix B of part 23 to determine the control surface loads?
No. Do not use Appendix B of part 23 to determine control surface loads. See 23.391, Control surface loads, for more guidance about Appendix B of part 23.

23.445 Outboard fins or winglets	(Amendment 23-42)

106. Is there any policy available on this section as of January 1, 2007? No.

AILERONS AND SPECIAL DEVICES

23.455 Ailerons	(Amendment 23-42)

107. What sections of the regulations are applicable to differential-deflection ailerons? These types are not subject to part 23, § 23.459, Special devices. Instead, apply the airworthiness standards for § 23.455, Ailerons, and § 23.683, Operation tests. Previously generated data may be used.

108. Is there any policy available on paragraph (b) of this section as of January 1, 2007? No.

23.457 Wing flaps	(Amendment 23-48) [Removed]

23.459 Special Devices	(Original)

109. What types of devices are subject to this regulation? Dive-brakes and spoilers are subject to this airworthiness standard (§ 23.459).

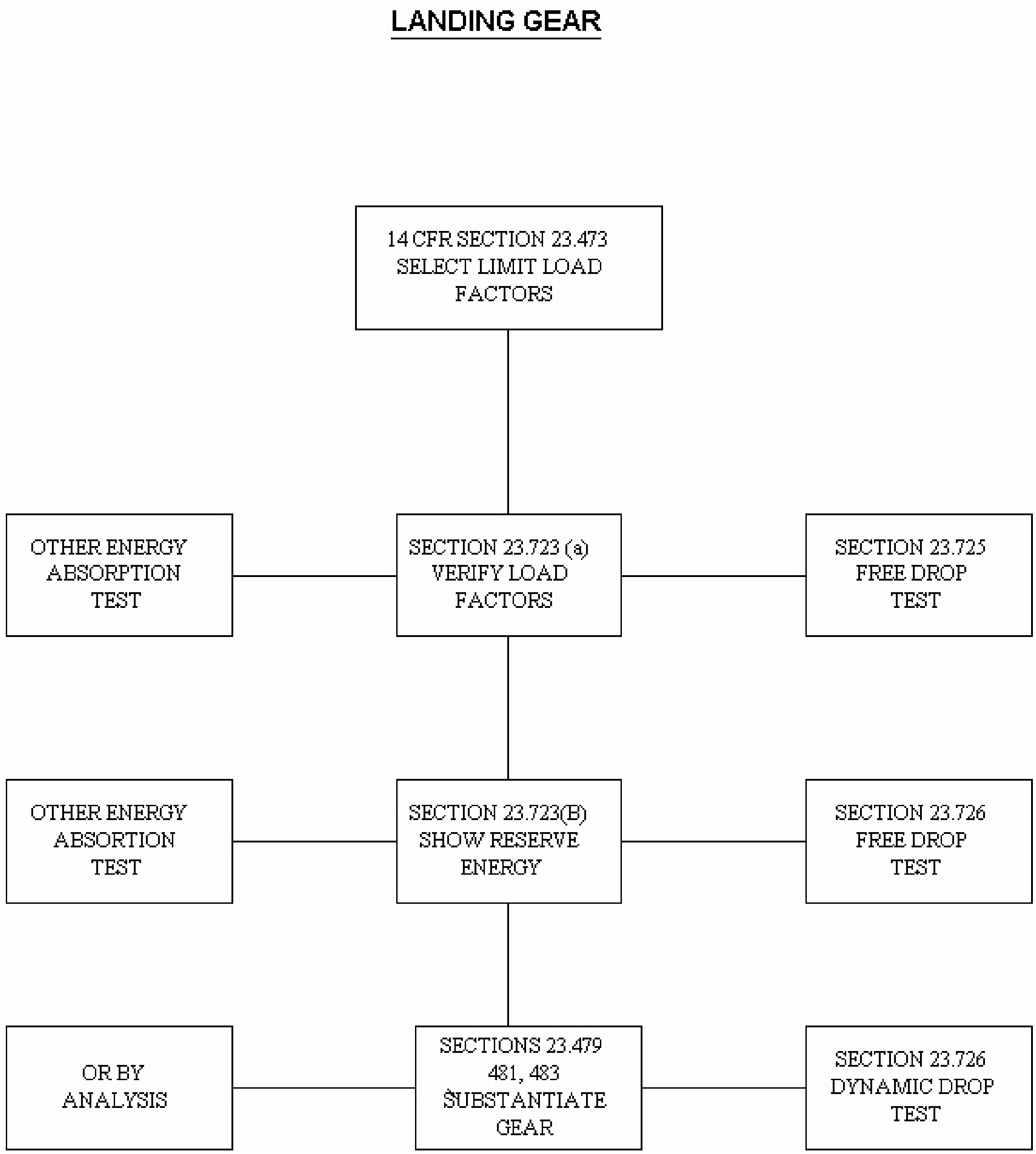
GROUND LOADS

23.471 General	(Original)

110. What load distribution is correct for the forward wheels of a four-wheel landing gear on amphibious airplanes with twin seaplane floats? A 50-50 load distribution is correct.

111. Are there other considerations for ground loads as they relate to amphibious airplane floats? Yes. You should assess the safety characteristics of the float configuration regarding the effects of float deflections and the skidding action of a float. Figure 7 presents an overall view of landing gear airworthiness standards.

FIGURE 7
LANDING GEAR



23.473 Ground load conditions and assumptions (Amendment 23-48)

112. If my airplane ramp weight is above the 12,500-pound limit for certification to part 23, can I still certify to that standard if my maximum takeoff weight is 12,500 pounds or less?

a. Yes. Ramp weights above 12,500 pounds and ramp weights over the airplane maximum takeoff weight can be used for small airplanes and still retain the part 23 certification basis. To use a ramp weight over the maximum takeoff weight, apply the following guidelines.

(1) The difference between ramp weight and takeoff weight should be limited to the weight of fuel that can reasonably be burned off by the engines from start-up to the point of initiating the takeoff roll. Fuel burn-off considerations will include engine start(s), taxi to the runway, engine run-up, and taxi to the initial takeoff point on the runway. Also, for the specific airplane, make these estimates for an average size airport that the airplane will likely operate out of during its operational use.

(2) Since airplane takeoff performance will be based on the maximum takeoff weight, the amount of fuel used for the takeoff run should not be counted as part of the difference between ramp weight and takeoff weight.

(3) Policy: The increment of weight above maximum takeoff weight should be limited to small values consistent with the above-noted reasoning and, generally, will not exceed 1 percent of the takeoff weight.

(4) Provide the pilot an accurate means to determine the airplane gross weight at the takeoff condition just before brake release.

(5) The airplane design should comply with § 23.485 through § 23.511, excluding § 23.511(b) and (c)(1), with ramp weight substituted for maximum weight. These airworthiness standards address:

(a) Side load conditions;

(b) Braked roll conditions;

(c) Supplementary conditions for tail wheels;

(d) Supplementary conditions for nose wheels;

(e) Supplementary conditions for skiplanes;

(f) Jacking loads;

(g) Towing loads; and

(h) Ground load; unsymmetrical loads on multiple-wheel units.

1. Two limitations are involved:

(aa) Ramp weight is limited by airplane structural integrity under ground loads, and

(bb) Maximum takeoff weight is limited by structural integrity or airplane performance.

(6) The Airplane Flight Manual (AFM) should clearly present these limitations to the pilot.

(7) Display maximum ramp weight limitations in at least two places—the Type Certificate Data Sheet and the AFM.

(8) Obtain the correct fuel capacity and fuel weight to show compliance for design landing weight (reference § 23.473(b)(2)) by using the following:

(a) The entire airplane fuel capacity (including unusable and residual fuel), with

1 The maximum appropriate fuel densities shown in the Note found in the Powerplant Guide for the Certification of Part 23 Airplanes (AC 23-16), 23.955 Fuel flow, (c) Pump Feed Systems, paragraph (3).

2 For avgas, use 6.0 pounds per gallon.

113. Why did a prior amendment level refer to part 25 regulations?
Before Amendment 23-7, § 23.473(c) referred to the requirements of § 25.1001 for fuel jettison requirements.

> **Warning:** The design landing weight of a part 23 airplane may be less than that allowed by § 23.473 when a fuel jettisoning system is installed and the one engine inoperative rate-of-climb requirements of § 23.67(a) are met.
>
> The other requirements related to this subject are so different in parts 23 and 25 that the jettisoning requirements of current part 25 are not compatible with part 23. These differences include structures and loads, aircraft performance, and accounting for temperature and altitude effects.
>
> Therefore, the FAA did not intend the jettison requirements of part 25 (Amendment 25-18) to be applied to part 23. The preamble of Amendment 23-7 states that amended § 25.1001 does not now reflect the appropriate requirements for part 23. Amendment 25-18 was intended to cater to the needs of airline transport airplanes and to preclude the need for additional exemptions from the pre-amendment jettisoning requirement.

114. Is there any policy available on paragraph (d), (e), (f) or (g) of this section as of January 1, 2007? No.

115. Where can I find more information about an increase in maximum weight, maximum landing weight, or maximum zero fuel weight? More information may be found in 23.307, Proof of structure.

116. What weight should be used in showing compliance with §§ 23.485, 23.493, and 23.499 (side load conditions, braked roll conditions, and supplementary conditions for nose wheels)? The design landing weight may be used in showing compliance to these regulations. Other ground load conditions, which address ground handling or taxiing conditions, should be substantiated to the design maximum weight.

117. Can I establish separate land and water weight limits for amphibian airplanes? Yes. Separate weight limits are acceptable for amphibians for operation on land and on water because separate certification criteria exist within the regulations.

118. What are the appropriate ground load conditions for an amphibious airplane design?

a. For an amphibious airplane design, the following ground load conditions and assumptions are appropriate (see § 23.473, paragraphs (e), (f), and (g)) when the design landing weight is less than the maximum weight (see § 23.473 (b)):

(1) § 23.473(d) - Determine the landing descent velocity from

$$V = 4.4\left(\frac{W}{S}\right)^{1/4};$$

(2) § 23.473(e) - Assume a wing lift not exceeding two-thirds of the airplane weight exists throughout the landing impact; and

(3) § 23.473(f) - Energy absorption tests.

