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MILITARY SPECIFICATION

AIRPLANE STRENGTH AND RIGIDITY GROUND TESTS

This specification is approved for use within the Naval Air Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification contains the requirements which, in combination with other applicable specifications, define the ground tests required for structural evaluation of fixed wing piloted airplanes. The types of testing include, but are not limited to:

a. Design development tests.

b. Pre-production component tests.

c. Static tests-complete airframe.

d. Fatigue tests-complete airframe.

e. Drop tests of structurally complete airframe.

f. Cabin pressure tests.

g. Leakage tests of integral fuel tanks.

h. Structural dynamic tests.

i. Proof tests for flight articles.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Naval Air Engineering Center, Systems Engineering and Standardization Department (Code 53), Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document, or by letter.

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1.2 Purpose. The purpose of this specification is to define the requirements for laboratory structural tests for development and proof-of-design of strength and rigidity of Navy fixed wing piloted airplanes.

1.3 Modifications and amplifications. This specification will be modified and amplified by contracts, by type and detail specifications, and by design data specifications and addenda thereto.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

MILITARY

MIL-L-8552	Landing Gear, Aircraft Shock Absorber (Air and Oil Type).
MIL-D-8708	Demonstration Requirements For Airplanes.
MIL-A-8860	Airplane Strength and Rigidity - General Specification for.
MIL-A-8863	Airplane Strength and Rigidity - Ground Loads for Navy Procured Aircraft.
MIL-A-8866	Airplane Strength and Rigidity - Reliability Requirements, Repeated Loads, Fatigue and Damage Tolerance.
MIL-A-8868	Airplane Strength and Rigidity - Data and Reports.
MIL-A-8870	Airplane Strength and Rigidity - Vibration, Flutter, and Divergence.

STANDARDS

MILITARY

MIL-STD-2066	Catapulting and Arresting Gear Forcing Functions for Aircraft Structural Design.

(Copies of specifications and standards required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

2.1.2 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets, or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 General. The contractor shall furnish test specimens for performance of tests specified herein as modified and amplified by the contract or supporting contractual documentation. Repairs or replacement of parts shall be made to test specimens as necessary to permit performance of tests to the specified loads herein. These repairs or replacements shall be representative of those installed in the flight test articles and fleet airplanes unless, for the convenience of the Government, the Government specifically decides otherwise. Such repairs or replacements shall be demonstrated by test or analysis as specified by the Government to comply with contract test objectives.

3.1.1 Terminology. Definitions and symbols are in accordance with 6.5 through 6.5.15 herein, MIL-A-8860, and MIL-A-8870.

3.1.2 Location of tests. The contract will specify whether the tests are to be performed by the Government or by the contractor at his plant.

3.1.3 Test witnesses. Before performing a required test, the contracting activity representative shall be notified in sufficient time so that he may witness the test and certify results and observations contained in the test report. When the contracting activity representative is notified, he shall be informed if the test is such that interpretation of the behavior of the structure under load is likely to require engineering knowledge and experience so that he may provide a qualified engineer to witness the test and certify the observations and results recorded during the test.

3.1.4 Tests performed by the Government. In the event structural tests are performed by the Government, the contractor shall provide test personnel to act in an advisory capacity in connection with the planning and execution of the tests. The advisory personnel shall be familiar with the stress analysis of the test structure. All loads and analysis data and drawings that will be required by the Government in the planning and performance of the tests are specified in MIL-A-8868. The responsibility for stopping any tests upon indications of premature failure and for making necessary structural alterations or reinforcements to preclude premature failure shall rest with the contracting activity. The contractor shall be responsible for services and material necessary to incorporate changes in the test article to preclude premature failure, and for repairs after failing load tests.

3.2 Design development and pre-production tests. For the initial phase of the required structural verification program, the contractor shall conduct design development and pre-production component tests as defined herein.

3.2.1 <u>Design development tests</u>. These tests are to establish design concepts, and to provide design information and early design validation. Design development, static and fatigue tests include but are not limited to:

a. Element tests for:

(1) Materials selection including crack propagation, fracture mechanics, and structural allowables.

(2) Fatigue spectrum variation effects.

(3) Process evaluation, including assessment of finish.

(4) Fastener and bonding evaluation.

(5) Manufacturing methods evaluation.

b. Structural configuration development tests for:

(1) Splices and joints.

(2) Panels (basic section).

(3) Panels with cutout.

(4) Fittings.

(5) Critical stuctural areas which are difficult to analyze due to complexity of design.

3.2.1.1 <u>Design development tests composites</u>. These tests are used to establish design allowables, verify analysis, and evaluate design details. Additionally, the design development tests are a part of the overall structural certification procedure in that the test results are used in the interpretation of the full-scale airframe static and fatigue test results. Design development tests range in complexity from coupon tests that are used to evaluate material and fastener behavior to full-scale components such as wing torque box structure and landing gear backup structure. Both static and fatigue tests are required in the design development test program. The actual number and types of tests required will depend upon the aircraft design. A design development test plan shall be prepared by the contractor and shall require approval by the procuring activity.

3.2.1.2 <u>Design development testing approach for composites</u>. A building block approach to design development testing is essential for composite structures, because of the mechanical properties variability exhibited by composite materials, the inherent sensitivity of composite structures to out-of-plane loads and their multiplicity of potential failure modes. The essence of the building block approach for composites is as follows:

a. Perform design allowables testing using coupon type test specimens. The purpose of design allowables testing is to establish strength and life parameters for structural design. In planning a design allowable test program, it is important that sufficient numbers of tests be conducted to generate meaningful statistical parameters. In general the number of specimens required depends on the scatter of the data. The higher the data scatter, the greater the number of specimens required. The design allowables tests should be planned to develop the strength to temperature/moisture envelope relationship for the full range of the service temperature of the airplane. Tests should provide design allowables for each failure mode anticipated.

b. Use the design/analysis of the airplane structure to select critical areas for test verification. Determine the most strength-critical failure mode for each area selected, and establish the test environment which will produce this failure mode. Special attention should be given to matrix sensitive failure modes such as compression and bondline and potential stress "hot spots" caused by out-of-plane loading. The sensitivity of composite matrix dominated failure modes to the temperature/moisture environment makes environmental test simulation a key issue in a design development program. The approach for static testing should be that the test environment used in the one that produces the failure mode which gives the lowest strength. That is, the worse case environment, or the temperature associated with the most critical load should be used. The environmental complexity necessary for fatigue design development testing will depend on the projected load-temperature profiles in service and the moisture content as a function of the airplane usage and composite laminate thickness.

c. Design and test a series of specimens representing these areas, each one to simulate a single failure mode. These initial specimens will generally be low complexity specimens. From this point a series of specimens should be designed and tested which simulate progressive design complexity. Premature failure or an unanticipated failure mode are indications of flaws in the design and/or analysis and corrective action must be taken before proceeding to the next level of complexity. If mixed failure modes are observed in a certain specimen type, more tests are required to determine the most critical failure mode and the associated mean strength/life. The building block approach is shown in Figure 1 which depicts a typical design development program for a wing structure.

3.2.2 Pre-production component design verification tests. These tests are to allow early verification of the static and fatigue strength capability of final or near-final structural designs of critical structural areas. The pre-production component test program shall be proposed by the contractor and conducted as approved by the contracting activity. These tests shall include but not be limited to:

a. Splices and joints.

b. Fittings.

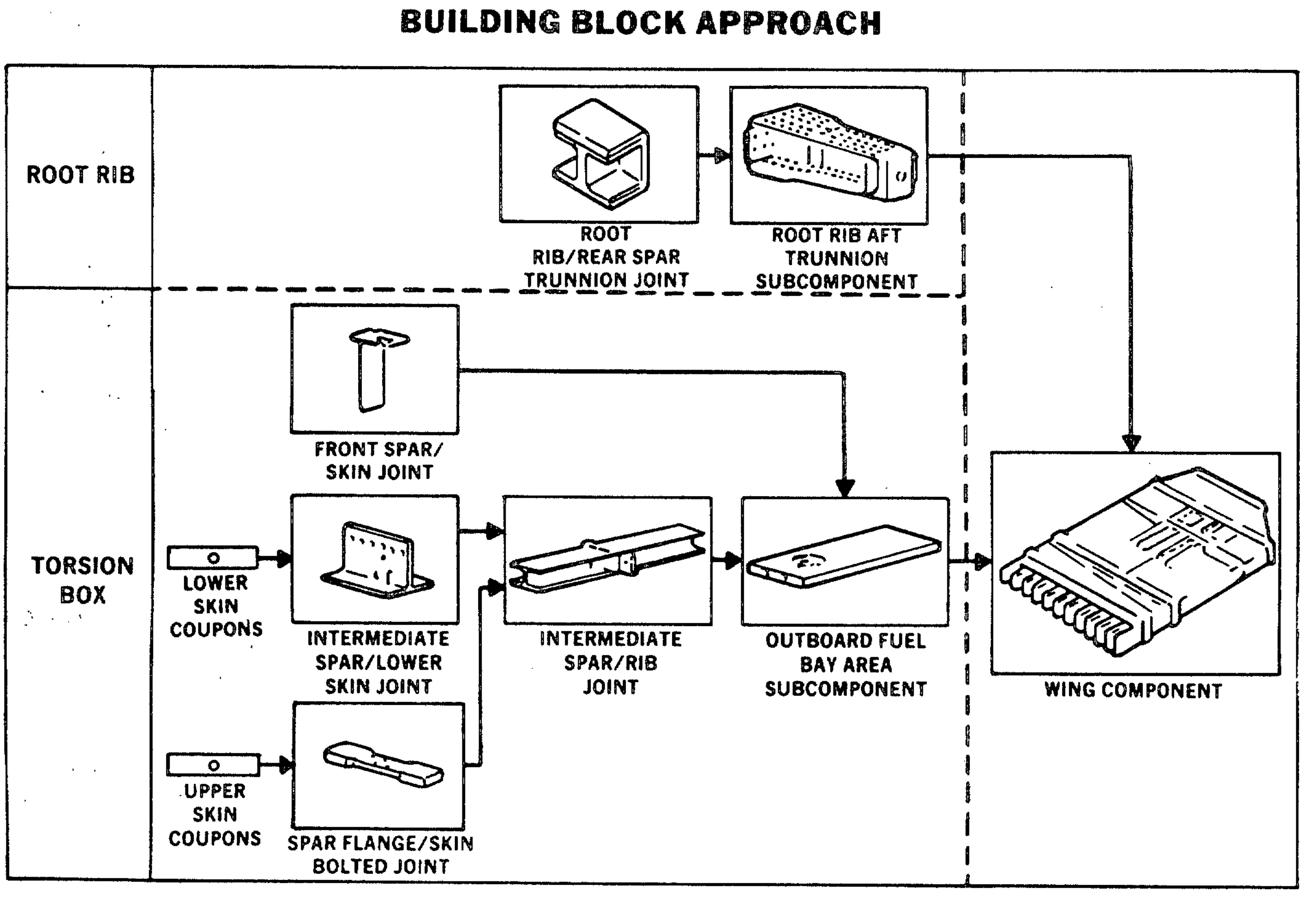


Figure 1. Building block approach.

c. Panels.

d. Assemblies, including 3.2.2a, b, and c, above.

e. Full-scale components such as wing carry-through, horizontal tail support, wing pivots, landing gear and support, composites, etc.

