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20 May 1987
SUPERSEDING
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MILITARY SPECIFICATION

AIRPLANE STRENGTH AND RIGIDITY DATA AND REPORTS

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 for data necessary to show compliance with the design and test requirements of MIL-A-8860 through MIL-A-8870 for the acquisition of naval airplanes, and to show the dependent relationship between the schedules for structural engineering analyses and testing and schedules for manufacturing.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks 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

DOD-D-1000	Drawing, Engineering and Associated List.
MIL-L-8552	Landing Gear, Aircraft Shock Absorber (Air-Oil Type).
MIL-D-8708	Demonstration Requirements for Airplanes.
MIL-A-8860	Airplane Strength and Rigidity, General Specifications for.

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 93), 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.

AMSC FSC 1510

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

MIL-A-8866	Airplane Strength and Rigidity, Reliability Requirements, Repeated Loads, and Fatigue.
MIL-A-8867	Airplane Strength and Rigidity Ground Tests.
MIL-A-8870	Airplane Strength and Rigidity, Vibration, Flutter, and Divergence.
MIL-A-8871	Airplane, Test, Strength And Rigidity Flight and Ground Operation.
MIL-M-81260	Manual, Technical, Aircraft/System/Equipment Maintenance.

STANDARDS

MILITARY

MIL-STD-1530	Aircraft Structural Integrity Program, Airplane Requirements.

HANDBOOKS

MILITARY

MIL-HDBK-5	Aerospace Vehicle Structures, Metallic Materials and Elements for.
MIL-HDBK-23	Structural Sandwich Composites.

2.1.2 Other Government documents (publications). The following other Government documents (publications) form a part of this specification to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

PUBLICATIONS

NAVAL AIR SYSTEMS COMMAND

SD-24	General Specification for Design and Construction of Aircraft Weapons System.

AIR FORCE

Regulation 80-13	Aircraft Structural Integrity Program (ASIP)

AIR FORCE Flight Dynamics Laboratory (AFFDL)

TR-67-140	Development of Criteria to Predict and Prevent Panel Flutter

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

2.1.3 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 Submittal, format, and revision.

3.1.1 Submittal. The required data items for the acquisition of airplanes within the scope of this specification are listed in Table I, which specifies the latest acceptable time for the initial submittal of each item. Each submitted report shall be accompanied or preceded by the contractor's reports or data referenced therein. A cross reference for all data items by paragraph number and applicable data item description (DID) number is also shown in Table I (see 6.2.2).

TABLE I. Latest initial submittal date. (Note 2)

Report	Applicable paragraph	Date	Applicable DID no. (see 6.2.2)
Schedule of structural work	3.2	90 days after date of contract (Note 1)	DI-P-21461A
Structural description	3.3	90 days after date of contract (Note 1)	DI-S-3595/ S-123-1
Flight loads design criteria	3.4.1	90 days after date of contract (Note 1)	UDI-S-23272C
Control systems loads design criteria	3.4.2	90 days after date of contract (Note 1)	UDI-S-23272C
Cargo, seat, and litters loads design criteria	3.4.3	90 days after date of contract (Note 1)	UDI-S-23272C
Ground loads design criteria	3.4.4	90 days after date of contract (Note 1)	UDI-S-23272C
Repeated loads criteria	3.4.5	90 days after date of contract (Note 1)	UDI-S-23272C
Dynamic loads and fatigue program and criteria	3.4.6	90 days after date of contract (Note 1)	UDI-S-23272C

TABLE I. Latest initial submittal date. (Note 2) - Continued

Report	Applicable paragraph	Date	Applicable DID no. (see 6.2.2)
Aeroelastic stability program	3.4.7	90 days after date of contract (Note 1)	UDI-S-23272C
Nuclear weapons delivery criteria	3.4.8	225 days after date of contract (Note 1)	UDI-S-23272C
Fracture control plan	3.4.9	90 days after data of contract (Note 1)	UDI-S-23272C
Inertia loads	3.5.1	30 days prior to submittal of stress or fatigue analysis supported by applicable loads analysis	UDI-S-21462A
Flight loads	3.5.2	30 days prior to submittal of stress or fatigue analysis supported by applicable loads analysis	UDI-S-21462A
Control system loads	3.5.3	30 days prior to submittal of stress or fatigue analysis supported by applicable loads analysis	UDI-S-21462A
Ground loads	3.5.4	30 days prior to submittal of stress or fatigue analysis supported by applicable loads analysis	UDI-S-21462A
Repeated loads	3.5.5	30 days prior to submittal of stress or fatigue analysis supported by applicable loads analysis	UDI-S-21462A
Initial dynamic loads environment analysis	3.6.1	270 days after date of contract or 90 days prior to structure CDR, whichever occurs first	UDI-S-23272C
Intermediate dynamic loads environment analysis	3.6.2	60 days after first flight	UDI-S-23272C