119. Can I use a landing weight less than the design maximum weight in § 23.473(g)? No. That is inappropriate since the airplane inertial load factor may not be less than 2.67. Correspondingly, the ground reaction load factor may not be less than 2.0 at design maximum weight.

120. How much can the gross weight be increased by analysis of prior drop tests without actually conducting a drop test at the increased weight?

a. Any answer should consider all the factors, such as remaining shock-strut travel, metering pin design, energy absorption characteristics (area under the accelerometer time-history trace), etc., and how those factors change at the increased gross weight configuration. The need to conduct or ignore drop tests should be reviewed cautiously.

● **Policy**: A decision about whether the maximum weight increase is “small” or “substantial” does not affect the application of guidance in this AC.

23.477 Landing gear arrangement (Original)

121. Is there any policy available on this section as of January 1, 2007? No.

23.479 Level landing conditions (Amendment 23-45)

122. Is there any policy available on paragraph (a) of this section as of January 1, 2007? No.

123. What is the background of paragraph (b) of this section?

a. The drag component for landing gear loads may not be less than 25 percent of the design load factor multiplied by the gross weight of the airplane. This equation is observed in Appendix C of part 23 under main wheel loads. This does not mean that a separate drop of the main gear, at maximum gross weight, is required to obtain the load factor used in making this calculation.

b. Two different incline plane angles are given in the Civil Air Regulations (CAR) and Title 14 of the Code of Federal Regulations (14 CFR).

c. Approvals have been granted using CAR 3, before May 3, 1962, which defines the inclined plane angle to be ARC tan K for the level landing case with the nose wheel just clear of the ground. In CAR 3 (Amendment 3-7), dated May 3, 1962, the regulations show the inclined plane angle to equal ARC tan [nk/(n-L)] (see CAR 3.245(b)(2). See Figure 3-12(b), and § 23.479(a)(2)(ii), Appendix C of part 23). Manufacturers of amphibious floats for aircraft certificated under part 23 have used inclined plane angles as ARC tan K. There are no unfavorable service history records of landing gear failures for part 23 airplanes that were substantiated and approved for the main landing gear drop test using the old CAR 3 regulations.

- **Policy**: CAR 3 landing gear drop test data substantiated to requirements dated before May 3, 1962, are not acceptable for aircraft certificated to CAR 3 or part 23 on or after the 1962 date.

124. Is there any policy available on paragraph (c) of this section as of January 1, 2007? No.

125. Is there any policy available on paragraph (d) of this section as of January 1, 2007? No.

23.481 Tail down landing conditions (Original)

126. Is there any policy available on paragraph (a) of this section as of January 1, 2007? No.

127. What are “spin-up” and “spring-back” loads?

a. When a landing airplane wheel touches the ground, a near instantaneous wheel spin-up occurs (since the wheel tangential velocity should quickly match that of the runway). Due to inertial properties, this phenomenon induces a drag load upon the landing gear. The drag force energy is stored in the landing gear as potential energy that causes the gear to spring-back (a negative drag force). The drag forces of spin-up and spring-back may reach maximum values at different times than when the vertical load on the landing gear is achieved. It would be unusual for both load maximums (drag and vertical) to occur simultaneously.

128. Should there be a drag load (spin-up), combined with the vertical load, for paragraph (b), tail down landing conditions?

a. A primary concern about the last phrase of paragraph (b) is that it can be interpreted at least two ways. The two interpretations are as follows:

(1) Since the wheel is assumed up to speed, the drag load caused by wheel spin-up is zero.

(2) Maximum wheel spin-up and spring-back occur before the landing gear maximum vertical load is attained; therefore, the drag load due to spin-up or spring-back combines with earlier lower-magnitude vertical loads but does not combine with the maximum vertical load.

b. The second interpretation of the regulation is correct. The different interpretations of tail-down landing requirements come from the Basic Landing Conditions table shown in Appendix C of part 23. The table does not include a load, D_r, which accounts for spin-up and spring-back loads. However, Appendix D provides D_r loads for the same landing conditions shown in Appendix C.

129. How are the landing gear loads typically determined and tested?

a. Airplane landing gear designers often estimate these loads analytically and test for these loads by dropping the airplane or the landing gear units. The drag loads are sometimes approximated using inclined planes (wedge blocks) and, at other times, they are created by reverse spinning the wheel and tire before the drop impact.

b. Incline planes are often suitable for small airplanes where the touchdown velocity is relatively small and the wheel and tire diameters are correspondingly small. Incline planes, which are used to induce the estimated drag load, may restrict proper development of the spring-back (negative drag) load—and should be viewed accordingly. For small airplane landing gear designs, incline planes may be an adequate method to use to show compliance with part 23.

c. Reverse wheel spin-up, to simulate the drag load caused by wheel spin-up, is frequently used by landing gear designers for larger, faster, airplane designs. Higher touchdown speeds and larger diameter tires cause disproportionate increases in the wheel and tire inertial properties; these create larger magnitude spin-up and spring-back loads.

- **Policy**: Reverse wheel spin-up and incline planes are both acceptable methods for imposing the drag inputs into a drop test when they are properly applied. Also see § 23.725(c).

23.483 One-wheel landing conditions (Original)

130. What wing lift should I use for this condition? Use wing lift consistent with that used for the other landing impact conditions.

23.485 Side load conditions (Amendment 23-45)

131. Is there any policy available on this section as of January 1, 2007? No.

23.493 Braked roll conditions (Original)

132. Is there any policy available on this section as of January 1, 2007? No.

23.497 Supplementary conditions for tail wheels (Amendment 23-48)

133. Is there any policy available on this section as of January 1, 2007? No.

23.499 Supplementary conditions for nose wheels (Amendment 23-48)

134. Is there any policy available on this section as of January 1, 2007? No.

23.505 Supplementary conditions for skiplanes (Amendment 23-7)

135. What is the typical method for determining the load factor for a ski installation?

a. A ski installation should use a load factor determined by either of the following two methods:

(1) Perform drop tests, with skis installed, on a surface simulating frozen hard-packed snow or ice; or

(2) Use a conservative formula (see SPECIFICATION—Aircraft skis, National Aircraft Standards Committee, NAS 808, paragraph 5.1(a)).

b. Ski installation factors should include consideration for fittings, tubes, axles, nuts, bolts, etc., which attach the skis to the fuselage. Ski-gear loads normally run about 115 percent to 125 percent of wheel-gear loads. Also see 23.737, Skis.

23.507 Jacking loads (Amendment 23-14)

136. Is there any policy available on paragraph (a) of this section as of January 1, 2007? No.

137. How do I meet the intent of paragraph (b) of this rule? The intent is accomplished when structure affected by jacking loads is designed to withstand the inertial load factors in part 23, § 23.507(a)(2) and (c). Section 23.507(b), in essence, is redundant with § 23.471 General (Ground Loads).

138. Is there any policy available on paragraph (c) of this section as of January 1, 2007? No.

23.509 Towing loads (Amendment 23-14)

139. Is there any policy available on paragraph (a), (c) or (d) of this section as of January 1, 2007? No.

140. What is an auxiliary gear? Auxiliary gear means a landing gear unit that is not part of the main landing gear.

23.511 Ground load; unsymmetrical loads on multiple-wheel units (Amendment 23-7)

141. Is there any policy available on this section as of January 1, 2007? No.

WATER LOADS

23.521 Water load conditions	(Amendment 23-48)

142. Is there any policy available on paragraph (a) of this section as of January 1, 2007? No.

143. Is there any policy available on paragraph (b) of this section as of January 1, 2007? No. See 23.603, Materials and workmanship, for information that pertains to floats.

23.523 Design weights and center of gravity positions	(Amendment 23-45)

144. Is there any policy available on this section as of January 1, 2007? No.

23.525 Application of loads	(Amendment 23-45)

145. Is there any policy available on this section as of January 1, 2007? No.

23.527 Hull and main float load factors	(Amendment 23-45)

146. Is there any policy available on paragraph (a) or (b) of this section as of January 1, 2007? No.

147. Does the term "seaplane structure," as used in paragraph (c), apply to the engine mounts? Yes. Therefore the factor K_1, used in the calculation of the water reaction load factor n_w, may be reduced at the bow and stern to 0.8 of the value shown in figure 2 of appendix I in part 23.

23.529 Hull and main float landing conditions	(Amendment 23-45)

148. Is there any policy available on this section as of January 1, 2007? No.

23.531 Hull and main float takeoff condition	(Amendment 23-45)

149. Is there any policy available on this section as of January 1, 2007? No.

23.533 Hull and main float bottom pressures (Amendment 23-45)

150. Is there any policy available on this section as of January 1, 2007? No.

23.535 Auxiliary float loads (Amendment 23-45)

151. Is there any policy available on this section as of January 1, 2007? No.

23.537 Seawing loads (Amendment 23-45)

152. Is there any policy available on this section as of January 1, 2007? No.

EMERGENCY LANDING CONDITIONS

23.561 General (Amendment 23-48)

153. Is there any policy available on paragraph (a) of this section as of January 1, 2007?
No.

154. What are the historical requirements of this section in reference to Cargo Restraints?

a. Guidance information about ultimate inertial strength requirements for cargo restraint devices in part 23 airplane designs originally centered around part 135 air taxi operators who carried mail sacks in an empty cabin after passenger seats were removed. The guidance is from around 1968.

b. There is an inconsistency between Civil Air Regulations (CAR) 3.386(d) and § 23.561(e), in recodified part 23, dated February 1, 1965. The inconsistency concerns protecting occupants from mass items that might cause injury if they come loose in a minor crash landing (up to 9g's). Another inconsistency exists between CAR 3.392 and § 23.787(c) when considering occupant protection. This inconsistency concerns the cargo compartment contents ultimate forward acceleration of 4.5g's. Another inconsistency exists between CAR 3.392 and § 23.787(c). Section 23.787(c) suggests that a designer should also consider the maximum flight and ground-load factors for load conditions.

c. As originally viewed, CAR 3.392 applied to airplane configurations that contained a forward crew compartment, a center passenger compartment, and an aft bulkhead, which separated a small cargo compartment from the passenger area. In this configuration, 4.5g restraint was considered adequate since the National Aeronautics and Space Administration (NASA) data showed that, in a typical crash, the g-forces became lower as distance increased aft from the airplane nose. Thus, what would be adequate cargo restraint in the aft fuselage would probably be inadequate near the cockpit. When CAR 3.392 was adopted, the Civil Aviation Authority did not envision all-cargo CAR Part 3 aircraft.

d. For § 23.561(b) and (e), the restraining devices should meet the 9g requirement.