3.3 Full-scale tests. The contractor shall perform tests in accordance with the requirements specified herein, as modified and amplified by the contract or supporting contractual documents, unless the contract specifies that tests will be performed by the Government. Three full-scale laboratory test articles shall be used: one for the static tests; one for the fatigue tests; and one for the drop tests. In addition, an empennage test article shall be used for dynamic fatigue test of 3.9.2.

3.3.1 Sequence of tests. The required structural tests of this specification shall be performed in such sequence and timeliness, that tests to the minimum loads and sinking speeds required prior to release for flight other than normal flying, release for demonstration, delivery of vehicles for preliminary evaluation and trials, and service use shall be completed at least 30 days prior to the scheduled date for such release or delivery. In particular, the structural tests shall be so sequenced that the flight loads survey and demonstration program will not be delayed. Test sequencing shall be such as to minimize the possibility of failures that would result in damage and subsequent repairs that would significantly delay completion or influence the validity of other required structural tests. All tests to design ultimate load and design sinking speeds shall be completed prior to performing failing load tests for any condition. In addition, loads for the failing load test shall reflect the data from the flight load surveys of MIL-D-8708, as applicable. In all cases, the test sequencing shall be approved by the Government prior to starting the test program. The following conditions shall also apply:

a. Repeated load tests of integral fuel tank structures on the test article shall be completed prior to performing tests for any other conditions to loads which would result in permanent deformation of the airframe structure.

b. Design ultimate load tests for flight conditions shall be completed prior to performing tests for other than flight conditions to design ultimate loads or to maximum design loads.

c. Should the test program be delayed such that fleet operations are scheduled before critical testing can be accomplished, the contractor shall revise the sequence of testing as directed by the Navy to ensure that critical testing is accomplished in a timely manner.

3.3.2 Strength-test structures.

a. Items such as fixed equipment and useful load and their support structures may be omitted from the test structure provided the omission of these parts does not significantly affect the load, stress, thermal distributions, or deflection of the structure to be tested, and provided the omitted parts would not be critically loaded in the tests if they were installed. All equipment, bracket, etc. attachment holes must be included.

b. Substitute parts may be used provided specific prior approval is obtained from the contracting activity, they reproduce the effects of the parts for which they are substituted, and the structural integrity of the parts for which substitutions are made are demonstrated by supplementary tests in a manner satisfactory to the contracting activity.

c. The powerplants and accessories may be replaced by a fabricated test fixture that properly transmits the powerplant loads to the powerplant vibration isolators or the engine mounts, or both, as applicable. The means for applying the loads to this fixture (such as, loading rods through the fuselage or engine support structure) shall be determined by the contractor. All structural modifications necessary to accommodate the loading devices shall be designed to assure that the strength and rigidity characteristics of the modified structure will be equivalent to those of the actual structure. All such modifications and test fixture designs shall be as approved by the contracting activity prior to fabrication. Engine access and service doors shall be installed and secured.

d. Paint or other finishes that do not affect strength and rigidity or fatigue structural integrity may be omitted.

e. Prior to any tests, or prior to shipping the test structures to Government facilities for testing, a number of buttock lines, water lines, fuselage stations, and wing stations shall be painted on the test structure. These should be clearly identified and of sufficient number to facilitate determining all desired reference points on the airframe.

f. All mechanical portions of the flight control system must be intact and all hydraulic actuators for the control systems shall be operable. When tests are conducted at Government facilities, special provisions shall be made for external hydraulic attachments to the actuating cylinders to permit externally controlled operation. When external power is to be utilized, any unnecessary portions of the normal internal hydraulic systems may be omitted.

g. All other actuating systems such as landing gear doors, armament bay doors, etc., shall be externally operable for tests at Government facilities. Air-actuated systems may be replaced by hydraulic systems in order to simplify testing procedures. The external actuation capability may be utilized for tests conducted by the contractor if test operations can be simplified.

3.3.2.1 Use of tested parts. Unless only proof-load tests are required and specifically approved by the contracting activity, parts of the strength-test structure which have been subjected to structural tests shall not be used on a flight article.

3.3.2.2 Structure to be loaded. All parts of the structure, including carry-through structure, except noncritical parts (the loading of which has no significant influence on critical parts), shall be loaded during a required structural test program. In each test condition, all parts of the structure critical for the pertinent design condition shall be tested and loaded simultaneously. Critical ribs, formers, and frames of each typical design shall be subjected to critical design loading during testing of the component in which these members are incorporated. Class I castings which form part of the primary structure shall have been substantiated by prior tests to failure, and contracting activity approval obtained, prior to performing the structural tests outlined in this specification.

3.3.2.3 Positions of control systems and control surfaces. Control systems and control surfaces shall be displaced to the positions corresponding to the design conditions, or the most critical position, for which the parts are being tested.

3.3.2.4 Test instrumentation.

3.3.2.4.1 General. The contractor shall determine the kind and amount of test instrumentation necessary to comply with the test requirements of this specification. All required instrumentation shall be furnished by the contractor as contractor-furnished equipment (CFE). The method of data acquisition, and the number and type of recording devices for each test shall be proposed by the contractor for approval by the contracting activity.

3.3.2.4.2 Installation, calibration, and maintenance. The contractor shall install and calibrate all airplane instrumentation used in performing the tests. All instruments and instrument systems shall be installed in accordance with the highest standards of mechanical, electrical and electronic installation practices. All transducers and gage installations shall be properly located, be properly damped, have flat frequency response characteristics commensurate with the frequencies of excitation of the variable to be measured, and be properly mounted to assure valid measurements and freedom from extraneous excitations. For dynamic tests, the maximum time lag between any two or more channels requiring time correlation shall not exceed the time constant corresponding to the channel having the lowest flat frequency response requirement. For landing gear jig drop tests, and airplane drop tests, the flat frequency response shall be not less than 60 Hertz for all strain gages, pressure transducers and accelerometers; for displacement and velocity measuring instruments, the flat frequency response shall be not less than 60 Hertz, unless lower response characteristics, if proposed by the contractor, are concurred with by the contracting activity. For such jig or airplane drop tests, the type and location of all transducers, accelerometers, and strain gages shall be identical to those installed in the demonstration airplane as required by MIL-D-8708. Strain gages and/or other instrumentation associated with on-board fatigue monitoring equipment shall be installed on the static, drop, and fatigue articles in the same location and in the same manner as that proposed for the production airplane. Calibration of each transducer or gage installation shall be made through the signal-conditioning equipment as installed in the laboratory to at least the maximum range of excitation expected during the course of the tests. Calibration test measurements shall be obtained and recorded during both increasing and decreasing values of the pertinent parameter which the instrument is intended to measure, to assure repeatability and freedom from hysteresis. All strain-gage installations on simple and complex structures shall be installed to minimize interactions or "cross-talk" during combined loadings; such interactions as do exist shall be properly accounted for during the calibration. Installation of strain-gages which are impossible or impractical to calibrate shall be resorted to only if it can be shown, prior to such installation, that the computed loads from such installations are meaningful and useful. The instrumentation shall be operated and maintained by the contractor during the test program. A detailed description of all instruments and recording devices, methods of calibration, locations of instruments and calibration data for each test and test article shall be documented in accordance with MIL-A-8868.

3.3.2.4.3 Government tests. If and when tests by the government are required under terms of the contract , the contractor shall consult with the designated test activity to determine the kind and amount of instrumentation required. All such required instrumentation shall be installed by the contractor as contractor furnished equipment and calibrated in accordance with the requirements of 3.3.2.4.2. A detailed description of all instruments and recording devices, methods of calibration, location of instruments, and calibration data for these tests shall be documented in accordance with MIL-A-8868.

3.3.2.5 Disposition of strength-test structures. The disposition of strength-test structures, after completion of authorized tests, shall be in accordance with instructions, issued by the contracting activity. Prior to receipt of such instructions, strength-test structures shall not be intentionally damaged or mutilated. The structural test articles shall be prepared for long term storage to avoid corrosion and degradation.

3.3.3 Support during test. Subject to the qualifications of 3.3.4.3, the actual interaction between the component being tested and its adjacent components shall be existent or simulated to the satisfaction of the contracting activity. Structural components may be tested in a jig, loaded by dummy structure, or tested in a jig and loaded by dummy structure only when there is no possibility of interference or deflection that would result in improper loading of the component under test, or adjacent components, and only when the loads and reactions that act on the component being tested are statically determinant or the reactions may be rendered statically determinant by neglecting redundant reactions that do not have a significant effect on loads in the component being tested.

3.3.3.1 Safety devices. When loads are applied in such a manner that they are not relieved when the rate of deformation of the specimen increases rapidly, as when failure occurs, safety devices such as shear links or pressure blow-off valves shall be employed to preclude excessive deformation or overloading of other parts of the structure, or excessive damage to test articles.

3.3.3.2 Support of control systems. All control systems shall be statically tested while installed in the strength-test structure, except that proof load tests required prior to flight shall be performed on a flight article.

3.3.4 Simulation requirements.

3.3.4.1 Test loads to be used. Initial static testing shall be conducted to analytically derived loads and available wind tunnel data. Loads measured in the flight load surveys program shall be incorporated into the static test program at a suitable time if these loads are higher than the analytical loads to the degree specified by the contracting activity. Particular consideration shall be given to the possible magnitude and distribution of loads that can be achieved in airplanes having programmable flight control systems which govern, and are readily capable of altering, the flight characteristics of the airplane.

3.3.4.2 Distribution of loads. The distribution of loads during the test shall duplicate the actual distribution as closely as possible, except as provided in 3.3.4.3.

3.3.4.3 Simplification and combination of loading. If sufficiently justified and if prior approval of the contracting activity is obtained, loading conditions may be simplified for static and repeated load tests. This may be accomplished by modifying the distribution of the loads applied to regions of a structure that (1) are not critical in the loading condition being simulated in the test or (2) are identical in construction to other regions of the structure that are more highly stressed during the same or another test condition. However, simplification of the method of loading shall not be such that unrepresentative permanent deformations or failures will occur. Where feasible, more than one loading condition may be applied simultaneously to different portions of the structure, provided that the interaction of the separate loading conditions does not affect the critical design loading on any portion of the structure.