TABLE I. Latest initial submittal date. (Note 2) - Continued

Report	Applicable paragraph	Date	Applicable DID no. (see 6.2.2)
Final dynamic loads environment analysis	3.6.3	60 days after completion of applicable flight tests	UDI-S-23272C
Preliminary aeroelastic analysis	3.7.1	270 days after date of contract or 90 days prior to structure CDR whichever occurs first	UDI-S-23272C
Initial aeroelastic analysis	3.7.2	90 days prior to first flight	UDI-S-23272C
Intermediate aeroelastic analysis	3.7.3	60 days after first flight or 15 days prior to start of aeroelastic stability flight tests, whichever comes first	UDI-S-23272C
Final aeroelastic analysis	3.7.4	60 days after completion of applicable flight tests	UDI-S-23272C
Internal loads methodology	3.8.1	90 days after date of contract (Note 1)	UDI-S-23272C
Stress analysis	3.8.2	120 days prior to start of applicable test	UDI-S-21462
Fatigue analysis	3.8.3	120 days prior to start of applicable test	UDI-S-21462
Damage tolerance analysis	3.8.4	120 days prior to start of applicable test	UDI-S-21462
Sonic fatigue analysis	3.8.5.1	30 days prior to structure contract data requirement (CDR)	UDI-S-23272C
Dynamic loads fatigue analysis	3.8.5.2	30 days prior to structure CDR	UDI-S-23272C
Empennage dynamic fatigue analysis	3.8.5.3	30 days prior to structure CDR	UDI-S-23272C

TABLE I. Latest initial submittal date. (Note 2) - Continued

Report	Applicable paragraph	Date	Applicable DID no. (see 6.2.2)
Final dynamic-fatigue analysis	3.8.5.4	90 days after completion of applicable flight tests	UDI-S-23272C
Air loads model wind tunnel test	3.9.1	Simultaneously with analyses reports that test report supports	DI-T-2072
Flutter model wind tunnel test	3.9.2	60 days after completion of each tunnel entry	DI-T-2072
Flutter compliance data	3.9.3	Note 3	DI-T-2072
Ground vibration modal test	3.9.4	Note 3	DI-T-2072
Thermoelastic test	3.9.4.1	90 days prior to first flight	DI-T-2072
Rigidity tests	3.9.5	90 days prior to first flight	DI-T-2072
Component endurance and wear test	3.9.6	60 days after completion of applicable test	DI-T-2072
Aeroacoustic environment ground test	3.9.7	60 days after completion of applicable ground tests	DI-T-3718A
Catapult aeroacoustic and thermal environment test	3.9.8	60 days after completion of applicable ground tests	DI-T-3718A
Description of test articles	3.10.1.1	90 days after date of contract (Note 1)	DI-T-30737
Static test plan	3.10.1.2	90 days prior to start of testing	DI-T-21463A
Fatigue test plan	3.10.1.3	90 days prior to start of testing	DI-T-30737
Sonic fatigue component test plan	3.10.1.3.1	90 days prior to start of testing	DI-T-30737

TABLE I. Latest initial submittal date. (Note 2) - Continued

Report	Applicable paragraph	Date	Applicable DID no. (see 6.2.2)
Dynamic fatigue component test plan	3.10.1.3.2	90 days prior to start of testing	DI-T-30737
Empennage dynamic fatigue test plan	3.10.1.3.3	90 days prior to start of testing	DI-T-30737
Structural design, development and preproduction verification test plan	3.10.1.4	90 days after date of contract	DI-T-30737
Static test progress	3.10.2.1	90 days after date of contract (Notes 1, 2)	DI-T-2072
Fatigue test progress	3.10.2.2	90 days after date of contract (Notes 1, 2)	DI-T-2072
Static test	3.10.3.1	90 days after completion of each test	DI-T-2072
Static design development and preproduction component design verification test	3.10.3.1.1	30 days after tests	DI-T-2072
Fatigue test	3.10.3.2	90 days after completion of each test	DI-T-2072
Fatigue development test	3.10.3.2.1	60 days after completion of each test	DI-T-2072
Fatigue test teardown inspection	3.10.3.2.2	90 days after completion of full scale cyclic test teardown inspection	DI-T-2072
Sonic fatigue component test	3.10.3.3	60 days after completion of each test	DI-T-2072
Dynamic fatigue component test	3.10.3.4	60 days after completion of each test	DI-T-2072
Empennage dynamic fatigue test	3.10.3.5	60 days after completion of each test	DI-T-2072
Material substantiating data and analysis	3.10.4	30 days prior to structure CDR	DI-T-2072