155. What are the historical requirements of this section in reference to Cargo Compartment Design?

a. Regulatory history about cargo compartment design practices and minimum airworthiness standards guidance is from around 1968.

b. CAR 3.392 requires a cargo restraint of 4.5g forward inertial load factor when structure separates the contents in a cargo compartment from occupants forward of the compartment. Section 23.787 requires a cargo restraint of 9.0g forward inertial load factor when structure separates the contents in a cargo compartment from occupants forward of the compartment. At Amendment 23-36, the FAA increased the mass item retention to 18.0g for occupant protection when the mass items are located in the cabin with the occupant (i.e., not located in a separated cargo compartment).

c. The emergency provisions protection, the intent of CAR 3.386, is as follows: Each acceleration specified in CAR 3.386 should be considered to act independently. If the occupants' heads could strike sharp edges of objects within the passenger cabin under combinations of load factors less than those given in CAR 3.386(a), then the designer should use the general requirement of the first paragraph of CAR 3.386 with the guidelines of CAM 3.386-1.

156. What are the historical requirements of this section in reference to Cabin Safety?

a. Airplane designers (and modifiers) and FAA Aviation Safety Engineers should pay attention to the need for increased emphasis in the design of cabin safety provisions in small airplanes. Observe the following guidelines: Strive for the highest level of occupant crash protection feasible within the state-of-the-art technology for the general emergency landing conditions and the occupant protection provisions given in §§ 23.561, 23.562 and 23.785. Do this early and frequently in the Type Certification Process.

b. Cabin safety emphasis is intended to influence an individual designer's choices early in the conceptual phases, when safety objectives can be achieved with little or no burden on the designer and the manufacturer. The level of occupant crash protection is determined by interrelated cabin features including, but not limited to, the following:

(1) Seating configuration (considering occupant flailing characteristics);

(2) Occupant restraint devices, supports, attachments, and installations;

(3) Energy absorbing padding (thoughtfully located); and

(4) Potentially hazardous hard points.

c. To clarify confusion about static side load factors: Mass items have a 4.5g static side load factor requirement, whereas occupants have only a 1.5g condition.

d. The occupant sideward static load factor requirement of 1.5g was recodified into § 23.561(b)(2)(iii) from the Civil Air Regulations, Part 3. Twenty-three years later, part 23, Amendment 23-36, put the 4.5g mass item requirement into the seat and restraint systems dynamic test requirements. The General Aviation Safety Panel (GASP) studied and recommended these actions.

e. GASP I, as the first group was known, recognized that 26g times the SIN 10° equals 4.5g, which is the sideward dynamic emergency landing condition for an airplane impact associated with a yaw. They further recognized that it would be much more economical to conduct static tests, or analyses, than dynamic tests for mass items installed on the airplane. Consequently, GASP I recommended the static load factor now contained in § 23.561(b)(3).

157. Is there any policy available on paragraph (c) of this section as of January 1, 2007? No.

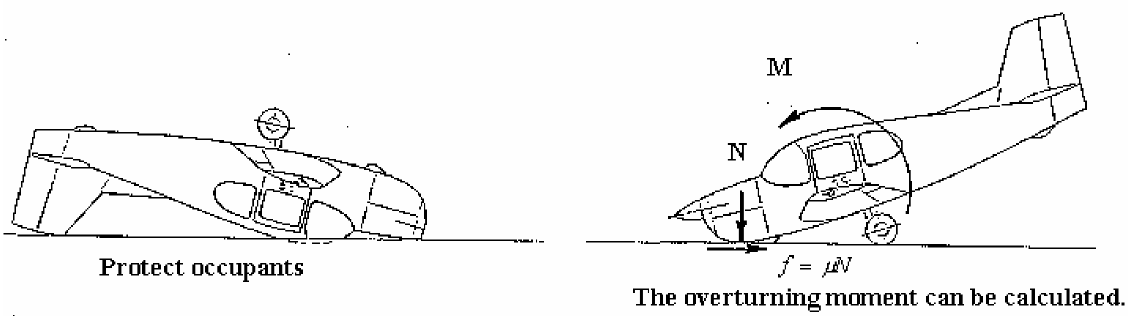
158. What is the background of protection of occupants in an airplane for a sliding bubble canopy and with no turnover structure? Until Amendment 23-36, effective September 14, 1988, the turnover requirement in § 23.561(d) was essentially the same as in CAR 3.386(c), which first appeared in CAR 3, as amended in November 1949.

159. What are the requirements of this section for airplane turnover?

a. Regardless of the type of landing gear installed, the inverted attitude is probable; therefore, the emergency exit requirements of § 23.807(a) should be demonstrated unless escape means are obvious.

b. Figure 8 presents an overall relational view of turnover protection airworthiness standards.

FIGURE 8
RELATIONAL VIEW OF TURNOVER PROTECTION



c. To meet the static emergency landing conditions requirements (see § 23.561(d)), the strength of turnover structure may be shown by analysis. However, conduct tests if an analysis is questionable (see § 23.601).

160. Is there any policy available for this section on a Jettisonable Canopy?

a. The airworthiness standard for § 23.807(a), Emergency exits, requires that emergency exits be located to allow escape in any probable crash attitude. Compliance with this requirement should be demonstrated with a rollover structure installed.

b. Section 23.807(b)(4), the emergency exits regulation, requires each emergency exit to have reasonable provisions against jamming by fuselage deformation. Compliance with this requirement should be demonstrated with the airplane resting inverted after accounting for any structural collapse.

c. In an acrobatic category airplane, the occupants should be able to bail out quickly, with parachutes, at any speed between V_{SO} and V_D (see § 23.807(b)(5)). Further, § 23.807(c) requires that the proper functioning of each emergency exit be shown by tests, which are usually demonstrated on the ground rather than in flight.

d. Forward sliding, jettisoning, and hinged canopy designs were not originally envisioned by CAR 3 or part 23. Occupant protection and escape from an airplane damaged in a turnover, and in-flight emergency escape provisions, should be addressed in any certification project, since adequate emergency exit airworthiness standards exist in these regulations. Special conditions may be required for a jettisonable canopy to address continued safe flight, inadvertent canopy opening hazards, and in-flight canopy jettison-safe trajectory. Other possible methods of showing compliance to the airworthiness standards include wind tunnel tests, sled tests, or other ground tests that simulate flight.

e. A jettisonable canopy may not jam when the airplane is resting inverted.

f. For the bail-out requirement of § 23.807(b)(5) for an acrobatic category airplane:

(1) If the canopy is not jettisonable, show that the occupants can safely exit the airplane between V_{SO} and V_D.

(2) If the canopy is jettisonable, show that the canopy trajectory will not injure the occupants while separating from the airplane between VSO and V_D. Also demonstrate that the airplane can continue safe flight and landing without the canopy. Alternatively, inadvertent canopy jettison should be improbable.

161. Is there any policy available for this section on Emergency Exit requirements in an Airplane Turnover Condition?

a. The inverted attitude is a probable crash attitude for small airplanes. The occupant emergency exit requirements of § 23.807(a) should be shown. If escape from the inverted attitude airplane is not obvious, or is questionable, compliance should be by demonstration.

b. It is not acceptable to rely on an emergency procedure that requires canopy jettison immediately before an impact accident (except for an in-flight canopy jettison above a safe parachute altitude required in § 23.807(b)(5)). If the canopy is made jettisonable, to comply with § 23.807(b)(4), avoid jams with fuselage deformation when the airplane is resting inverted. If there is any doubt, the applicant should demonstrate by tests.

162. Is there any policy available on paragraph (e) of this section as of January 1, 2007? No.

163. Do internal cabin doors have to remain operational after an emergency landing? Do not allow an internal cabin door to jam during an emergency landing and block the flight crew's escape path. See the Systems and Equipment Guide for Certification of Part 23 Airplanes, AC 23-17B, 23.807 Emergency Exits, for further guidance.

164. What minimum occupant weight should I use? Use, at least, the following minimum occupant weights when showing compliance with the emergency landing conditions static strength airworthiness standards of § 23.561:

a. Design each seat and its supporting structure for an occupant weight of at least 170 pounds, for normal and commuter category airplanes. Use a 190-pound occupant weight, which includes a parachute, for utility and acrobatic category airplanes. (Reference § 23.25(a)(2).)

b. Also, design each seat and restraint system for at least a 215-pound occupant weight when considering maximum flight and ground-load conditions of the airplane-operating envelope.

NOTE: A 1.33 factor should be applied to all loads that affect the strength of fittings and attachment of the following:

(1) Each seat to the structure, and
(2) Each safety belt and shoulder harness to the seat or structure.

23.562 Emergency landing dynamic conditions (Amendment 23-50)

165. Is there any policy available on paragraph (a) of this section as of January 1, 2007? No.

166. Do I have to retest the seats in my airplane if I want to change the fabric dress covers, following the conduct of dynamic certification tests per the seat dynamic performance standards? No. You may substitute typical dress fabrics for each other, including leather, without retest. The change in friction due to dress cover alone is less significant than the variation possible due to clothing, etc. However, dress covers that exhibit low friction coefficients (i.e., hard plastics, which are not in use, to our knowledge) may require some resubstantiation.

167. Are there any certification issues at all for changing the dress covers or seat cushions on seats? Yes. Dress cover and cushion changes that affect the flammability of the dress cover and seat do require resubstantiation to the respective flammability requirements. Also see the next question about cushions.

168. Do I have to retest or analyze the seats in my airplane if I want to change the seat cushions, following the conduct of dynamic certification tests per the seat dynamic performance standards? Yes. The seat cushion static and dynamic response characteristics can affect the lumbar column/pelvic load measured during the seat dynamic certification tests. Thus, a change in the seat cushion would require re-substantiation. Analysis may be used per the guidance in AC 20-146.

169. In the acquisition of data for Head Injury Criteria (HIC), are 8-bit analog to digital converters adequate? No. In accordance with Society of Automotive Engineers (SAE) recommended practice J211 “Instrumentation for Impact Tests,” the converter should be at least 10-bit in order to obtain a sufficient level of resolution.