3.3.4.4 Load application during tests. The first consideration for load application shall be the factor of time. If complete flight condition simulation is required for structural verification, such as, if thermal stresses become significant, then true time-load profiles must be applied to the strength-test structure. If time is not a factor, the test may then be considered a static test and the load shall be applied in discrete increments. Up to limit load, these increments shall be not more than 20 percent of limit load. Test loads between limit load and ultimate load shall consist of load increments not greater than 10 percent of limit load.

3.3.4.5 Environmental effects other than load. All environmental effects which may produce significant reductions in strength of the structure or which may produce significant induced stresses shall be simulated in appropriate tests. These shall include elevated and lower than ambient cryogenic temperature effects. Thermal effects such as produced by high temperatures from aerodynamic heating, engine heat, deicing systems, or other internal sources of heat, and low temperatures, such as, those produced by cold or cryogenic fuels, shall be simulated on a realtime basis in order to produce true thermal gradients. Testing on any other basis, such as, room-temperature increased-load compensation for thermal effects or thermal simulation on a non-realtime basis shall be accomplished only as approved by the contracting activity.

3.3.4.5.1 Static testing of composites. To account for the degradation of material properties due to combined temperature and moisture effects one of the following shall be applied to the testing of composites:

a. Environmentally precondition the test article for the worst case combination temperature-moisture condition and test under these conditions.

b. Select the critical test conditions based upon consideration of potential failure modes and quantitative "compensation" or "knockdown" factors derived from the environmentally compensation design allowables and development test results (as shown in Figure 2).

If the latter is chosen, the actual failure load shall be applied load adjusted by the appropriate environmental and statistical "knock down" factors derived from the design allowable development test results for the same failure mode. Additionally, at 150 percent design limit load all measured strains must not exceed allowable strain levels developed for the worst expected load environmental degradation combinations.

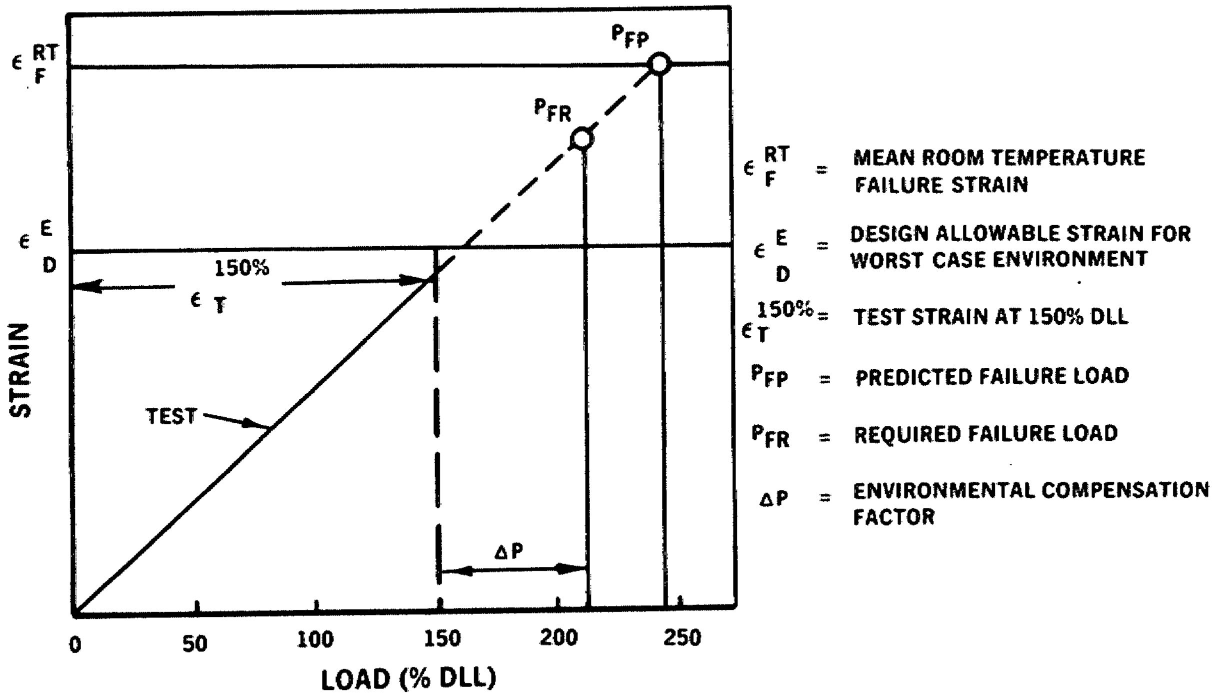
3.3.4.6 Effects of internal pressurization. Critical loads resulting from the pressure differentials on pressurized portions of the structure shall be simulated. This requirement is also applicable to the loads resulting from the pressurization of items of equipment, such as, fuel tanks or cells. When static or fatigue tests of airplane cabins will be performed, the methods of testing shall include means of controlling the release of energy in the event of abrupt failure and shall be subject to contracting activity approval.

3.3.4.7 Sinking-speed increments. The sinking speed increments during drop tests above 80 percent of the maximum design sinking speed shall not exceed one-half foot per second.

3.3.4.8 Simulation of wing lift. The method of simulation of wing lift during airplane drop tests shall be as approved by the contracting activity.

3.3.4.9 Deformation of doors, cowling, locks, and fasteners. During structural tests for flight conditions, the deflection, deformation and operation of doors, cowling, movable and removable coverings, and items of mechanical equipment such as landing gear doors, shall be determined with respect to retention in their intended positions without gapping, and operate as intended, e.g., no unusual force required to open and close doors.

3.3.4.10 Movable surface and variable geometry operational tests. Movable surfaces, including control surfaces, wing pivots, pylon pivots, shall be tested to determine satisfactory functioning within design operating limits. These tests shall be performed with the associated load induced deflection in the movable surface and airplane structure to which the movable surface is attached. These tests may be performed on suitable components up to 1.25 limit load including deflections to 1.25 limit load factor, subject to the approval of the contracting activity.



REQUIREMENTS

- $\epsilon_{T}^{150\%} \leq \epsilon_{D}^{E}$
- $P_{FP} \geq P_{FR}$
- $\dfrac{P_{FR}}{P_{150\%}} \geq \dfrac{\epsilon_{F}^{RT}}{\epsilon_{D}^{E}}$

Figure 2. Static strength testing approach for composites.

3.3.5 Test measurements. All measurements recorded during static and fatigue tests shall be consistent with the test program objectives. Strain, deflection, temperature and applied load data are generally the required measurements, except for specific deviations requested by the contractor and approved by the Government. Measurements shall be made at representative points and of sufficient quantity and accuracy to verify the assumed load distributions, stress analysis, thermal analysis and deflections. For static tests conducted in discrete load increments (see 3.3.4.4), measurements shall be made at each increment. For true-time flight profile testing, the test data will be recorded on a time basis and with a data sampling rate sufficient to accomplish the above required measurement objectives (see MIL-A-8868).

3.3.5.1 Measurements of forces and stroke positions. The vertical, drag, and side forces transmitted through the main and auxiliary landing gear and the stroke positions of the shock absorbers shall be recorded on the same time scale throughout the deceleration of the aircraft in the specified drop tests. Trend curves shall be reviewed prior to the next increment.

3.3.5.2 Measurements of accelerations. Accelerations of engines, wingtip tanks, stores, tails, or other items of appreciable mass that may be significantly affected by the flexibility of the structure shall be recorded on the same time scale throughout the deceleration of the aircraft in the specified drop tests.

3.3.6 Miscellaneous.

3.3.6.1 Determination of deformation load. Compliance with deformation load requirements of MIL-A-8860 for each structural component shall be demonstrated during each test of that component.

3.3.6.2 Failing load tests. Failing load tests shall be conducted as required for specific purposes, such as, fleet inspections and growth potential. The contract addenda will specify required failing load tests.

3.3.6.3 Test-correction factor. Test-correction factors shall be determined and the test results shall be corrected to represent a structure having mechanical properties in accordance with MIL-A-8860, and having minimum dimensions.

3.3.6.4 Metallurgical analysis. Analyses of the failure in each static and fatigue test shall be made to assure that the failure was mechanical in nature or fatigue, and not due to manufacturing or metallurgical peculiarities.

3.3.6.5 Premature failures. If premature failures occur, the cause of the failure shall be determined prior to continuing with or repeating the test and prior to corrective action on test or flight articles.

3.3.6.6 Structural failure definition. A test failure shall be considered the occurence of one or more of the following events during testing:

a. Inability to sustain the applied test load.

b. Evidence yeild and/or permanent set of metal structure at or below 115 percent limit load and no yield of composite structures at 150 percent limit load.

c. Partial or full separation of a bonded or mechanically fastened composite structural joint.

d. Initiation of a crack or delamination in a primary load carrying composite element.

e. Any unpredicted strain redistribution in or nonlinearity within the composite structure at or below 150 percent limit load.

f. Measurement of strains which exceed the environmentally and statistically reduced design ultimate allowables.

g. Any event which creates a condition which will not satisfy fatigue, crack growth or stiffness requirements of MIL-A-8866.

h. Any structural failure that normal service operating conditions would necessitate a structural repair to critical safety of flight components.

The actual failure load of the composite structure shall be the applied load adjusted by the appropriate environmental and statistical "knock down" factor derived from design allowables development test results for the same failure mode.

3.4 Static tests.

3.4.1 Test conditions. Static tests shall be performed as follows in Tables I through IX.

a. Catapulting and arrestment tests (Table I).

b. Wing group tests (Table II).

c. Tail group tests (Table III).

d. Fuselage tests (Table IV).

e. Landing gear installation tests (Table V).

f. Control system tests (Table VI).

g. Engine installation tests (Table VII).

h. Supporting structures for fixed-equipment and useful load items tests (Table VIII).

i. Miscellaneous parts tests (Table IX).

3.4.2 Overpressure, thermal, and gust response. The contractor shall substantiate overpressure, thermal, and gust response limits on critical components by laboratory tests. Results of these tests shall be documented as special weapons delivery capability or supporting document.

3.4.3 Proof tests.

3.4.3.1 Proof tests prior to first flight. Design limit pilot effort shall be applied to each major control subsystem up to the control surface attach points with simulated subsystem blockage at intermediate locations and at the surface. Each major control subsystem shall be operated through its full travel while supporting design-limit hinge moment. These tests shall be conducted on the first flight article. The primary flight control surfaces shall be tested to design limit load and may be conducted on a flight article, on the static test article, or on appropriate test jigs.

3.4.3.2 Pressurized cabin proof tests. Pressurized cabins shall be tested to 1.33 times maximum operating pressure on each flight article prior to pressurized flight.

TABLE I. Catapulting and arrestment tests.

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Airplane	Catapult release	Failing	Simulate transient loading and off-center effects
b.	Airplane	Catapult run	Failing	
c.	Catapult launch bar	Maximum tow load	Failing	Include side load and bending
d.	Airplane	Arresting with maximum drag load and maximum side load	Failing	
e.	Airplane	Arresting with 2.0w drag load and maximum side load	Design ultimate	
f.	Arresting hook	Maximum drag load	Failing	Include side load and bending. Fail each component
g.	Buffing	Maximum side load	Ultimate	

TABLE II. Wing group tests.