TABLE I. Latest initial submittal date. (Note 2) - Continued

Report	Applicable paragraph	Date	Applicable DID no. (see 6.2.2)
Aeroelastic stability, vibration and aero-acoustic flight test planning	3.11.1	90 days prior to start of instrumentation on airplane	DI-T-3707A
Structural flight and ground operations test planning	3.11.2	90 days after date of contract (Note 1)	DI-S-30589
Flight and ground load survey instrumentation calibration planning	3.11.3	45 days prior to start or instrumentation	DI-T-30589
Structural flight ground operations test program	3.11.4	90 days prior to flight of test airplane	DI-S-30729
Aeroelastic stability flight test letter	3.11.5.1	Every two weeks after start of test program	DI-T-2072
Vibration and aero-acoustic flight test letter	3.11.5.2	Every two weeks after start of test program	DI-T-2072
Aeroelastic instability, vibration or sonic fatigue occurrence	3.11.5.3	Immediately	DI-R-4805
Vibration environment measurement	3.11.5.4	60 days after completion of tests	DI-T-3718A
Aeroacoustic environment measurement	3.11.5.5	60 days after completion of tests	DI-T-3718A
Gun fire vibration and aeroacoustic environment measurement	3.11.5.6	60 days after completion of tests	DI-T-3718A
Missile vibration and aeroacoustic environment measurement	3.11.5.7	60 days after completion of test	DI-T-3718A
Flight and ground load survey instrumentation and calibration progress	3.11.6	Each 30 days until calibration is completed	DI-T-30728

TABLE I. Latest initial submittal date. (Note 2) - Continued

Report	Applicable paragraph	Date	Applicable DID no. (see 6.2.2)
Flight and ground load survey instrumentation and calibration	3.11.7	60 days after completion of calibration	DI-T-30728
Flight load and ground operations survey data	3.11.8	60 days after completion of tests	DI-T-30729
Dynamic response test	3.11.9	120 days after completion of tests	DI-T-30730
Structural flight test anomaly and failure	3.11.10	30 days after occurrence	DI-R-4805
Nuclear weapons delivery capability	3.12	30 days prior to delivery for Navy nuclear weapons Board inspection & survey (BIS) trials	UDI-S-23272C
Strength summary and operating restriction	3.13	30 days prior to request for authorization for first flight (Note 2)	DI-S-3589/ S-111-1
Structural redesign	3.14	60 days prior to a proposed redesign production change	DI-S-30590
Service life analysis	3.15	180 days after full-scale test completion and revised as dictated by the life history recorder program	UDI-S-23272C
Service airplane fatigue estimate	3.16	To coincide with initial operational capability (IOC) (Note 2)	UDI-S-23272C
Life history recording program	3.17	Every 180 days after start of program	UDI-S-23272C
Structural integrity methodology	3.18	270 days prior to initial operational capability	DI-S-30584

TABLE I. Latest initial submittal date. (Note 2) - Continued

Report	Applicable paragraph	Date	Applicable DID no. (see 6.2.2)
Sonic fatigue inspection and repair schedule	3.19	60 days after test	UDI-S-23272C
Airplane structural integrity program (ASIP) master plan	3.20	90 days after date of contract	DI-S-3570A
Fatigue life monitoring systems	3.21	30 days before structure CDR (Note 2)	UDI-S-23272C
Structural manual	3.22	90 days after date of contract	UDI-S-23272C
Structural dynamic manual	3.23	90 days after date of contract	UDI-S-23272C
Maintenance instructions for control surfaces and tabs	3.24	Concurrent with delivery of first fleet airplane	UDI-E-21353A

Note 1 - Date of authorization-to-proceed shall apply if such authorization is granted prior to date of contract.

Note 2 - The dates in this table are initial submittal dates. Revisions to be submitted in accordance with applicable paragraph.

Note 3 - Fifteen days prior to first flight, or the contractor's flutter engineer shall present and discuss the results of the tests at the contracting activity 7 days prior to first flight. In the latter case these reports shall be submitted not later than the date required for submittal of the intermediate aeroelastic stability analyses report.