170. Can I run a vertical drop test as an acceptable alternate means for the determination of seat/floor deformation requirements found in § 23.562(b)(2)?

a. No. The seat/floor deformation requirement is more an assessment of the airplane seat’s tolerance to structural deformations than it is an assessment of potential airframe deformations. Intolerance of seat/floor interface to deformation is deemed a major cause of structural failure of the seat/floor structural attachment. If you want to pursue this type of test for information for research only (but not for certification), the following are the kind of items that you should consider.

(1) Drop tests are typically a simulation of the vertical impact velocity only; an actual airplane accident possesses both vertical and longitudinal impact velocity vectors. While the measured impact acceleration levels may provide some insight into the overall vertical impact characteristics of the airframe, the test condition does not simulate the combined vertical and longitudinal (and potentially lateral) loads on the airplane seat, its attachments, and interface structure.

(2) An actual airplane accident frequently occurs on an irregular impact surface that may also contain local obstructions, which can cause significant local loading, structural fractures, and deformations. A vertical drop test on a flat surface does not address the common and more critical impact case that may occur on irregular and obstructed surfaces.

(3) Large, significant, dynamic, structural deformations can occur during an impact test, or airplane accident that are not readily detectable for measure after the impact condition. These results have been demonstrated during the general aviation airplane impact test series. Consider this if you plan to measure the residual static floor deformation after the impact test.

(4) Choose accelerometers with an amplitude class that is adequate for the g-loads expected during your particular drop test.

b. The above paragraphs attempt to address the kinds of considerations that the 10-degree pitch and 10-degree roll in part 23, § 23.562, already account for.

171. Can I use static ultimate load tests as an alternate means of showing compliance to the dynamic seat test requirements of § 23.562? No. One of the key requirements of part 23, § 23.562 is to assure that an occupant's vertical lumbar load is limited to 1,500 pounds or less during the 30 degree incline test. In addition, the HIC and upper torso restraint maximum loads can only be demonstrated by dynamic testing. The FAA is unaware of any analytical (except computer modeling techniques, discussed below) or static test procedure that will meet the dynamic seat test requirements.

172. Is there any policy available on paragraph (c) of this section as of January 1, 2007? No.

173. Is there any policy available on paragraph (d) of this section as of January 1, 2007? No.

174. Is analysis alone an acceptable alternative approach as stated in paragraph (e)?

a. Yes, per the guidance in AC 20-146.

b. The following two SAE papers provide helpful, related, information:

(1) SAE Paper No. 850853, "The Development of Dynamic Performance Standards for General Aviation Aircraft Seats," Stephen J. Soltis and John W. Olcott.

(2) SAE Paper No. 851847, "Human Injury Criteria Relative to Civil Aircraft Seat and Restraint System," Richard F. Chandler.

c. AC 23.562-1, Dynamic Testing of Part 23 Airplane Seat/Restraint Systems and Occupant Protection, contains useful guidance about this airworthiness standard topic.

175. How are the minimum safety standards determined for restricted category airplanes? The FAA issues type certificates under the regulatory procedures of part 21, Certification Procedures for Products and Parts. The Small Airplane Directorate decides the appropriateness of part 23 airworthiness standards as they apply to the special purpose restricted category airplane. If a regulation is found inappropriate, the FAA excludes that regulation from the certification basis of that airplane.

NOTE: A finding of equivalent level of safety or the need for an exemption is unnecessary for that specific airworthiness standard.

176. How are the minimum safety standards determined for agricultural or special purpose airplanes?

a. The FAA has allowed the certification of restricted category aircraft since Civil Air Regulations (CAR) Part 8 was introduced (around 1950). The preamble to CAR 8 recognized that, for restricted category aircraft where the public was not endangered, it was unnecessary to provide an equivalent level of safety to the standard airworthiness requirements.

b. Policy: As of December 1, 1997, for emergency landing dynamic conditions, evaluate the airplane using at least the following considerations:

(1) The placement of the chemical hopper forward of the cockpit so that there is no large item of mass that threatens to collapse the cockpit should a crash occur.

(2) The elimination of any protruding knobs, handles, or other rigid structures from the cockpit that the pilot or crew member may contact in a crash. Approved Department of Transportation or Mil-Spec protective headgear is mandatory.

(3) The installation of a military type lap belt and shoulder harness having a 5,000-pound rating or greater or approved equivalent.

(4) Special purpose crew members who assist in the aerial application operation, i.e., flaggers, loaders, may be carried in ferry flights provided certain conditions are met. First, each crew member must have a seat, a lap belt and shoulder harness comparable in strength to that of the pilots. Second, the crew seat must not be in the cockpit. Third, the crew seat must be located behind the pilot seat. Special purpose crew members that are carried for any other purpose will be afforded the same protection as that of the pilot.

c. Dynamic seat airworthiness standards used in part 23 were developed for normal, utility, and acrobatic category airplanes only. These standards were never intended for use on restricted category airplanes. When NASA, the general aviation industry, NTSB, and the FAA examined survivability envelopes, they did not consider restricted category airplanes in the database because there were notable differences in the crash scenarios.

d. The Small Airplane Directorate decides whether dynamic seat test requirements are appropriate or not, after reviewing crashworthiness design features of the specific make and model airplane. Service experience shows that agricultural airplane operators have a lower accident fatality rate than general aviation operators. Certain make and model agricultural airplane designs contain increasingly effective crashworthy features throughout recent development history, which are the obvious reasons for the fatality rate differences.

e. Policy: The FAA will not automatically exclude the emergency landing dynamic conditions requirement (§ 23.562) for any applicant who is seeking a type certificate for an agricultural airplane. Instead, the Small Airplane Directorate reviews the design for compensating features to the dynamic seat airworthiness standards and decides whether the dynamic seat test requirements are appropriate or not on a case-by-case basis.

f. For useful guidance, refer to AC 21.25-1, Issuance of Type Certificate: Restricted Category Agricultural Airplanes.

177. I would like to use ejection seats for emergency egress. Can I get my part 23 airplane certificated with ejection seats installed? Yes.

178. What are the criteria or minimum safety standards for approving ejection seats for use in an airplane certificated to part 23? Part 23 does not have any minimum safety standards for ejection seats, and the FAA does not have the expertise to evaluate ejection seat testing. However, the military has been developing ejection seat technology for 40 to 50 years. Therefore, the applicable sections of the Air Force Systems Requirement Document (SRD) are used as the minimum safety standards. The SRD provides specific criteria for crew escape, and for ejection seat testing and verification. The Air Force is used as a consultant. We only approve the ejection seat data after the Air Force has reviewed the data and concurs that the ejection seat satisfies the SRD crew escape, testing, and evaluation requirements.

179. Do I have to show literal compliance to the emergency landing dynamic conditions of this rule (23.562) for ejection seats?

a. No. You may show literal compliance if you choose to, or you may pursue an Equivalent Level of Safety (ELOS) finding for compliance to this rule. An ELOS is allowed instead of literal compliance to a rule, by part 21, § 21.21(b)(1). You may use the Air Force SRD as the basis for this finding.

b. The lower limits of the ejection seat operating envelope must be zero altitude above ground level and zero airspeed if you choose to pursue an ELOS for this rule.

180. Are there other rules relevant to ejection seats that I may pursue an ELOS for? Yes. You may also pursue an ELOS for the applicable portions of § 23.807 and § 23.1309.

181. The original certification basis of my airplane is before Amendment 23-36 and was manufactured on, or before, December 12, 1986. I would like to install side-facing seats. Do I have to comply with the emergency landing dynamic conditions of this rule (23.562)?

a. Yes. You must comply with the emergency landing dynamic conditions of this rule if you want approval by a Supplemental Type Certificate (STC), an amended Supplemental Type Certificate (ASTC), or an amended Type Certificate (ATC) for the installation of side-facing seats.

b. Earlier regulations were written with forward or aft-facing seats in mind, and they do not provide adequate standards for protection of occupants in side-facing seats. Therefore, in accordance with part 21, § 21.101, an applicant must comply with the current standards, including the emergency landing dynamic conditions contained in this rule (23.562), before any side-facing seat installation (to be occupied during takeoff or landing) can be approved.

c. An alternative to compliance with the current regulations is to prohibit occupation of side-facing seats during takeoff and landing through the use of a flight manual supplement and clearly visible placards. This type of installation should include a restraint system that keeps the occupant securely seated during turbulence or maneuvering.

d. This policy is applicable to airplanes whose original certification basis was before Amendment 23-36 to part 23, and the airplanes that were manufactured on, or before

December 12, 1986. This includes normal, utility, acrobatic, and commuter category airplanes with earlier amendments to part 23, Civil Air Regulations 3 (CAR-3), or airplanes with any previous airworthiness regulations as their original certification basis.

e. The one exception to this policy is an airplane that had side-facing seats as part of its original certification basis and with a certification basis that falls within the scope of paragraph d, above. In this instance, an application for an STC, ASTC, or ATC for side-facing seats does not need to meet the requirements of emergency landing dynamic conditions of this rule (23.562).

f. Also see § 23.785 in AC "Systems and Equipment Guide for Certification of Part 23 Airplanes and Airplanes".

FATIGUE EVALUATION

23.571 Metallic pressurized cabin structures	(Amendment 23-48)

182. What is the history of this regulation?

a. History: Fatigue evaluation of pressurized cabins was first required for small airplanes by Amendment 3-2 of the Civil Air Regulations (CAR), Part 3, effective August 12, 1957, and it continued into the original part 23.

b. Safe-life requirements mandate that certain critical structural elements have a fatigue life determined during the airplane type certification process. Life-limited items are normally identified in the Type Certificate Data Sheet Note 3. As of Amendment 23-26, part 23, § 23.1529 requires time-limited items to be shown in the Instructions for Continued Airworthiness—Airworthiness Limitations Section.

c. Amendment 23-45, effective September 7, 1993, provides § 23.573(b), Damage tolerance and fatigue evaluation of structure, as an option to § 23.571(a) and (b).

d. Policy: The FAA allows an extension of the originally imposed safe-life limits only through a formal reinvestigation of the life-limited parts. Generally, the type certificate holder conducts a new fatigue certification program. This requires specific FAA attention since life-limit approvals are normally beyond the scope of delegation authority granted by the FAA. Replacing the safe-life structural elements is a viable alternative to recertification. However, this is not always the best course of action because some major structural elements, like the wing and fuselage pressure vessel assemblies, are not easily or economically replaceable.