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Wing	Most critical condition for wing bending	Failing	
b.	Wing	Second most critical condition	Design ultimate	
c.	Wing	Critical condition with stores	Design ultimate	
d.	Wing	Rolling pull-out-in more critical of basic and high-drag configuration	Design ultimate	
e.	Wing	Negative angle of attack	Design ultimate	
f.	Wing	Gust	Failing	Test to design ultimate if wing more critical for Table IIa above
g.	Center box (variable sweep)	Most generally critical combined bending and torsion condition	Failing	
h.	Outer panel (variable sweep)	Maximum bending moment at pivot	Failing	
i.	Flap and supporting structure	Critical	Failing	
j.	Aileron and supporting structure	Critical	Failing	
k.	Aileron tab and supporting structure	Critical	Failing	Test each type of tab

TABLE II. Wing group tests. - Contiuned

Test	Component	Loading condition	Magnitude of load	Special requirements
l.	Wing-folding or sweeping mechanism and supporting structure	Critical	Design ultimate	
m.	Slat, spoiler, wing-mounted speed-reduction device, leading edge droop, and supporting structure	Critical	Failing	Test each type of slat, spoiler wing-mounted speed-reduction device, leading edge droop, and supporting structure
n.	Barricade engagement	Critcal	Design ultimate	

TABLE III. Tail group tests.

Test	Component	Loading condition	Magnitude of load	Special-requirements
a.	Horizontal tail	Critical stabilizer bending	Stabilizer failing	Applicable also to unit, one-piece, or all movable horizontal tails
b.	Horizontal tail	Critical stabilizer torsion	Design ultimate	
c.	Horizontal tail	Critical loading	Elevator failing	
d.	Elevator tab and supporting structure	Critical	Failing	Test each type of tab
e.	Vertical tail	Critical fin bending	Fin failing	Applicable also to unit, one-piece, or all movable vertical tails
f.	Vertical tail	Critical fin torsion	Design ultimate	

TABLE III. Tail-group tests. Contiuned

Test	Component	Loading condition	Magnitude of load	Special requirements
g.	Vertical tail	Critical rudder loading	Rudder failing	
h.	Rudder tab and supporting structure	Critical	Failing	Test each type of tab
i.	Canard	Critical	Failing	
j.	Canard	Second most critical	Design ultimate	
k.	Tail folding mechanism and supporting structure	Critical	Design ultimate	

TABLE IV. Fuselage tests.

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Fuselage	Maximum vertical bending including torsion	Fuselage failing	Test only to design-ultimate load if the tests specified in Table IVb, c, or d herein are more critical
b.	Fuselage	Maximum lateral bending including torsion	Fuselage failing	Test only to design-ultimate load if the tests specified in Table IVa, c, and d herein are more critical

TABLE IV. Fuselage tests. Contiuned

Test	Component	Loading condition	Magnitude of load	Special requirements
c.	Fuselage	Maximum torsion	Fuselage failing	Test only to design-ultimate load if the tests specified in Table IVa, b, or c herein are more critical
d.	Fuselage	Maximum total tail load	Fuselage failing	Test only to design-ultimate load if the tests specified in Table IVa, b, or d herein are more critical
e.	Fuselage	Flight load - in condition that is critical for fuselage in way of and forward of the wing	Fuselage failing	
f.	Fuselage-mounted speed reduction device and supporting structure	Critical	Failing	Test each type of fuselage-mounted speed reduction device
g.	Fuselage fuel tanks	Critical	Ultimate	

TABLE V. Landing gear installation tests.

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Main landing gear and carry-through structure	Side drift landing, inboard and outboard loads	Max design side loads in combination with max design vertical load	
b.	Auxiliary landing gear and carry-through structure	Critical side load	Design	Turning, steering, pivoting, drift
c.	Main landing gear and carry-through structure	Critical ground towing	Design ultimate	
d.	Auxiliary landing gear and carry-through structure	Critical ground towing	Design ultimate	
e.	Main landing gear retracting mechanism	Critical, including braking	Design ultimate	Gear in most critical position of retracting and alternatively extension cycle
f.	Auxiliary gear retracting mechanism	Critical	Design ultimate	Gear in most critical position of retracting and alternatively extension cycle
g.	Main and nose landing gears	Sudden extension from most critical compressed position and the most critical servicing	Failing	Strut shall have maximum clearance between inner and outer cylinders based on maximum production tolerances

TABLE VI. Control system tests.

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Longitudinal control system	Critical	Failing	Test each type of system. For each system that contains an irreversible mechanism, test the control system on each side of and including the irreversible mechanism
b.	Lateral control system	Critical	Failing	
c.	Directional control system	Critical	Failing	
d.	Control system for tab, slat, spoiler, and speed reduction device, arresting hook, wing fold, leading edge, droop, etc.	Critical	Failing	
e.	Flap control system	Critical	Failing	
f.	Operational		Ultimate	Demonstrate that each control and control system operate under ultimate load

TABLE VII. Engine installation tests.

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Engine installation	Critical symmetrical positive flight condition	Mount failing	
b.	Engine installation	More critical of spin or symmetrical flight conditions	Design ultimate	
c.	Engine installation	Critical nonflight condition	Design ultimate	

TABLE VII. Engine installation tests. - Continued

Test	Component	Loading condition	Magnitude of load	Special requirements
d.	Engine installation	Fail safe	Limit	Demonstrate that catastrophic failure cannot occur if each member, taken separately, fails
e.	Ducts, ramps, inlets	Critical	Failing	

TABLE VIII. Supporting structures for fixed-equipment and useful load items.

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Armament and auxiliary fuel-tank supporting structure	Critical	Design ultimate for less critical condition, failing for more critical condition	Test with typical bomb, missile, rocket, and auxiliary fuel-tank supporting structure for its two most critical conditions including critical combinations
b.	Bomb displacing gear	Critical	Design ultimate	
c.	Seat supporting structure	Critical	Failing	Test each typical seat supporting structure
d.	In-flight fueling installation	Critical	Design ultimate	

TABLE IX. Miscellaneous parts tests.

Test	Component	Loading condition	Magnitude of load	Special requirements
a.	Cockpit enclosure	Critical symmetrical	Failing	Test only to design-ultimate load if test of Table IXb herein is more critical. Simulate temperature gradients.
b.	Cockpit enclosure	Critical unsymmetrical	Failing	Test only to design-ultimate load if test of Table IXa herein is more critical. Simulate temperature gradients.
c.	Hoisting sling	Critical	Failing	
d.	Doors and removable sections	Critical flight	Design ultimate	Test each external door and removable section, excluding small inspection-hole covers. Doors that are supported wholly or partially by retracting mechanisms shall be tested while so mounted. Test also with critical 10 percent of fasteners removed.
e.	Main ribs, bulkheads, and frames	Critical	Failing	Test each main rib, bulkhead, or frame of the wing, tail surface, and fuselage, the design ultimate strength of which is not demonstrated by other tests.
f.	Fittings	Critical	Failing	Test each principal fitting, the design ultimate strength of which is not demonstrated by other tests.
g.	Miscellaneous assemblies	Critical	Failing	Test those miscellaneous assemblies, the allowable loads of which are not known and cannot be calculated with reasonable accuracy.
h.	Elements		Failing	Test each structural element, the allowable stresses of which are not known and cannot be calculated with reasonable accuracy.

TABLE IX. Miscellaneous parts tests. - Continued

Test	Component	Loading condition	Magnitude of load	Special requirements
i.	Balance weight installa-tions	Critical	Failing	The static and repeated-load failing strength of balance weight installations shall be demonstrated.
j.	Tie-down and carry-through structure	Critical	Failing	Test to requirement of MIL-T-81259
k.	Hoisting points and carry-through structure	Critical	Failing	
l.	Windshied	Bird strike	Maximum design	

3.5 Drop tests. The drop tests of Table X shall be performed on a full-scale test article. The integral fuel tanks shall be made fuel tight with sealing representative of production airplanes. These tanks shall contain, under normal pressure, an equivalent amount of nonflammable liquid whose viscosity and density are representative of the fuel. During the drop tests periodic inspections shall be made for leakage and the amount of leakage shall be recorded. For carrier-based airplanes, the gross weight shall be the carrier-landing design gross weight; for non-carrier-based airplanes, the landing design gross weight shall be the landplane landing design gross weight. The tests shall include a survey of wheel touchdown speeds to investigate critical effects of spin-up and spring-back loads. The coefficient of friction developed shall be representative of that occuring in landings on concrete runways and carrier decks, as applicable. The wheel radii to be used in the determination of wheel touchdown speed shall be the static rolling radius of the tires at the appropriate weight. Wing lift forces shall be applied during the tests; the method of application shall be such that no extraneous effects are introduced. For wing-mounted engine installations, at least on one side of the airplane the engine propeller combination or engine alone shall be simulated by rotating masses to demonstrate structural adeqaucy for the dynamics involved. The cockpit shall be instrumented to measure accel-lerations which would be experienced by the crew to assure that accelerations are not excessive.

TABLE X. Airplane drop tests.

Test	Condition	Weight distribution	Attitude	Sinking speed
a. b.	Tail down	Critical for main landing gear (MLG)	Pitch 0.9 C_{Lmax} Roll 0° and 2°	Maximum design
c.	Multivariate	Critical for MLG	Roll and Pitch Survey to determine critical combination	Most critical for the multivariate envelope
d.	Multivariate	Critical for nose landing gear (NLG)	Roll and Pitch Survey to determine critical combination	Most critical for the multivariate envelope
e. f.	Three point	Critical for NLG	0° and 2° Roll	Maximum design
g. h.	Tail Bumper	Critical for Tail Bumper	Maximun Tail Down 0° and 2° Roll	Maximum design
i. j.	Free Flight Engagement	Critical for NLG	Pitch Corresponding to 1.0W and 1.3W at wire pick up	Maximum NLG resulting from design conditions
k.	Failing test for MLG	Critical for MLG	Most critical resulting from tests a., b., c.	Fail by gradually increasing weight and sinking speed. Increments to be approved by NAVAIR
l.	Failing test for NLG	Critical for NLG	Most critical resulting from tests d., e., f.	Fail by gradually increasing weight and sinking speed. Increments to be approved by NAVAIR
m.	Failing test Bumper	Critical for Tail Bumper	Most critical	Fail by gradually increasing weight and sinking speed. Increments to be approved by NAVAIR

3.5.1 Drop test with recommended landing gear servicing. The drop tests of Table X shall be performed at the gross weight distributions specified, and also with alternate configurations of internal and external loadings that may be critical for other structural components because of transient and other effects. One of these configurations shall be a clean airplane with maximum internal fuel.