3.1.2 Form of reports. Each report shall be securely bound in a loose leaf style with stiff resin impregnated cardboard covers, approximately 1/32-inch thick and shall be reinforced at the binding edge. The binding shall afford easy insertion of revision pages. Reports shall be 11-1/2 inches by 9-1/2 inches by approximately 2 inches thick. If the 2-inch dimension is inadequate, reports shall consist of separate volumes, each not more than approximately 2 inches thick. Each page shall be titled in sufficient detail to identify that page as associated with a specific condition, airplane component, or member. Each page shall bear the page number, report number, model designation, and date. Reports shall consist of the following parts:

3.1.2.1 Cover. The cover shall contain the contractor's identification of the report by title, number, and aircraft model designation.

3.1.2.2 Title page. The title page shall contain the following:

a. Contractor's identification of report by title and number.

b. Aircraft model designation(s) and contract number(s).

c. Date of issue.

d. Signature of the report originator, the report checker, the department head, and in the case of test reports, the test witnesses.

e. Index of revisions. Such index may be shown on a page following the title page, if extensive.

3.1.2.3 Table of contents. The table of contents shall be arranged in order of sequence. The table may be omitted from reports of 15 pages or less.

3.1.2.4 References. The table of references shall list all report and drawing numbers, and titles referred to in the report. When reports are referenced which are essential (or submittal is prerequisite) for review of the report under consideration, the date of submittal of the reference report shall be included.

3.1.2.5 Symbols. Symbols, abbreviations, and units, if they do not appear in standard lists of aircraft nomenclature, shall be defined in the table of symbols. The symbols and terms used in the structural reports shall conform to those contained in MIL-A-8860. The units of all quantities shown in the reports shall be noted.

3.1.2.6 Summary. The summary shall list the principal results discussed by the report. Summaries are not required for design loads reports.

3.1.2.7 Introduction. The introduction shall include the purpose and authorization for the report. Introductions are not required for design loads and stress analysis reports.

3.1.2.8 Discussion. The discussion shall include a description of the item investigated, loading conditions involved, and methods of analysis. Descriptions of the structure adequately supplemented by sketches showing structural or mechanical details, including the attachments of all major components, shall be included for clarity.

3.1.2.9 Analysis. Steps in arithmetic or algebraic solutions shall be included only when necessary for clarity. Lengthy derivations of formulas shall be placed in an appendix. When calculations performed by computer are included, adequate information shall also be included to explain the methods used and the results obtained. Suitable diagrams or sketches showing points of application of loads shall be included.

3.1.2.10 Conclusions. Conclusion are not required for design loads or stress analysis reports.

3.1.3 Airplane modifications. Modifications of the airplane structure or modifications affecting the loads on the structure, including new or revised equipment installations made subsequent to the latest submitted data, will require that new reports or revisions to previously delivered reports be submitted. These shall substantiate the modifications concerned.

3.1.4 Substantiation of related models. Contract documents shall define by reference to this specification, the data required for substantiation of prototype and production aircraft. For related models, revised or added pages may be submitted for incorporation in reports that have been submitted for earlier models if the material in the basic report is applicable to the subsequent model.

3.1.5 Revision. Revised material shall bear the same page number as those pages which are to be replaced plus the word "revised" and date of revision. The revised subject matter shall be identified. Additional pages shall bear the same number as the preceding page followed by a lower case letter unless the additional pages follow the last page of the report. Revised or added material shall include a revised title page indicating the date of the revision. The revised title page shall contain the information of 3.1.2.2.

3.1.6 Microfiche copy of reports. After a report has been approved and accepted by the contracting activity, microfiche cards (105 mm by 148 mm) containing miniaturized images of original hard copy report pages shall be submitted to the contracting activity. In addition, to ensure maximum retention and distribution of selected reports, a copy (or copies) shall be submitted to the Defense Documentation Center (DDC) for appropriate storage and dissemination.

3.2 Schedule of structural work report. This report shall contain a complete list of the estimated dates for performance of all related structural work and shall be kept current by revisions at not less than 60 days intervals or as specified in the contract. The report shall contain, but not be limited to, the following:

a. Report titles and submittal dates of all design, analysis, and test data. The contents of each report shall be indicated by reference to the numbers of this specification.

b. By major structural components, dates for:

(NOTE: Availability in the following means available at the contractor's engineering facility for review by representative of the contracting activity.)

(1) Availability of preliminary loads.

(2) Availability of final loads.

(3) Furnishing loads data to the structural test group.

(4) Availability of preliminary stress analysis.

(5) Availability of preliminary fatigue analysis.