183. Is there other guidance available on fatigue? Yes. AC 23-13, Fatigue and Fail-Safe Evaluation of Flight Structure and Pressurized Cabin for Part 23 Airplanes, contains useful guidance about this airworthiness standard topic.

184. What features should be given special consideration as it relates to fatigue and damage tolerance? Cutouts: Doors, windows, access holes, etc., in aircraft structure cause redistribution of axial and shear loads, pressure loads, and stiffness changes. Fatigue capabilities may be affected. Damage tolerance capabilities may be affected. Account for all such design changes.

23.572 Metallic wing, empennage, and associated structures	(Amendment 23-48)

185. What is the history on paragraph (a) of this regulation?

a. Civil Air Regulations (CAR) 3, Amendment 3-2, effective August 12, 1957, first imposed a fatigue evaluation of pressurized cabin airplane designs.

b. Part 23 adopted an airworthiness standard to evaluate fatigue of an airplane wing and associated structure at Amendment 23-7, effective September 14, 1969.

c. Amendment 23-34, effective February 17, 1987, added commuter category airplanes to part 23. Empennage fatigue requirements were included for these airplanes. SFAR 41, which applied to part 23 derivative-model airplanes, always had such a requirement. Effective October 26, 1989, the FAA issued Amendment 23-38, which extended the fatigue requirement for empennage, canard surfaces, tandem wing, winglets, and tip fins to all part 23 airplanes. Amendment 23-45, effective September 7, 1993, added the option of a damage tolerance evaluation, as defined in § 23.573(b). Amendment 23-48, effective March 11, 1996, made damage tolerance evaluation mandatory for commuter category airplanes.

d. The narrative on spar-component fatigue tests, combined with the safe-life and fail-safe design philosophies, displays the FAA's intentions before 1971.

186. What testing is typically required?

a. Component testing, while acceptable under certain conditions, presents a problem of determining which structure to test and how to ensure that the correct testing conditions are applied. The FAA intends for the airplane designer to show that the wing, wing carry-through structure, and attaching structures comply with the fatigue requirements (§ 23.572). These examinations may exclude the control surfaces and their attachments.

b. These examinations normally include the main spar, the secondary spar, stringers, torque box skin, and at least the main internal ribs. While a main spar-component test could adequately substantiate the spar, the remaining structures should be proven by additional component tests, or analyzed as either safe-life or fail-safe structures. If fail-safe compliance is chosen, determine if the specified loads can be supported with a failed element. Also determine the number and kind of inspections to find the damage before catastrophic failure.

c. When testing the main spar, simulate load transfer through skin attachment units and the associated fretting. Further, consider and simulate any significant eccentricities and rib-to-spar-cap loads.

d. Exercise good judgment to ensure that elements and aspects of primary importance to safety receive the most emphasis.

187. Which design fatigue life governs when the airplane is certificated for use in normal and utility categories? When a safe-life limit is established for airplane designs certified in both normal and utility categories, show the lower of the two lives in the TCDS. Show the following note in the TCDS, the Airplane Flight Manual, and the Airworthiness Limitations Section of the Instructions for Continued Airworthiness (when they exist): "Since the airplane is type certificated under both normal and utility categories, the lower fatigue life has been listed in the TCDS."

188. Is fatigue an issue for wood structure? Research indicates wood is not sensitive to fatigue if the stress levels are low. Emphasis should be placed on ultimate load tests and environmental protection of the wood to prevent deterioration due to dry rot and other related environmental factors.

189. What effect will an increase in gross weight or an increase in airplane speed have?

a. A gross weight increase or an increase in airplane speed frequently demands an increase in horsepower. An engine horsepower increase may significantly relocate the engine center of gravity or increase engine weight with respect to the original installation, or both. A different engine mount (stiffness change) may accompany a different engine installation. When engine c.g., engine weight, or the engine mount is changed, one should consider the benefits of a pre-modification and post-modification ground vibration survey. The purpose of the survey is to identify any coupling or resonant characteristics changed by a different engine installation (i.e., nodes, modes, and frequencies).

b. An in-flight vibration monitoring program or a flight-strain survey could assess the effects of fatigue on airplane empennage structure, due to propeller slipstream impingement. These in-flight tests could also provide insights on whether increased horsepower forced vibrations affect airplane critical vibration environments that were previously benign.

c. One should also compare the in-flight torsional and bending peak stresses, and some selected panel strain-gauge readings, with the original airplane design data. The objective is to verify that the new stress levels will not adversely affect the fatigue life of the empennage.

d. Often, a modifier neither has, nor can they get, access to the original airplane design data. Consequently, other means of showing compliance to the airworthiness standards may be used. One evaluation technique is to compare the new fatigue stresses to the material endurance level, i.e., the S-N curves. A ground vibration survey and a flight-strain survey conducted before and after the modification can provide some data to perform a comparative analysis. If changes in the stresses are large enough to affect the empennage fatigue life, the modifier should determine appropriate structural design changes to include in the modification. Good engineering judgment should be exercised here. The service history of a similar type airplane incorporating a like modification may be used to identify potential fatigue crack locations and to serve as a guide when preparing detailed structure inspection methods and frequencies.

e. Fatigue critical structure is defined as structure whose failure would cause catastrophic loss of the whole airplane. Critical structure would include the spar, the primary fittings, the pressurized fuselage skin-stringer combinations, and the frames.

f. Instead of a fatigue or fail-safe strength investigation, § 23.572(a) permits alternate compliance. It permits compliance by showing that the structure, operating stress level, materials, and expected use are comparable, from a fatigue standpoint, to a similar design that had extensive satisfactory service experience.

g. FAA Report No. ACE-100-01, "Fatigue Evaluation of Empennage, Forward Wing, and Winglets/Tip Fins," contains comprehensive guidance on this subject. It is available from the National Technical Information Service, Springfield, VA 22161.

h. See 23.571(a), Metallic pressurized cabin structures, for FAA guidance about safe-life airplane fatigue limitations imposed during the type certification process of civil aircraft.

i. Fail-safe strength: No policy available as of January 1, 2007.

j. Damage tolerance: Effective September 7, 1993, Amendment 23-45 provided damage tolerance, § 23.573(b), as an option to § 23.572(a)(1) and (a)(2).

190. Is there any policy available on paragraph (b) of this section as of January 1, 2007? No.

191. What other guidance is available for fatigue? AC 23-13, Fatigue and Fail-Safe Evaluation of Flight Structure and Pressurized Cabin for Part 23 Airplanes, contains comprehensive guidance about this airworthiness standard topic. Please refer to it for additional information. AC 23-13A will soon be released. Therefore, until AC 23-13 is revised to convey the following information, it is presented here as a courtesy: Report AFS-120-73-2, "Fatigue Evaluation of Wing and Associated Structure on Small Airplanes," contains fatigue load spectra for various part 23 airplane usage categories. It also contains detailed procedures for the fatigue strength (safe life) investigation of § 23.572(a)(1).

192. Should a pilot make airplane maintenance record entries about airplane operations that relate to the established life-limits of the airplane according to instructions in a Pilot Operating Handbook? A type certificate applicant should show compliance with § 23.572 (fatigue life limits) using certification procedures for airplane design. The FAA does not allow a type certificate applicant to impose a requirement for the pilot to record aerobatic flight time in the airplane maintenance record. It is not possible for the FAA to validate these kinds of airplane record entries. Maintenance records, in the 1997 version of part 91, require the following registered owner or operator entries for the airframe, each engine, each propeller, and each rotor:

a. Total time in service; and

b. Current status of life-limited parts.

23.573 Damage tolerance and fatigue evaluation of structure	(Amendment 23-48)

193. Is there any policy available on paragraph (a) of this section as of January 1, 2007? Since Amendment 23-45 (effective September 7, 1993), the damage tolerance and fatigue evaluation of composite structure has been based on the applicable requirements of part 23, § 23.573. AC 20-107A, Composite Aircraft Structure, which existed before Amendment 23-45, contains acceptable means of showing compliance with these requirements. One consideration that is different for composite materials than for metallic structures is that of impact damage. For composite structures, impact damage resulting from events such as dropped tools or hail impacts is difficult to detect, but it may cause degradation of static or fatigue strength. Another difference for composite structures is that, in addition to tensile loads, compressive loads may also drive damage growth. When demonstrating compliance with the growth rate or no-growth rate of a damage requirement (§ 23.573(a)(2)), it is important to consider compressive loads that may drive the growth of disbonds or delaminations in composite structures. For movable control surfaces, include any structure that, if it failed, would cause loss of the airplane. Also see Policy Statement PS-ACE100-2001-006, "Static Strength Substantiation of Composite Airplane Structure".

194. Is there any policy available on paragraph (b) of this section as of January 1, 2007? There is no guidance for metallic structures damage tolerance assessment for part 23 airplanes. Now, a Transport category airplane (part 25), AC 25.571-1C, Damage-Tolerance and Fatigue Evaluation of Structure, dated April 29, 1998, provides the only information available from the FAA.

23.574 Metallic damage tolerance and fatigue evaluation of commuter category airplanes	(Amendment 23-48)

195. Is there any policy available on this section as of January 1, 2007? No.

23.575 Inspections and other procedures	(Amendment 23-48)

196. Is there any policy available on this section as of January 1, 2007? No.

SUBPART D—DESIGN AND CONSTRUCTION

23.601 General (Original)

197. Are there any special considerations for testing?

a. The manner of testing can bias the test results. Several years ago, the wings failed on an FAA-approved airplane whose pilot was performing aerobatic maneuvers with a full load of passengers. When comparing the static test results with the pattern of failure of the wing, investigators cast suspicion that the tension pads used to apply wing-bending loads likely stabilized the upper wing skin during tests. The stabilizing effect kept the upper wing skin from buckling during the tests. More static tests verified the theory; the retested wing failed below ultimate load.

b. When approving any static tests set up for thin-skinned structure, consider the effects of installing tension pads because they may contribute a stabilizing effect on the structure and bias the test results.

c. See 23.307, Proof of structure, for secondary structure guidance.

198. Is there any guidance available specifically for composite structures?
Yes. See Policy Statement PS-ACE100-2001-006, "Static Strength Substantiation of Composite Airplane Structure".