3.5.2 Drop tests with variations in landing gear servicing. Drop tests for each of the tests of Table X, and for the particular weight distributions and touchdown conditions that were proven to be critical by the tests of 3.5.1, shall be repeated for various combinations of tire and shock strut pressures and oil volume within the variations of MIL-A-8863. Sufficient drops shall be made to determine the servicing that produces the least and, alternately, the most critical loading condition. During these tests, it shall be demonstrated for each landing gear unit and with the most critical servicing, in successive drops not more than five minutes apart, that each shock strut fully recovers its absorption capabilities. At the conclusion of these drops, it shall also be demonstrated that each dry deflated shock strut can be serviced in accordance with nameplate instructions, without resorting to special tools or jacks, in not longer than 30 minutes. In the event the strut does not comply with the venting provisions of MIL-L-8552, this time limit requirement includes time required for elimination of all trapped air.

3.5.3 Drop tests over carrier deck obstructions. The drop test program shall include sufficient drops to determine the effects of the landing gears rolling over deck obstructions during carrier landings. For this purpose, airplane drops shall be made on a moving platform to which a 1-3/8-inch deck pendant and a 1-1/4-inch high guide light cover plate is attached. The airplane shall be dropped so that each landing gear unit rolls over each deck obstruction at the critical time and at the most critical engaging speed weight distribution, attitude, sinking speed, and servicing as determined from the tests of paragraph 3.5.1 and 3.5.2.

3.6 Miscellaneous tests.

3.6.1 Integral fuel tank test. Slosh, pressure, temperature, and vibration tests shall be performed on representative test-box specimens, as necessary, to substantiate that the sealing characteristics of the tank are satisfactory for all critical environmental conditions of the airplane.

3.6.2 Pressurized cabin static test. Pressurized cabins shall be tested to 2.0 times the maximum relief valve pressure. The static tests of Table IV shall also include the effects of the cabin maximum operating pressure.

3.6.3 Air loads model wind tunnel tests. Air loads model wind tunnel tests shall be performed early in the design stage to determine external component loads within the airplane maneuvering envelope. Loads (shears, bending moments, and torques), hinge moments and pressure shall be measured. Wind tunnel tests shall also be performed to investigate the characteristics of the oscillatory pressures on: the empennage; inside large bays which will be open during normal flight; and on other parts of the airplane which will experience aeroacoustic loads. Flow visualization and other techniques (e.g., hot-wire, optical interferometers, etc.) shall be used to study the flow pattern in and near the empennage and large bays.

3.7 Fatigue tests.

3.7.1 Fatigue tests. All fatigue tests shall be performed on the fatigue article, unless otherwise specified or agreed to in writing by the contracting activity. In addition, separate fatigue tests shall be conducted on one main and one nose landing gear (see 3.7.1.7). Tests shall continue until the specified life times the scatter factor of two is demonstrated, and thence until major, non-repairable failure occurs, or until a scatter factor of four is demonstrated. The loads shall be increased during the fourth lifetime, if required, to bring on a major failure. Inspections shall be made to detect cracks and to track crack progression. General inspections shall be made at least every 250 hours with major inspections each 1000 hours. Any crack, delamination or similar defect occurring during the first two lifetimes shall be considered a failure and require redesign and retest.

3.7.1.1 Test rigs. The test rig and associated equipment shall be capable of applying a minimum of 150 percent of design limit load for the maximum wing deflection condition. This is to provide for possible increases in initial loading requirements and for failing load test capability.

3.7.1.2 Crack propagation and fail-safe tests. Any fail-safe or crack propagation testing conducted on a fatigue test article shall not in any manner interfere with the fatigue life evaluation testing and shall not be conducted without the approval of the contracting activity.

3.7.1.3 Instrumentation. Strain gages shall be used on the test articles at control points selected to monitor those regions shown by fatigue analysis to be critical for repeated loads. These gages will be read at suitably frequent intervals, consistent with test program objectives. Strain gages will also be used to verify critical assumed load distributions not verified by other testing (e.g., static strength testing). In addition, suitable instrumentation shall be used to monitor applied test loads. Crack-detection instrumentation shall be installed where appropriate.

3.7.1.4 Temperature effects. Environmental effects which may produce creep and/or significant reductions in fatigue strength of the structure or which may produce significant induced stresses shall be simulated in appropriate tests.

3.7.1.5 Wing and fuselage tests. The wing, fuselage, and carry-through structures shall be tested for flight and ground loads in accordance with the load spectra of MIL-A-8866. Loads shall be applied to the empennage, fuselage, and canards to balance the wing loads. The spectra shall be applied in a flight-by-flight sequence. Internal pressurization cyclic loads shall be applied in conjunction with the appropriate flight and ground loading spectrum. The ground-air-ground cycle shall be accounted for in as realistic a manner as possible. The test loadings for flight conditions shall be those which result in the greatest wing root bending moments and shall include a realistic combination of symmetric and rolling pull-out conditions subject to the approval of the contracting activity.

3.7.1.6 Empennage, canards, and fuselage tests. Additional cycles over and above those applied to balance the wing loads of 3.7.1.5 shall be applied to the empennage, canards, and fuselage, as necessary, to produce a spectrum of empennage, canard, and aft fuselage loads for which the airplane is designed. The CG position shall be that which will produce critical loads in empennage, canard, and fuselage.

3.7.1.7 Main and nose landing gear fatigue tests. Fatigue tests for the loads of MIL-A-8866 in a flight-by-flight sequence shall be performed on the main and nose gear mounted on a test rig. After the completion of the second life time tests for the nose gear, two life times of catapult loads shall be applied followed by the third fourth life time tests as descibed in 3.7.1.

3.7.1.8 Determination of fatigue life of arresting hook assembly and nose gear major elements. After completion of tests of 3.7.1.5 and 3.7.1.7, fatigue tests of the arresting hook assembly and nose gear shall be continued to determine the fatigue life of each major elements.

3.7.1.9 Control system tests. The lateral, directional, and longtitudinal control systems which are subject to aerodynamic loads shall be repeat-load tested. An approved rational loading schedule shall be sustained without failure. Particular attention shall be paid to the provisions of 3.3 during these tests.

3.7.1.10 Control system reliability tests. Typical slat, flap, aileron components and controls and unusual structural features, such as, thrust augmentation surfaces and controls, shall be fatigue tested to assure structural reliability.

3.7.1.11 Integral fuel tank test. For aircraft where a fatigue test article has been provided, fuel tank tests shall be conducted on the article during the fatigue testing or alternatively on full-scale representative section(s). Where no fatigue test article has been provided, a full-scale fully representative section(s) of the proposed integral tank(s) shall be subjected to test. This article(s) shall be subjected to repeated loadings simulating flight conditions, carrier and ground loadings, temperatures, and pressures.

3.7.1.11.1 Leakage inspection tests. The contractor shall propose, for NAVAIR approval, leakage, repair, and inspection criteria. A method for readily detecting leaks, such as, the use of special dyes in the test fluid, shall be used and accurate records of all leakage, repairs, and inspections shall be kept. The use of a test fluid other than the standard airplane fuel shall be contingent upon the results of investigations made by the contractor relative to the deteriorating effects of actual fuel and the test fluid upon the tank sealant. The test fluid shall simulate the viscosity and surface tension of the standard fuel. For purposes of qualification, 2,000 hours of fatigue spectrum of 3.7.1.5 shall be sustained without disqualifying leakage or disqualifying repair. No scatter factor is required for this test. If the leakage exceed limits specified in the approved criteria or other normal servicing procedures and repairs become necessary, the qualification portion of the test shall be repeated after redesign of the critical leakage area.

3.7.1.12 Pressurized cabin tests. A repeated pressure test of the cabin shall be performed for cabins which are designed for pressurized operation. The test pressure shall be the maximum cabin pressure including tolerance and including considerations of relief valve malfunction resulting from contaminants. Flight loads, landing loads, or both, which may be critical, shall be simulated. Each major section of the cabin shall be repeated-pressure tested to failure.

3.7.1.13 Armament supporting structure tests. Pylon and other armament supporting structure shall be repeat load tested for flight, launch and landing loads.

3.7.1.14 Repeated landing test programs. All parts of the airplane critical for landing conditions shall be tested.

3.7.1.14.1 Carrier-based airplanes and trainers. These airplanes shall be dropped at least 1,000 times (1,500 for VS, VC, VE) at the sinking speeds and frequencies required for the most severe 500 landings during the specified life of the airplane, after which the airplane shall be placed in a fixture and subjected to repeated applications of loads which simulate landings at all required sinking speeds and frequencies until the accumulated history of sinking speed and number of landings, both in drops and in the fixture, equals the total spectrum specified in MIL-A-8866 times the scatter factor. The landing gear shall be retracted and extended after each 100 drops. Alternatively, carrier-based airplanes, other than trainers, may be dropped at sinking speeds and frequencies required for the entire spectrum of landings times the scatter factor during the specified life of the airplane, with no fixture test being required. Drop tests performed during the tests specified in 3.5 may be applied to the accumulation of history, provided the same landing gear and carry-through structure, with no replaced parts, is used for both drop and repeated-load tests.

3.7.1.14.2 Airplanes other than carrier-based airplanes and trainers. Multiple drops at high sinking speeds, similar to those required for carrier-based airplanes and for trainers are not specified. However, the drop test requirements of 3.5 are applicable. In addition, the airplane shall be placed in a fixture and subjected to repeated loads simulating landings at all sinking speeds and frequencies until the accumulated history equals the total spectrum specified in MIL-A-8866.

3.7.1.14.3 Attitudes for drop tests and fixture tests. The repeated-load tests shall be performed in the pitch and roll attitudes specified in Table XI, except that a more complex system of attitude combinations which adheres more closely to the design requirements of MIL-A-8863 may be used if approved prior to starting the test. The relative frequency column denotes the number of times out of each 10 simulated landings that each particular roll-pitch combination occurs.

TABLE XI. Pitch and roll attitudes for drop tests.

Pitch attitude	Roll attitude	Relative frequency of attitudes
Tail low	0°	3
Tail low	3°	4
Mean	0°	1
Mean	3°	2

3.7.1.15 Teardown inspection. A complete detailed teardown inspection, including fractographic examination, of test article(s) of paragraphs 3.7.1.5 through 3.7.1.14 and 3.9.2 shall be accomplished for occurrence of the following events:

a. Following catastrophic failure within two lifetimes testing of the test article(s) thus requiring repair and requalification.

b. Following completion of four lifetimes testing of the test article(s), and with concurrence of the contracting activity. Inspect and locate areas of the structure which are sensitive to fatigue for determination of periodic inspections throughout the service life of the airplane. Areas determined to have initiated defects prior to two lifetimes shall require fleet forward and retrofit repairs, which shall have been certified for two lifetimes.