23.603 Materials and workmanship (Amendment 23-23)

199. Is there any guidance available specifically for composite structures relative to materials and workmanship?
Yes. The following advisory circular and policies on composites are related to this section:

- Advisory Circular 23-20, "Acceptance Guidance on Material Procurement and Process Specifications for Polymer Matrix Composite Systems"
- Policy Statement PS-ACE100-2001-006, "Static Strength Substantiation of Composite Airplane Structure"
- Policy Statement PS-ACE100-2002-006, "Material Qualification and Equivalency for Polymer Matrix Composite Material Systems"
- Policy Statement PS-ACE100-2004-10030, "Substantiation of Secondary Composite Structures"
- Policy Statement PS-ACE100-2005-10038, "Bonded Joints and Structures – Technical Issues and Certification Considerations"

200. Is there any policy available for glass fiber fabric? See AC 20-44, Glass Fiber Fabric for Aircraft Covering, for more guidance about this airworthiness standard topic.

201. Is there any policy available for floats constructed from composite materials? Both Technical Standard Order TSO-C27 and National Aircraft Standards NAS 807, "Twin Seaplane

Floats," and AC 20-107A, Composite Aircraft Structure, contain guidance and criteria for floats constructed from composite materials. While NAS 807 does not specifically address composite materials, the standards in Section 3, Material and Workmanship, and in Section 4.2, Strength, are general enough to apply to materials other than the conventional aluminum materials normally employed.

202. Are there any special considerations for composite materials (relative to floats)? Composite materials require special considerations for handling and storage that are not commonly required for metallic materials. These factors may affect material and process specifications.

203. Do any special factors apply for composite materials (relative to floats)? In addition to the 1.5 factor of safety, another factor could be applied for material variability when substantiated by tests. Environmental effects include moisture, saltwater exposure, ultraviolet light, temperature variations, material composition, and geometric dimensions. These factors can be required under Section 4.2.1, Material Strength Properties, and Section 4.2.3.1, Special Factors, of NAS 807.

204. What kind of defect testing should I consider for composite materials (relative to floats)? Component static strength tests should include defects such as disbonds and voids. They should also reflect impact damage, up to the threshold of detectability, for the inspection system in use during manufacturing and operations. Both defects and impact damage should be located in critical areas that are expected as a result of production assembly bonding processes, and in operational service conditions. The designer should identify the nature and size of such defects, and damage. The manufacturer should have an inspection system functioning during production and operational service. This system should ensure that defects do not reduce structural strength below ultimate load. Critical areas should include bonding of support strut attachment fittings to the basic structure. An alternative approach would be the use of mechanical fasteners, in critical areas, where bonding defects would cause critical loss of strength.

205. What are some considerations regarding corrosion when dealing with composite materials (relative to floats)? Galvanic corrosion may occur when unprotected metal is in contact with graphite composite material in a corrosive environment. Affected metal parts will need suitable protection. Cadmium plated metals will corrode. Use fasteners made of corrosion resistant materials (e.g., titanium or corrosion resistant steel). Also, the bonds of aluminum parts in contact with composite material (including fiberglass) may seriously degrade over time due to moisture absorption. Special treatment (e.g., phosphoric anodizing) of the aluminum is necessary to maintain the original strength of the bond.

206. Are there any fatigue requirements for composite materials (relative to floats)? Fatigue requirements appearing in NAS 807, Section 4.2.1, are minimal; they are also identical to the Civil Air Regulations (CAR) 3.307 general requirement for airframe construction. The FAA has generally not required fatigue testing or analysis to meet this requirement. Float service history has generally been satisfactory and more stringent fatigue requirements have not been applied to part 23 airplane landing gear, therefore, AC 20-107A, Section 6, Proof of Structure - Fatigue, does not apply. However, the manufacturer should develop instructions for appropriate tests or inspections to detect problems of hidden damage or delaminations. The manufacturer should also develop repair instructions for the composite material structures. For float design, maintaining the integrity of watertight compartments is a special concern—disbonding or delaminations that cause inter-compartment leakage may reduce the level of safety intended by part 23, § 23.751 and CAR 3.371.

207. Are there any requirements for maintenance instructions (relative to floats)? There are no requirements for maintenance instructions under the TSO general requirements (refer to part 21, Subpart O) or in both TSO-C27 and NAS 807 specifications for seaplane floats. However, § 21.50(b) requires that the applicant prepare Instructions for Continued Airworthiness according to § 23.1529 for each supplemental type certificate (STC) applied for after January 28, 1981.

208. Is there additional guidance for this topic?

a. See AC 20-107A for additional guidance about this airworthiness standard topic.

b. All composite structures that are critical to flight safety should be designed to be damage tolerant. If impractical, the applicant is referred to § 23.573(a)(6), Damage tolerance and fatigue evaluation of structure. The manufacturer should substantiate scatter factors. Consider the following items when demonstrating the damage tolerance capability of structures critical to safe flight:

(1) Introduce manufacturing defects and realistic impact damage up to the threshold of detectability.

(2) Substantiate the static ultimate load retention capability with impact damage up to the threshold of detectability.

(3) Introduce initially detectable damage.

(4) Apply a statistically significant number of flight-by-flight spectrum repeated-load cycles to validate one lifetime or an inspection interval for operational service use. An inspection program suitable for operation and maintenance application needs to be developed by considering the damage growth.

(5) Limit load retention capability should be demonstrated after repeated-load cycling.

(6) Environmental accountability should be included in the above demonstrations.

(7) Residual strength capability to withstand critical limit flight loads should be demonstrated. Demonstrate this with the extent of detectable damage consistent with the results of the damage tolerance evaluations and the maximum disbonds of bonded joints permitted by design. (The damage tolerance evaluations include damage sizes ranging from small detectable damages to larger damage sizes that are possible in service.) Consider the two damages separately.

(8) All tests should be on actual composite material being used. The alternative use of any other composite material should be substantiated.

(9) Repair procedures may be part of the substantiation program and can be published in the Continued Airworthiness Section of the Maintenance Manual. This is not a regulatory requirement, but rather a highly desirable FAA goal.

(10) All ultimate static tests on structures critical to flight safety should be conducted on full-scale component articles. Environmental effects should be considered.

(11) All critical conditions should be substantiated by tests, or by analysis supported by tests.

209. Is there any guidance on solar and thermal effects when designing composite airplane structures?

a. The thermal environmental analysis should be based on a parametric study of the following data to identify the highest structural temperature:

Hour	Ambient Temperature (°F)	Solar Radiation (Btu/ft^2 /hr)
1100	111	330
1200	114	355
1300	119	355
1400	122	330
1500	123	291
1600	124	231
1700	123	160

NOTE: The above temperature values would not be exceeded 99.9 percent of the time, as derived from MIL-STD-210C statistical data. For the above data, the wind speed was 14 feet per second, and the relative humidity was 3 percent.

b. The effect of cooling airflow may be considered. We recommend that, after heat soak at the critical condition, the airplane taxi, take off, and climb to 1,000 feet above sea level. The airplane should accelerate in level flight to:

(1) The lesser of the design maneuvering speed, (V_A); or the aircraft operating speed limit (in § 91.117(b)) if maneuver loads are critical;

Or,

(2) The lesser of the design cruise speed, (V_C), or the aircraft operating speed limit (in § 91.117(b)) if gust loads are critical.

NOTE: In a commuter category airplane, the design speed for maximum gust intensity, (V_B), applies instead of the design cruise speed, (V_C). The aircraft operating speed limit in § 91.117(b) is 200 knots. This applies to major structure and may not be applicable to certain structures, such as flaps and landing gear doors that would be subject to limit loads at an earlier time in the flight profile. For a small airplane, a maximum taxi speed of 10 m.p.h. is recommended. A four-minute taxi-time would be reasonable.

23.605 Fabrication methods (Amendment 23-23)

210. Is there any guidance available specifically for composite structures relative to fabrication methods?
Yes. The following advisory circular and policies on composites are related to this section:

- Advisory Circular 23-20, “Acceptance Guidance on Material Procurement and Process Specifications for Polymer Matrix Composite Systems”
- Policy Statement PS-ACE100-2001-006, “Static Strength Substantiation of Composite Airplane Structure”
- Policy Statement PS-ACE100-2002-006, “Material Qualification and Equivalency for Polymer Matrix Composite Material Systems”
- Policy Statement PS-ACE100-2004-10030, “Substantiation of Secondary Composite Structures”
- Policy Statement PS-ACE100-2005-10038, “Bonded Joints and Structures – Technical Issues and Certification Considerations”

211. Are there any known processes that may have detrimental effects on a material?

a. The FAA found the process of paint removal by the Plastic Media Blasting method to show varying degrees of decrease in fatigue life and an increase in crack growth rate. Reports submitted by Battelle, Columbus Laboratories, indicate variations were experienced, depending on the material, material thickness, and number of plastic bead blastings. The FAA is concerned about the detrimental effects that plastic bead blasting could have on the static and fatigue strength of the base metal(s) when removing the paint or protective coating.

b. To approve a process specification for Plastic Media Blasting paint removal, it is necessary to establish that the method is not damaging to the aircraft; therefore, as a minimum, the following parameters should be considered:

(1) Material variations, e.g., 7075-T6 alclad, 7075-T6 bare, 2024-T3 alclad, 2024-T3 bare, etc.;

(2) Paint, primer, and number of coatings to be removed;

(3) Plastic media size and type;

(4) Plastic media hardness;

(5) Nozzle pressure (maximum);

(6) Distance (nozzle to component);

(7) Angular nozzle displacement;

(8) Plastic media (mesh) flow level and nozzle diameter; and

(9) Dwell time.

c. Plastic media vendor suppliers should demonstrate that their materials could be supplied to the same standards (shown above).

d. Coupon tests for static strength and fatigue properties (including crack initiation and propagation) should demonstrate the compatibility of the material and the non-plastic media blasted material.

e. Blasting equipment users should demonstrate that the equipment would give the proper pressures and precise metering of the plastic media flow rate. The media separator should be capable of removing foreign particles from the reclaimed media using methods, such as the following:

(1) Vibrating screens;

(2) Magnetic separation;

(3) Electrostatic separation;

(4) Floatation method;

(5) Liquid gravity settling;

(6) Wet classification;

(7) Dry screening;

(8) Air separators;

(9) Gravity separators;

(10) Fixed chamber separators; and

(11) Mechanical separators or cyclone classifiers.

212. Is wood spar construction with Weldwood Plastic Resin Glue approved? Weldwood Plastic Resin Glue has been approved for wood spar construction in a few airplanes.

23.607 Fasteners	(Amendment 23-48)

213. Is it appropriate to use self-locking nuts without a secondary locking mechanism?

a. Self-locking nuts, alone, should not be used in any system when movement of the joint may result in motion of the nut or bolt head relative to the surface against which it is bearing. Joint seizure (bearing, uniball, or bushing) does not have to be considered by this regulation when determining the relative motion of the parts in question, although it is advisable to do so. Suitable protection and material properties of the joint are required by part 23, §§ 23.609 and 23.613.

b, Self-locking castellated nuts, with cotter pins or lockwire, may be used in any system.

c. Self-locking nuts should not be used with bolts or screws on turbine-engine airplanes in locations where the loose nut, bolt, washer, or screw could fall or be drawn into the engine air-intake scoop.

d. Self-locking nuts should not be used with bolts, screws, or studs to attach access-panels or doors, or to assemble any parts that are routinely disassembled before or after each flight. This advice does not intend to exclude self-locking nut plates in these named applications. Nut plate designs permit the fastener to float, which is a desirable feature that is not provided by a non-floating fastener device.

214. Is there any intended difference between the terminology used in paragraph (a), "retaining devices," and that used in paragraph (b), "locking devices"? No. The lack of consistency in the terminology between these two paragraphs was not intentional. The terminology "retaining devices" (in paragraph (a)), is identical in meaning and purpose to "locking devices" (in paragraph (b)), in this instance.

215. Is there any related guidance material on this subject? Yes. See AC 20-71, Dual-Locking Devices on Fasteners, for guidance about removable-fastener dual-locking devices for rotorcraft and transport category aircraft.

23.609 Protection of structure	(Original)

216. Is there any policy available on this section as of January 1, 2007? No.

217. Is there any guidance available specifically for composite structures relative to protection of structure? Yes. See Policy Statement PS-ACE100-2001-006, "Static Strength Substantiation of Composite Airplane Structure".

23.611 Accessibility (Amendment 23-48)

218. Is there any policy available on this section as of January 1, 2007? No.

23.613 Material strength properties and design values (Amendment 23-45)

219. Is there any policy available on this section as of January 1, 2007? No.

220. How should the structural test article be configured?

a. Ideally, the structural test article (a whole wing, an empennage, a fuselage, etc.) would contain all elements that are made of specification guaranteed-minimum-strength materials. Also, each element's physical dimensions (geometry) would be at the nominal size, plus or minus specified tolerances, to conservatively represent the least strength or least stiff part that could be used according to approved design data (drawings, specifications, stress, or structural analyses).

b. Parts (elements) are manufactured and delivered to nominal sizes within tolerances. This means that they will either deliver minimal performance or more than promised.

221. How do I determine the strength of the airplane's structure?

a. There are, fundamentally, four actions an airplane designer can take to determine the strength of the airplane's structure:

(1) The designer can analyze the airplane structure to both limit and ultimate load conditions, using guaranteed minimum-strength-material properties and conservative geometric characteristics;

(2) The designer can test the airplane structure to limit loads and then analyze the airplane structure to ultimate loads;

(3) The designer can test the airplane structure to limit loads and, later, to ultimate conditions; and

(4) The designer can test the airplane structure to beyond ultimate load conditions.

b. This last option is usually chosen to determine excess strength or growth capabilities. It also exceeds the minimum FAA airworthiness standards for which compliance should be shown. Certain airworthiness standards require one of these methods instead of the others.

c. An applicant should substantiate that the strength properties of components used in structural tests are such that subsequent components used in airplanes presented for certification will have strengths equal to or exceeding the demonstrated strength of the tested components.

d. If the applicant chooses to demonstrate strength capability by tests of structural components, the applicant should substantiate that the strength of the tested component conservatively represents the strength of subsequent production components. Substantiating data might include quality control data, material and process specifications, material certifications, coupon sampling tests, or other appropriate information.

e. An applicant may also apply material correction factors to the applied test loads to account for material variability. Applicants should use material correction factors for ultimate load tests of single load path critical flight structure and for fail-safe tests of dual load path critical flight structure with one load path failed. Applicants do not need to use material correction factors for limit load tests or for ultimate load tests of fail-safe designs where loads from one failed component are distributed to and carried by two or more remaining components.

222. Is there any guidance available specifically for composite structures relative to material strength properties and design values? Yes. See Policy Statement PS-ACE100-2001-006, "Static Strength Substantiation of Composite Airplane Structure".

223. Are there any other useful references for this section? Yes. See AC 20-33B, Technical Information Regarding Civil Aeronautics Manuals (CAM's) 1, 3, 4a, 4b, 5, 6, 7, 8, 9, 13 and 14; CAM 3, paragraphs 3.174-1 and 3.301-1; and CAM 4a, paragraph 4a.230.

224. Are there any other part 23 rules related to the material correction factors?

a. Yes. See §§ 23.305(a) and (b); 23.307(a); 23.603(a); 23.613(c); and, before Amendment 23-45, § 23.615(a) and (c).

b. Section 23.305, paragraphs (a) and (b), Strength and deformation requirements, § 23.307(a), Proof of structure standards, and § 23.603(a)(1), Materials and workmanship regulations has one objective. The objective is that the lowest strength conforming airframe produced to a set of FAA-approved type design data will comply with the requirements of § 23.305.

23.615 Design properties	(Amendment 23-45) [Removed]

23.619 Special factors	(Amendment 23-7)

225. Can you summarize the various special factors and where they are located? Yes. This table (see Figure 9) summarizes various special factors and where they are located. Read the appropriate airworthiness standards to determine when these special factors replace the factor of safety and when they multiply the factor of safety.

FIGURE 9
SUMMARY OF VARIOUS SPECIAL FACTORS

	§ 23.303	§ 23.365	§ 23.621	§ 23.623	§ 23.625
Factor of Safety	1.5				
Burst pressure factor		1.33, 1.67 with Special Conditions			
Casting factor			1-1.25 1.25-1.5 1.5-2.0 2.0-higher		
Bearing factor				FS = 6.67 FS ≥ 3.33 2.0≤FS≤3.33	
Fitting factor					1.15 1.33

226. What is the difference between a Factor of Safety and a Margin of Safety, and how is the Factor of Safety determined relative to § 23.303 – Figure 9?

Traditionally, a Factor of Safety (FS) is defined as the maximum allowable load (P) divided by the maximum applied load (p);

FS = P/p

A Margin of Safety (MS) is defined as the Factor of Safety minus one;

MS = FS – 1 = (P/p) –1

The Factor of Safety as discussed in Figure 9, relative to **§ 23.303** refers to the multiplying factor used to determine the ultimate loads from the limit loads (**§ 23.301**(a)). In other words:

Ultimate Load = [Limit Load] * [FS] = [Limit Load] * [1.5 (minimum)]

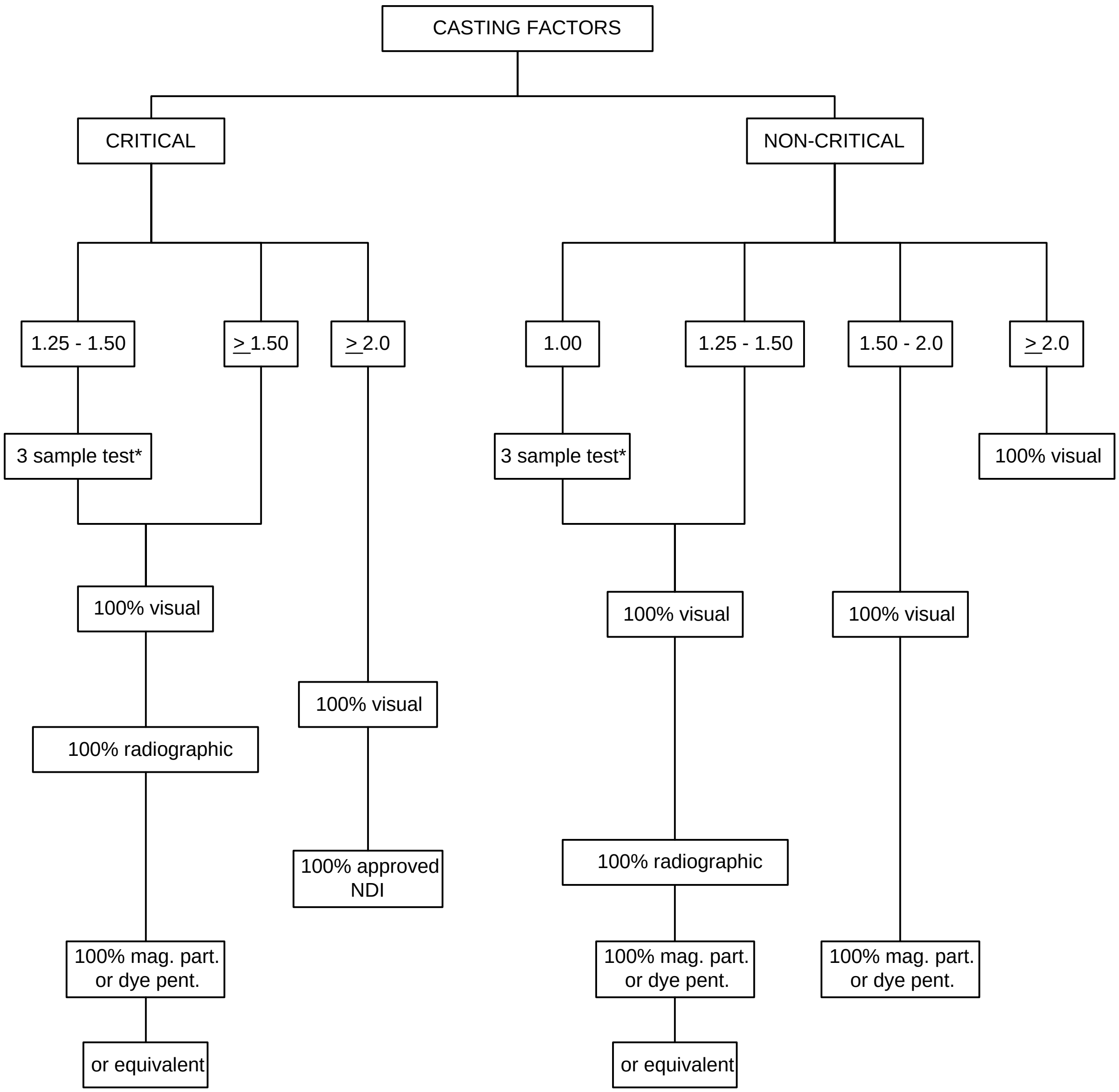
227. Is there any guidance available specifically for composite structures relative to special factors? Yes. See Policy Statement PS-ACE100-2001-006, “Static Strength Substantiation of Composite Airplane Structure”.