3.8 Structural dynamic tests.

3.8.1 Flutter model wind tunnel tests. Flutter model wind tunnel tests shall be performed early in the design stage to substantiate the specified flutter margins or to substantiate flutter analysis used to perform parameter variation investigations. Transonic models shall be used when limit speed, V_L, is greater than 0.7 Mach number. These tests shall be performed for a sufficient range of all design variables to include the design flight envelope; a complete range of weights; required external store loadings and conditions, including down loading and hung stores; and the reduction of stiffnesses due to maneuvers and thermal environments. As a minimum, the investigation shall include the flutter characteristics of the wing, fuselage, empennage, and control surfaces. Where the flutter speeds are sensitive to variations in one or more parameters, the critical parameters shall be varied to cover the expected range. It shall be demonstrated by suitable analysis and tests that the model dynamically simulates the full-scale airplane. If it is determined by analysis, static tests or vibration tests that significant discrepancies exist between the flutter parameters of the model and the airplane, additional tests on suitably modified models shall be performed. Before the flutter models are installed in the wind tunnel, the following tests shall be performed to validate the models:

a. Static load-deflection tests to verify the calculated stiffness distributions.

b. Section mass properties (weight, CG location and mass moments of inertia) tests to verify the calculated values.

c. Vibration modal tests on the complete flutter model to determine modal frequencies, mode shapes and node lines, and modal damping coefficients to correlate with analytical modal parameters.

3.8.2 Compliance tests. These tests shall be made on a flight article prior to first flight of any article. When a change is made that is likely to affect the flutter characteristics of the airplane, the tests shall be performed on a flight article incorporating the change prior to flight of any changed article. Tests of 3.8.2.1, 3.8.2.2 and 3.8.2.3 shall be repeated on the last full-scale development (FSD) airplane.

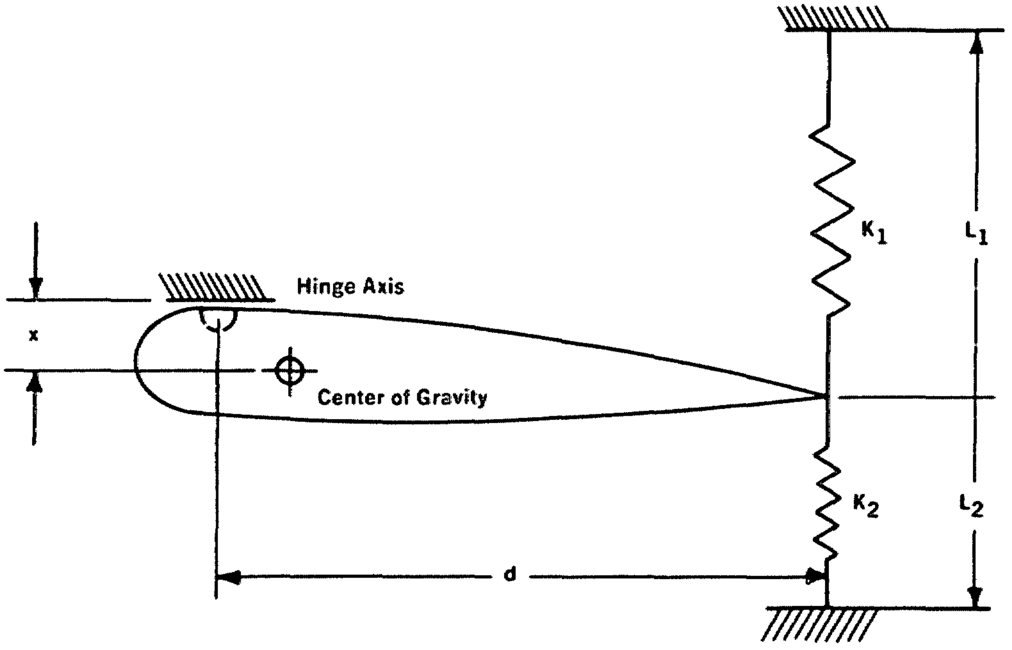
3.8.2.1 Mass measurements of control surfaces and tabs. The total weight, static unbalance, and mass moment of inertia of all control surfaces, tabs, leading and trailing edge flaps about their hinge lines shall be accurately measured and recorded.

3.8.2.1.1 Static unbalance. Static-unbalance measurements require that the movable surface, tab or flap be carefully supported at its hinge line on knife edges or in a jig with a minimum of friction. Its attitude with respect to the horizontal should be identical to its attitude at high speed with respect to the chord of the airfoil that supports it. The weight necessary to balance the control surface, tab or flap as applied at a given point from the hinge line (and in its correct attitude) is then measured by means of an accurate weighing scale and the static balance or unbalance is calculated.

3.8.2.1.2 Mass moment of inertia. A suggested method of experimental determination of the mass moment of inertia consists of supporting the control surface, tab or flap at the hinge line with a minimum of friction in a jig in an attitude by means of one or two springs, as shown in Figure 3. One spring is sufficient for control surfaces with large static unbalances, while two are generally used for surfaces which are fairly well statically balanced. The natural frequency of the surface (for small oscillations) under the restraining action of the springs is then determined. In order to reduce experimental errors to a minimum, the time for a large number of cycles (about 30) is measured. The spring stiffnesses are then dynamically calibrated using a weight that will deflect the springs by an amount approximately equal to the average spring deflection used during the mass moment of inertia tests. The mass moment of inertia is finally calculated from the formulas given in Figure 3, taking into consideration the corrections for the center of gravity position of the control surface with respect to the hinge line.

3.8.2.2 Free play measurements of control surfaces and tabs. The contractor shall demonstrate that the free play for control surfaces, tabs, wingfold(s), speed brakes, spoilers, scoops, leading edge flaps, trailing edge flaps which are impractical to lock, and fixed, retractable, or jettisonable ventral fins is within the limits specified in MIL-A-8870 by making measurements. Incremental loads shall be applied first in one direction, normal to the mean plane of the surface, and then in the opposite direction. Corresponding deflection measurements shall be taken. The total free play shall be determined from a plot of applied load vs measured deflection for both directions of loading. The free play measurements shall be made for both normal and emergency operating conditions. The loads used in the tests shall not cause appreciable structural deformations. (For tabs, the maximum loads employed shall not exceed three times the tab weight and shall be applied near the trailing edge of the tab midspan.) These shall be performed prior to or during the ground vibration modal tests.

3.8.2.3 Rigidity tests for control surfaces and tabs. Rotational rigidity tests shall be performed on all control surfaces and tabs to determine the rigid-body rotation of the surface or tab as a function of applied torque for both normal and emergency operating conditions. These tests may be combined with the free play tests specified in 3.8.2.2. The data obtained, together with the measured mass moment of inertia, shall be used to calculate the uncoupled control-surface rotational frequency. Both clockwise and counterclockwise moments shall be applied to determine rotational rigidity data. Both symmetrical and antisymmetrical loading conditions shall be employed if the actuating system is such that



If control surface center of gravity is below hinge axis:

$$I = (d^2/f_0^2)\ (W_1\ f_1^2 + W_2\ f_2^2) + 9.788\ W_0 x/f_0^2 \quad \text{LB-IN}^2$$

If control surface center of gravity is below hinge axis:

$$I = (d^2/f_0^2)\ (W_1\ f_1^2 + W_2\ f_2^2) - 9.788\ W_0 x/f_0^2 \quad \text{LB-IN}^2$$

Spring Calibration

Note: The total length of each spring under the gravity effect of its calibration weight should be approximately equal to the total length of the spring as used to determine the control surface mass moment of inertia.

List of Symbols

I = Moment of inertia of surface about hinge axis (pound-inches^2)
W_0 = Weight of surface (pounds); W_1, W_2 Spring calibration weights (pounds)
x = Distance of surface CG above or below hinge axis (inches)
d = Distance from hinge axis to springs (inches)
f_0 = Frequency of surface when restrained by springs (Hz)
f_1 = Calibration frequency of spring k_1 under weight W_1 (Hz)
f_2 = Calibration frequency of spring k_2 under weight W_2 (Hz)

FIGURE 3. Schematic sketch of the test setup for the experimental determination of the mass moment of inertia of movable control surface and tabs.

the frequencies for the symmetrical and antisymmetrical rotational modes differ as in the case where the left-hand and right-hand elevators are connected by a torque tube. Applied moments to all control surfaces and tabs shall be as large as practicable, but shall not cause structural deformations; for horizontal surfaces, the applied moment shall be at least large enough to overcome gravitational effects. Rotational rigidity tests shall be made for wingfold(s), speed brakes, spoilers, scoops, and leading and trailing edge flaps unless the flap(s) are positively locked in the retracted position for high-speed flight.

3.8.2.4 Component wear tests. Tests shall be performed on control surfaces, tabs, wingfold(s), and leading and trailing edge flaps, and on their supporting structure and other movable components which are exposed to the airstream. These tests are required to demonstrate that normal wear will not cause freeplay values to exceed those specified in MIL-A-8870 nor rotational stiffness to be less than those established for flutter safety throughout the service life of the component. The test components shall be installed on a test structure duplicating airplane geometry, installation and boundary conditions and capable of loading all flight control actuators. The test shall be performed under accelerated loads and motions simulating those encountered during the service life of the airplane. Prior, during, and at completion of the test, the freeplay and rigidity tests of 3.8.2.2 and 3.8.2.3 respectively shall be performed.

3.8.2.5 Balance weight attachment tests. Experimental tests shall be performed on balance weights, attachments, linkages and supporting structure to demonstrate that these components can withstand, without failure, the static and repeated inertia load factors specified in MIL-A-8870. These tests are listed as test i of Table IX.

3.8.2.6 Damper tests. If dampers are used, experimental tests shall be performed on the damper and supporting structure to assure that components will not fail under static or repeated loads, that the dampers will operate at high temperatures, and that proper maintenance and inspection under service conditions can be readily accomplished. In addition, freeplay measurements shall be performed to substantiate that the freeplay is within the prescribed limits. Tests shall be performed to obtain the damping characteristics as a function of frequency up to at least twice the frequency range that the damper is designed to be effective.

3.8.3 Airplane ground vibration modal tests. Airplane ground vibration modal tests shall be performed on the first FSD airplane prior to its first flight and on the FSD airplane to be used for aeroelastic stability flight tests (if first FSD airplane is not used for this flight testing) prior to its first flight. These tests shall determine modal frequencies, mode shapes and node lines and modal damping coefficient for the assembled airplane and main airplane components. The objective of the test shall be to obtain sufficient modal data to verify, and update if required, the analytical modal data which were used in the structural dynamic analyses (i.e., flutter, dynamic analyses, flutter models, etc.). Where applicable, these tests shall be used to demonstrate that resonant vibrations of the airplane components have been avoided when actual airplane periodic vibratory excitation loading has been applied. In addition to the conventional ground vibration modal tests on the airplane and main airplane components, component vibration modal tests for control surfaces, tabs, flaps, actuating systems, and linkages for balance weights shall also be performed. The pitching and yawing frequencies and mode shapes of the powerplant system, including propeller, rotor, or fan if applicable, shall be measured for use in whirl flutter calculations. These tests shall be repeated on the last FSD airplane. The contractor shall notify the contracting activity at least three weeks prior to commencement of these tests, so that the contracting activity representative can witness the tests.

3.8.3.1 Vibration test apparatus.

3.8.3.1.1 Exciting equipment. The airplane shall be vibrated by means of an exciter(s) attached at one or more places on the structure. The exciter(s) shall be designed to produce simple harmonic motion, have stable output frequency characteristics, and have a force output relatively independent of the vibration amplitude of the structure being excited.

3.8.3.1.2 Measuring equipment. Accelerometers and associated electronic equipment shall be used to monitor and record vibration amplitude and phase. Force gages shall be installed in the drive connection between the exciter(s) and the airplane structure to monitor and record the excitation force.

3.8.3.2 Airplane configuration. The airplane shall be equipped with all items having appreciable mass, such as, engines, tip tanks, guns, and similar items. Stores such as fuel tanks, bombs, rockets, ammunition, and other items that may constitute a safety hazard shall also be in the airplane or be simulated with ballast weight or be inert stores. Whenever practicable, fuel in partially full tanks shall be simulated by a suitable liquid. Tests shall be performed for several weight configurations if variable gross weight conditions are possible and they cause significant changes in the vibration modes and frequencies of the airplane. (A likely example is an expendable store or fuel tank located in the wing.) In addition, tests on variable geometry aircraft shall be performed for appropriate positions to cover the important range of geometric variation.

3.8.3.3 Support of airplane. The airplane shall be supported so that the rigid body frequencies of the airplane on its support are less than one-half the frequency of the lowest elastic wing or fuselage mode to be excited. For heavy or large airplanes where unusually low structural frequencies are obtained, the method of aircraft restraint shall be discussed with the contracting activity. Some methods of support that have been used for airplanes of moderate size and gross weight are as follows:

a. Support the airplane on its landing gear and deflate the tires sufficiently to achieve the above result. This is generally satisfactory for airplanes that do not carry heavy masses outboard on the wings.

b. Suspend the airplane on springs. With this type of suspension, the landing gear can be retracted to simulate a flight configuration. This type of support is generally satisfactory for fighter airplanes even when they carry relatively large external masses near the wingtips.

c. Support the airplane on its landing gear resting on spring platforms.

d. Support the airplane fuselage and wings on large air-filled flotation bags.

3.8.3.4 General vibration test procedure. A vibration pickup shall be placed at a suitable location and an amplitude-frequency response curve obtained to determine the natural frequencies. The frequency increments selected shall be sufficiently small so that no important resonant peaks are overlooked. The frequency range covered during the vibration tests shall include all modes that may be important with respect to flutter. Alternate pickup and vibrator locations shall be employed as a check since node lines may have passed through the first selected vibrator and pickup locations. At each resonant frequency, amplitude and phase measurements shall be carefully taken at a sufficient number of positions to define the mode of vibration. A complete airplane modal survey shall be made. At least 6 spanwise stations and 3 chordwise stations shall be selected in making amplitude measurements perpendicular to the plane of the wing, fin, or stabilizer. Additional chordwise locations will probably be necessary for low-aspect-ratio surfaces. At least six fore-and-aft stations shall be selected in making amplitude measurements in the plane of the wing, fin, or stabilizer. The mode shape measurements obtained shall be plotted as tests progress so that the vibration modes can be evaluated. In addition, the relative orthogonality of the modal data shall be determined as each successive mode is obtained. The generalized mass matrix obtained from an integrated triple product of the experimental orthonormalized mode shape and the theoretical mass of the system shall not have off-diagonal elements greater than 10 percent of the unit diagonal elements.

3.8.3.5 Airplane structural modes usually encountered. The modes excited during ground vibration tests depend on the type of configuration being tested. The vibration modes of an airplane that carries heavy masses on the wing, pylon su-spended engines, has the stabilizer located near the top of the fin, or, in general, carries heavy masses on the outer span locations of its main components, will be highly coupled and generally cannot be described except by diagrams which show the vibratory deflection shapes and relative motion and phase of each part of the airplane. Airplanes that do not carry these masses usually have relatively uncoupled vibration modes which can be described by naming the type of motion which is predominant, such as, wing bending, wing torsion, stabilizer bending, or some other uncoupled mode. In general, the following predominant vibration modes shall be obtained.

3.8.3.5.1 Wing group.

3.8.3.5.1.1 Wings without engines. For wings without engines, tip tanks, or heavy external or internal stores:

a. Wing vertical bending, symmetric and antisymmetric, fundamental and higher modes.

b. Wing torsion, symmetric and antisymmetric.

c. Wing fore-and-aft bending, symmetric and antisymmetric.

d. Wing pitching for aircraft having all-movable wings, symmetric and antisymmetric.

3.8.3.5.1.2 Wings with concentrated mass items. For wings carrying heavy masses outboard of the fuselage, the wing bending coupled with wing torsion, symmetric and antisymmetric, fundamental and higher modes. Propeller or rotor-powerplant-mounting structure modes for pitch, yaw, bending and torsion of various components of this system.

3.8.3.5.1.3 Wing mounted control surfaces. For all control surfaces on wings, including but not limited to, ailerons, spoilers, leading and trailing edge flaps, and wing tip controls:

a. Rotation about the hinge axis, symmetric and antisymmetric.

b. Bending (including rib bending) and torsion of the control surface, fundamental and higher modes.

c. For control surfaces whose rotational frequency varies with position, such as, leading edge and trailing edge flaps, the rotational frequency for several positions.

3.8.3.5.1.4 Wing mounted accessories. For devices located on the leading or trailing edges of wings, including but not limited to, coupling probes and heavy pitot tubes, the vibration modes of these devices, including the response of the structures, to which they are attached.

3.8.3.5.2 Propeller aircraft. For turbo-prop engines, the engine with propeller shall be mounted to a rigid structure. With the exciting equipment attached to the hub, propeller plane natural frequencies in pitch and yaw shall be measured. Propeller bending and torsion modes shall be measured.

3.8.3.5.3 Tail group.

a. Fuselage torsion and fuselage side bending, fundamental and higher modes.

b. Fuselage vertical bending, fundamental and higher modes.

c. Stabilizer symmetric and antisymmetric bending, fundamental and higher modes.

d. Stabilizer torsion, symmetric and antisymmetric modes.

e. Stabilizer pitching, symmetric and antisymmetric modes. For all-movable stabilizers the symmetric rotational modes may be highly coupled with stabilizer symmetric bending and torsion, and with fuselage vertical bending.

f. Stabilizer rocking about its attachment to the fuselage or fin.

g. Stabilizer yawing. Generally a very important mode for stabilizers located at the outer span stations of the fin.

h. Stabilizer fore-and-aft bending, symmetric and antisymmetric.

i. Elevator rotation about its hinge line, symmetric and antisymmetric.

j. Elevator bending (including rib bending) and torsion, fundamental and higher modes.

k. Fin bending (symmetric and antisymmetric for multitail airplanes). Fin bending in phase and out of phase with stabilizer bending shall be included.

l. Fin torsion (generally highly coupled with stabilizer yawing if stabilizer is located at the outer span stations of the fin).

m. Fin yawing and rocking if fin is all-movable.

n. Rudder rotation about its hinge axis (symmetric and antisymmetric for multitail airplanes).

o. Rudder spanwise and chordwise bending and torsion.

3.8.3.5.4 Canards.

a. Canard symmetric and antisymmetric bending, fundamental and higher modes.

b. Canard torsion, symmetric and antisymmetric modes.

c. Canard pitching, symmetric and antisymmetric modes. For all-movable canards, the symmetric rotational may be highly coupled with canard symmetric bending and torsion, and with fuselage vertical bending.

d. Canard rocking about its attachment to the fuselage.

e. Canard yawing.

f. Canard fore-and-aft bending, symmetric and antisymmetric modes.

3.8.3.5.5 Tabs.

a. Rotation about hinge line.

b. Tab spanwise and chordwise bending and torsion.

c. In order to evaluate the tab with respect to the requirement of MIL-A-8870, the frequencies shall be corrected to include the inertia and spring effects of the vibration test apparatus. The tab relative amplitude of vibration shall be at least twice the freeplay amplitude.

3.8.3.5.6 Spring tabs.

a. If a preloaded spring is used, tests shall be performed for several amplitudes and, also, the preload shall be completely removed.

b. The control column at the pilot's location shall be locked, the spring tab shall be locked to the control surface, and the rotational frequency of the control surface shall then be obtained against the elastic restraint of the control system for both symmetric and antisymmetric modes.

c. The spring tab shall be locked to the control surface, the control surface shall be locked to its supporting structure, and the control column shall then be vibrated against the elastic restraint of the control system. Fundamental and higher modes of vibration shall be obtained.

d. The control cables or linkage shall be disconnected at their attachments to the control surface pivot bar or crank, the control surface shall be locked to its supporting structure and the spring tab rotational frequency shall then be obtained against the elastic restraint of the springs in the tab system.

3.8.3.5.7 Actuating systems. Vibration tests shall be performed to determine the dynamic characteristics of actuating systems, such as, servo boost, fully powered servo control, closed-loop airplane flight control systems and other related powered control systems. The tests shall be performed with the actuating system installed in the airplane. The impedance of the control systems shall be determined both from the input and output sides of the control surfaces. In addition, tests shall be performed to determine parameters for servo-flutter stability analyses.

3.8.3.5.8 Externally suspended stores. If more than one type store is to be used on a given pylon, then a sufficient number of store installations shall be vibration tested to cover the probable ranges of frequencies that will be encountered. If the mass of the store is variable, such as, in a fuel tank, then the empty, half-full, and full cases shall be tested. At least the following frequencies shall be measured for all externally suspended store-pylon installations.

a. Yaw frequency.

b. Pitch frequency.

c. Side bending frequency.

d. Fore-and-aft bending frequency.

3.8.3.5.9 Concentrated balance weights and attachments. The frequencies of concentrated balance weights attached to control surfaces by arms, by overhanding horns, or by linkages shall be obtained in both lateral and vertical airplane directions.

3.8.3.5.10 Airplane rigid body modes on landing gear or on low-frequency suspensions. Airplane rigid body modes shall include:

a. Vertical, side, and fore-and-aft translations.

b. Pitching, rolling, and yawing.

3.8.3.5.11 Landing gear. The following modes and the amount of damping shall be determined with the wheel free from the ground:

a. Fore-and-aft motion, symmetric and antisymmetric.

b. Lateral motion, symmetric and antisymmetric.

c. Torsional motion, symmetric and antisymmetric.

d. Any other degree of freedom which may be important for dynamic load investigations.

3.8.3.5.12 Accessories. The frequencies of accessories installed on the airplane, including but not limited to, pitot tubes, antennae, and instruments shall be determined if they affect the vibration modes of structural components which are important with respect to flutter.