23.621 Casting factors	(Amendment 23-45)

228. Is there any policy available on paragraph (a), (b) or (e) of this section as of January 1, 2007? No.

229. Can you summarize the inspection requirements for a given casting factor as dictated by paragraphs (c) and (d) of this section? Yes. The following logic tree (Figure 10) permits a reader to quickly determine the inspection requirements associated with a chosen casting factor.

FIGURE 10
CASTING FACTOR INSPECTION REQUIREMENTS



* Ultimate load corresponding to a casting factor of 1.25 (U = L x 1.5 x 1.25 = 1.875L); deformation requirements of § 23.305 at a Load = 1.15 x L, where U = ultimate and L = limit load.

23.623 Bearing factors (Amendment 23-7)

230. Is there any policy available on this section as of January 1, 2007? No.

23.625 Fitting factors (Amendment 23-7)

231. Is there any policy available on paragraph (a), (b) or (c) of this section as of January 1, 2007? No.

232. Should the 1.33 fitting factor be applied to the dynamic emergency landing conditions as well as the static emergency landing conditions (see part 23, §§ 23.562 and 23.561, respectively)? The seat attachment fittings must be included in the dynamic test and, therefore, there is no need to apply a fitting factor.

23.627 Fatigue strength (Original)

233. Is an actual fatigue evaluation required? Regarding the fatigue evaluation (under part 23, § 23.627), the FAA has interpreted this standard as requiring only that the manufacturer exercise good design practice when avoiding severe stress concentrations, but not requiring a fatigue evaluation in itself.

234. What is meant by the "fatigue limit" (also known as the endurance limit)? When the results of a fatigue test are plotted on an S-n diagram (stress versus number-of-cycles to failure), the fatigue limit is the constant stress level reached at a high number of cycles. Below that stress level, failure is not expected to occur. Aluminum alloys may not show a clearly defined fatigue limit. Guidance provided in FAA report AFS-120-73-2, Fatigue Evaluation of Wing and Associated Structure on Small Airplanes, defines the fatigue endurance limit as the stress at 3×10^7 cycles.

235. Is there additional guidance available for this section? Yes. See AC 23-13, Fatigue and Fail-Safe Evaluation of Flight Structure and Pressurized Cabin for Part 23 Airplanes, for additional guidance about this airworthiness standard topic.

23.629 Flutter (Amendment 23-48)

236. When did the regulations start requiring flutter clearance to 1.2 V_D for the rational analysis? Flutter clearance, using rational analyses, has been required to 1.2 V_D since Amendment 23-7 became effective on September 14, 1969. Clearance, for true or equivalent airspeed, depends on whether appropriate density correction factors are included in the analysis. Before Amendment 23-7, including Civil Air Regulations (CAR) 3, it was required to show flutter-free operation to 1.0 V_D only.

237. When was the first authorization of the use of AEER 45 as a means of meeting flutter prevention requirements? Authorization to use AEER 45 (corrected February 1952) as a means of meeting the flutter prevention requirements of CAR 3.311 first appeared in Civil Aeronautics Manual (CAM) 3.311-1 on March 13, 1952. The simplified criteria do not specify applicable airspeed or altitude limits.

> **NOTE**: Existing copies of AEER 45 are undated and do not indicate if they are corrected. The correction appears on page 8 in the equation at paragraph 3(a). The corrected equation constant is 48.

238. What is history of the airspeed and altitude (if any) limitations for the use of AEER 45?

a. Under **CAM 3.311-1**, no airspeed or altitude limits were given.

b. On December 1, 1978, Amendment 23-23 established an airspeed limit less than 260 knots equivalent airspeed (EAS) at altitudes below 14,000 feet and less than Mach 0.6 at altitudes at and above 14,000 feet. See below.

Amendment 23-23

V_D < 260 EAS below 14,000 feet

and

M_D < Mach 0.6 at and above 14,000 feet

c. On January 8, 1979, AC 23.629-1, Means of Compliance with Section 23.629, "Flutter," set new lower airspeed limits for AEER 45 to a design dive speed less than 200 m.p.h. EAS at altitudes below 14,000 feet. See below.

AC 23.629-1

V_D < 200 m.p.h. EAS below 14,000 feet

d. On October 23, 1985, FAA published revised AC 23.629-1A and changed the airspeed limits for AEER 45 to a design dive speed less than 260 knots EAS at altitudes below 14,000 feet. See below.

AC 23.629-1A

V_D < 260 EAS below 14,000 feet

e. On September 7, 1993, Amendment 23-45 again changed the Mach number for AEER 45 to a design dive Mach number less than Mach 0.5 to closely agree with the calculated Mach number at 14,000 feet and 260 knots EAS. See below.

Amendment 23-45

V_D < 260 EAS

and

M_D < Mach 0.5 at and above 14,000 feet

f. Note that part 23 never established an altitude limitation on the applicability of AEER 45. Speed units, although not addressed in AEER 45, have historically been taken as EAS—

except for wing torsional stiffness criteria that specify indicated airspeed (IAS) be used. However, at 14,000 feet in altitude, the difference between EAS and IAS is small (about 3½ knots).

239. When did flight flutter tests become a requirement? Amendment 23-48 made flight-flutter tests a requirement. Before February 9, 1996, the date of the amendment, freedom from flutter, control reversal, and divergence could be shown by either a rational analysis, by flight-flutter tests, or by simplified flutter prevention criteria. For all new type certification projects for which application was made after February 9, 1996, flight flutter tests are required to demonstrate compliance to § 23.629.

240. Where can I get a copy of AEER 45? Airframe and Equipment Engineering Report No. 45, "Simplified Flutter Prevention Criteria for Personal Type Aircraft," by Robert Rosenbaum, and Civil Aeronautics Manual 3, Supplement No. 11, dated March 28, 1952, may be used for simple airplane designs to show compliance with flutter. Copies may be obtained by mail from the following: Manager, Standards Office (ACE-110), Federal Aviation Administration, Small Airplane Directorate, DOT Building, 901 Locust, Room 301, Kansas City, MO 64106.

241. How can I achieve the objective of paragraph (f) of this section?

a. The objective is to prevent airplane flutter from occurring after the failure, malfunction, or disconnection of any single element in the primary flight-control system, in any tab-control system, or in any flutter damper. Balancing the control systems and then showing that the airplane is free from flutter can achieve this. Alternatively, the objective can also be shown by doing the following:

(1) Incorporating a structural fail-safe design throughout the entire flight-control system and then demonstrating that the airplane is free from flutter; or

(2) Incorporating a combination of structural fail-safe designs and balanced-control system.

b. If a hinge pin single failure would allow the pin to fall out of the hinge, create hinge design features to prevent the pin from separating.

242. Is the fail-safe design criterion of § 23.572(a)(2) an acceptable method of compliance for flutter? No. Section 23.629(f)(2) requires the failure, malfunction, or disconnection of any single element be considered. Both control-surface balance and dual-load, path-tab-system designs have been judged as meeting the airworthiness requirement for irreversible systems.

243. Why isn't the fail-safe design criterion of § 23.572(a)(2) an acceptable method of compliance for flutter? The fail-safe criterion in § 23.572(a)(2) imposes a static ultimate-load factor of 75 percent of the critical limit-load factor at design cruise speed, V_C. This criterion is inadequate for flutter substantiation of dual-load path primary-control systems, or tab-control systems because of the lower speeds and lower structural loads imposed.

244. Is there any additional guidance available for this section? Yes. See AC 23.629-1B, Means of Compliance with Section 23.629, "Flutter," for additional information about this airworthiness standard topic.

WINGS

23.641 Proof of strength	(Original)

245. Is there any policy available on this section as of January 1, 2007? No.

CONTROL SURFACES

23.651 Proof of strength (Original)

246. Is there any policy available on this section as of January 1, 2007? No.

23.655 Installation (Amendment 23-45)

247. Is there any policy available on this section as of January 1, 2007? No.

23.657 Hinges (Amendment 23-48)

248. Is there any additional guidance available for hinges? See 23.393, Loads parallel to the hinge line, for additional guidance about hinges. Also see 23.651, Proof of strength, for information that may affect hinges.

23.659 Mass balance (Original)

249. Is there any policy available on this section as of January 1, 2007? No.

APPENDIX A TO PART 23—Simplified Design Load Criteria

A23.1(a) References:

1. Clousing, Lawrence A. and Turner, William N.: Flight Measurements of Horizontal Tail Loads on a Typical Propeller-Driven Pursuit Airplane During Stalled Pull-Outs at High Speed. RMR (WR A - 81), May 1944.

2. Matheny, Coyce E.: Comparison Between Calculated and Measured Loads on Wing and Horizontal Tail in Pull-Up Maneuvers. ARR L5H11 (WR L-193), Oct. 1945.

3. Garvin, John B.: Flight Measurements of Aerodynamic Loads on the Horizontal Tail Surface of a Fighter-Type Airplane. TN 1483, Nov. 1947.

4. Sadoff, Melvin and Clousing, Lawrence A.: Measurements of the Pressure Distribution on the Horizontal-Tail Surfaces of a Typical Propeller-Driven Pursuit Airplane in Flight. III—Tail Loads in Pull-Up Push-Down Maneuvers. TN 1539, Feb. 1948.

5. NACA Flight Research Maneuvers Section: Flight Studies of the Horizontal-Tail Loads Experienced by a Modern Fighter Airplane in Abrupt Maneuvers. Report 792, 1944.

6. AC 23-15A, Small Airplane Certification Compliance Program

The first paragraph of the Reference 1 CONCLUDING REMARKS reads:

"With the test airplane operated within maneuvering limits which were considered safe by design specifications in use at the time the airplane was designed, units loads were measured on the stabilizer which were not only considerably in excess of the design unit loads, but which occurred in a direction opposite to the design loads."