3.8.3.5.13 Auxiliary components. The frequencies and mode shapes of speed brakes, spoilers, scoop, leading edge flaps, winglets, trailing edge flaps which are impractical to lock, ventral fins (fixed, retractable, or jettisonable) and weapon bay doors shall be measured.

3.8.3.5.14 Skin panels. The modes and frequencies of skin panels which have been determined to be flutter critical by analysis shall be measured on the airplane or in laboratory tests for flutter safety evaluation required by MIL-A-8870. The effects of inplane stresses on panel modes and frequencies due to maneuvering loads or aerodynamic heating shall be determined when they are of sufficient magnitude to effect panel flutter speeds, laboratory vibration tests shall accurately simulate the edge conditions, substructure, and cavity depth of the panel as mounted in the airplane.

3.8.4 Influence coefficient and structural rigidity tests. Structural rigidity or influence coefficient tests shall be performed to substantiate stiffness characteristics being employed in the flutter analyses and those used in designing flutter models. Airplane components shall be loaded statically at those loading conditions which result in reduction of structural stiffness which in turn causes flutter margins to be lowered. Airplane components shall be statically tested at various loading conditions up to and including 1.2 times limit load. At each load increment, static deflections at selected locations on the components shall be recorded. These tests shall be performed on the static test article.

3.8.5 Thermoelastic tests. Thermoelastic tests shall be performed on airplane components fabricated from fibrous composites. Thermoelastic tests of components from material other than fibrous composites shall be performed unless the results of analysis required by MIL-A-8870 indicate that a critical problem does not exist. Full-scale components of the airplane shall be heated and cooled in a manner to simulate the most critical heating and cooling rates and temperatures to be encountered in flight. The components shall be vibrated in their natural modes as the heat is applied and removed so that time histories of the changes in natural frequencies are obtained. These tests shall be performed on fully instrumented components or partial components of a test article having restraint or boundary conditions as if installed on the airplane. The test articles shall not have been subjected to yield loads at any time prior to these tests.

3.8.6 Pylon component tests.

3.8.6.1 Influence coefficient and structural rigidity test. A pylon influence coefficient or structural rigidity test shall be performed to substantiate the pylon-rack stiffness characteristics being used in the flutter analyses or those used in designing flutter models.

3.8.6.2 Vibration modal tests. A jig-mounted pylon vibration modal test shall be performed to determine the modal frequencies, mode shapes and node lines, and modal damping coefficients. The test article shall consist of the pylon, pylon-store interface structure, wing-pylon interface structure and store(s). A sufficient number of store installations shall be tested to cover the probable ranges of frequencies. If the mass property of the store is variable, such as in a fuel tank, the empty, half-full (forward and aft), 85-percent full, and full cases shall be tested. At least the following frequencies shall be measured for all externally suspended store-pylon installations on the jig (fixture).

a. Yaw frequency.

b. Pitch frequency.

c. Side bending frequency.

d. Fore-and-aft bending frequency.

3.8.7 Component vibration modal tests. Component surface free-free or cantilevered vibration modal tests shall be performed to verify, and update if required, the dynamic math modeling of each component. The test articles shall include control surfaces, tabs, leading edge flaps, trailing edge flaps, all-movable control surface, horizontal stabilizer (no elevator), vertical stabilizer (no rudder), wing torque box, etc. These tests shall be performed on the first component fabricated early in the development phase.

3.9 Dynamic fatigue tests.

3.9.1 Sonic fatigue component tests. Sonic fatigue component tests shall be performed on aircraft structural components to establish their prospective service lives and to substantiate the analysis of the sonic fatigue prevention program. These tests shall be completed during the design and analysis phase of the sonic fatigue prevention program and as far in advance of the final design release as possible to allow sufficient time for the redesign and retesting of components that may be found to have inadequate fatigue lives.

3.9.1.1 Structural components to be tested. Candidate structural component assemblies and subassemblies, both internal and external, for sonic fatigue tests shall be selected from each zoned area of the aircraft and shall include, but not be limited to, any of the following:

a. Structural components whose fatigue lives cannot be adequately predicted (e.g., structural components composed of untested or new materials, unusual design configuration, light weight structures, etc.).

b. Structural components subjected to predicted sound pressure levels greater than 140 dB.

c. Structural components whose predicted lives are less than that required to survive sound pressure levels 3.5 dB greater than the predicted environment for the service life of the airplane with a scatter factor of four.

3.9.1.2 Test environment. Sonic fatigue tests shall be performed until the service life with a scatter factor of two is demonstrated with applied sound pressure levels 3.5 dB greater than simulated predicted environment. Thereafter, testing shall be continued until a scatter factor of four is achieved or a major nonrepairable failure occurs. Other simulated environments (e.g., temperature and pressure differential) combined with the sonic environment shall be imposed when applicable.

3.9.2 Empennage dynamic fatigue tests. In addition to fatigue testing for maneuver loads in 3.7.1.6, a dynamic fatigue test shall be performed on the empennage as early as possible in the program. The dynamic test shall be based on dynamic data measured on the FSD airplane during the flight vibration and acoustic tests. The test shall be performed until the service life with a scatter factor of two is demonstrated with applied dynamic environment 3.5dB greater than simulated predicted environment. Thereafter, testing shall be continued until a scatter factor of four is achieved or a major nonrepairable failure occurs.

3.9.3 Dynamic fatigue component development tests. When structural components of the airplane are susceptible to vibration (from sources other than acoustic excitation) and whose predicted fatigue life is less than that required to survive a level of 3.5 dB greater than the predicted environment for the service life of the airplane with a scatter factor of four, component development tests are required. When the vibration environment is simulated, test amplitude shall contain test time compression factors when the duration of the test is less than the duration of exposure of the test article to the service excitation. The tests shall be performed until the service life with a scatter factor of two is demonstrated with applied accelerations 3.5dB greater than simulated predicted environment. Thereafter, testing shall be continued until a scatter factor of four is achieved or a major nonrepairable failure occurs.

3.9.4 Measurement and instrumentation requirements. Microphones shall be used to control and continuously monitor the acoustic environment for the test of 3.9.1. Vibration transducers shall be used to control the vibration environment for the tests 3.9.2 and 3.9.3. Strain gages, vibration transducers, or other instrumentation shall be placed on the specimen in such a manner that the dynamic response of the structure can be measured and the strain distributions can be determined. Continuous recording and monitoring of the dynamic response is necessary to detect changes which may be indicative of fatigue failures in the structure.

3.9.5 Fatigue-detection methods. The failure criterion shall be based on the detection of cracks by unmagnified visual means. The fatigue detection methods shall not alter the natural response of the structure to dynamic (sonic or vibration) excitation or otherwise influence the fatigue life of the test article. Changes in dynamic responses of complex structural parts could indicate out-of-sight failures. These changes include shifts in resonant frequencies and amplitude changes in vibration or stress.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of section 3. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, and does not commit the Government to accept defective material.

4.2 Addition of tests. If the tests performed by the contractor are inadequate to prove that the test structure meets the specified strength and rigidity, the contractor or the contracting activity will propose amendments to the contract to include additional tests which will provide that proof.

4.3 Design data. Structural test data shall be in accordance with MIL-A-8868 and as specified in the applicable contract.

5. PACKAGING

This section is not applicable to this specification.

6. NOTES

6.1 Intended use. The requirements of this specification are intended for use in the structural design and substantiation of airplanes.

6.2 Ordering data.

This paragraph is not applicable to this specification.

6.3 Place of test. The contract will specify whether the tests are to be performed by the Government or by the contractor. The contractor will normally be required to conduct the tests, except in those cases where the Government possesses the only capability for conducting the tests. The Government may choose to conduct tests at its own facility when cost savings would be realized and the Government facility is available for the required time period.

6.4 Contractor furnished test data. When approved by the contracting activity, the contractor may submit data in lieu of conducting tests as specified herein.

6.5 Definitions. The following terms and symbols are defined for use or reference herein.

6.5.1 Critical loading condition. The design loading condition for which margins of safety indicate the structure is most likely to fail.

6.5.2 Load factor. The ratio of a given load to the weight with which the load is associated. If employed, a subscript designates the direction of the load.

6.5.3 Limit load or limit factor. A load or load factor which establishes a strength level for design of the airplane and components and is the maximum load factor normally authorized for operations. The concept of limit load with a corollary ultimate factor of safety is not employed for landing loads in this specification.

6.5.4 Ultimate load or ultimate load factor. Limit load or limit load factor multiplied by a factor of safety, usually 1.5.

6.5.5 Failing load. Load at which failure occurs.

6.5.6 Proof load. Arbitrary load, applied to provide test substantiation of strength and rigidity of a magnitude less than that which would induce permanent deformation or damage to the structure.

6.5.7 Wing lift. Magnitude, usually expressed as percent of airplane weight supported by the wing at landing touch down. Magnitude of load applied to the wing in drop tests.

6.5.8 C_L max. Maximum aerodynamic lift coefficient.

6.5.9 V_v or sinking speed. Vertical velocity of airplane at landing touchdown.

6.5.10 V_v max. Specified maximum vertical velocity at landing touchdown.

6.5.11 W. Specified weight of the airplane for a test condition.

6.5.12 Springy tab. A tab which is restrained directly from the control surface by a spring such that during flight the tab deflection is directly proportional to the aerodynamic forces exerted upon it.

6.5.13 PLAT-head. Protrusion above the carrier deck, on the center line of the landing area, which houses the television camera of the pilot landing aid television (PLAT) system.

6.5.14 FSD. Full-scale development.

6.6 Supersession data. See supersession data in section 6 of MIL-A-8860. This specification supersedes MIL-A-8867(ASG). It also supersedes, in part, MIL-A-008867A(USAF), although MIL-A-008867A(USAF) will remain in effect until cancelled by the Air Force.

6.7 Subject term (key word) listing.

Airplane tests
Arresting tests
Cabin pressure tests
Carrier-based airplanes
Catapult tests
Control system tests
Drop tests
Elevated temperature tests
Engine-mounted tests
Fatigue tests
Fuel tank leakage
Fuselage tests
Ground tests
Landing gear installation tests
Repeated load tests
Static tests
Strength tests
Tail group tests
Test measurements
Trainers
Vibration tests
Wing group tests

6.8 Changes from previous issue. Asterisks or vertical lines are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Preparing activity:
Navy - AS

(Project 1510-N026)

INDEX

(TO DETACH THIS FORM, CUT ALONG THIS LINE.)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-A-8867C(AS)	Airplane Strength and Rigidity Ground Tests

3a. NAME OF SUBMITTING ORGANIZATION

b. ADDRESS *(Street, City, State, ZIP Code)*

4. TYPE OF ORGANIZATION *(Mark one)*

- [ ] VENDOR
- [ ] USER
- [ ] MANUFACTURER
- [ ] OTHER *(Specify)*: ______

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional

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