(6) Availability of final stress analysis.

(7) Availability of final fatigue analysis.

(8) Engineering drawing release to manufacturing.

(9) Start of component assembly.

(10) Completion of first component assembly.

c. Dates for performance of laboratory tests.

d. Titles of applicable data which have been submitted previously.

e. Dates for submittal of structural drawings with separate listing of titles and drawing numbers for each major component group.

f. Date of first flight.

g. Dates scheduled for expansion of authorized contractor operating limits in general terms of

(1) Increasing load factors.

(2) Increasing speed.

(3) Store carriage limits.

(4) High sinking speed landing.

(5) Catapulting.

h. Dates for release for demonstration.

i. Date of first delivery to contracting activity for flight tests, preliminary evaluations or board of inspection and survey (BIS) trials.

j. Date of first delivery to service operating activities.

k. The code used to identify flight and ground loading conditions. This identification shall correlate conditions selected for analyses and test with those of this series of specifications.

3.3 Structural description report. This report shall contain reduced size drawings, perspectives, sketches, or other data, as necessary, to permit an intelligent review by the contracting activity of related structural design and analysis data. Included therein shall be information concerning the general arrangement, inboard profile, wing group, tail group, body group, powerplant housing, engine mount, armament arrangement including internal and external stores, landing gear, and operation of the control systems which depict clearly the information of the following subparagraphs relative to the skin, stringers, longerons, ribs, formers, frames, and spars. If the information is presented by drawings, it is desired, but not necessary, that they be folded in the lengthwise direction only. Specially prepared drawings are not required and need not comply with DOD-D-1000 or other specifications, provided that the information presented is legible. Reduced size copies of drawings are acceptable. This report need not be complete at first submittal and need not present final data, but shall be revised and amended at intervals of not more than 60 days as the design progresses.

a. Location.

b. Skin panel size and gage.

c. Material and material condition: The report shall contain, as a separate section, a description of the materials used in the airplane. The description shall consist of lists, divided by form (for example, castings, forgings, sheet, sandwich or bonded construction, integrally stiffened sheet) of the names of the parts made of each material, and of separate perspective sketches either of the entire airplane, or of major components (wing, fuselage), showing the location of use of each material in each form. Usage of the following materials and alloys, where applicable, shall be described:

(1) Aluminum.

(2) Magnesium.

(3) Titanium.

(4) Corrosion-resistant steel.

(5) Low alloy steels.

(6) Special steels, such as die steels.

(7) Nonmetallics, both reinforced and transparent.

(8) Heat-resistant alloys.

(9) Other materials.

d. Methods of attachment and assembly of skin panels and major components.

3.4 Criteria and program reports. The reports of 3.4.1 through 3.4.9 shall consist of that information necessary to detail the design criteria for determining all external loads. All deviations from applicable specifications that are pertinent to a particular report authorized by change orders subsequent to date of contract and the justifications for the deviations shall be included as an appendix to each report. These reports shall not repeat the explicit design requirements of this series of specifications or the detail specification, but shall expand, or amplify, generalized requirements as contractually necessary and appropriate to make the requirements specifically applicable to the airplane under acquisition. Where the requirements grant the contractor an option, or alternative, in the method of compliance therewith, this report shall state the option, or alternative, chosen.

3.4.1 Flight loads design criteria report. This report shall present all design weights specified in MIL-A-8860 and the derivations thereof; center of gravity (CG) envelopes, including weight vs CG diagrams and the derivations thereof; design V-n diagrams for symmetrical and unsymmetrical flight; design load factors, airspeeds, and rotational velocities and accelerations; elevated temperature criteria; and all critical loading configurations, including all external stores specified for carriage on the airplane in applicable contractual documents. This report shall set forth the specific design conditions selected for analysis, including a list of the store loading configurations selected for analysis, together with the basis for selection of those conditions and configurations; discussion of design features which affect determination of critical conditions; sources of aerodynamic data; and methods and assumptions to be used in the calculation of aerodynamic loads. Structural maneuvering capability shall be defined by superimposing all limiting factors, including, but not limited to, control power, angle of attack, and buffet, on altitude vs Mach number envelopes. Effects of weight and CG and variable geometry component positions shall be included. A range of KEAS curves and V_G, V_H, and V_L curves shall be superimposed, and the design gust load factor shall be shown.

3.4.2 Control system loads design criteria report. This report shall present a detailed description of the control system, its components, and the functions thereof. This report shall also show clearly the sources and complete explanations of all loads on the system and its components.

3.4.3 Cargo, seat, and litter loads design criteria report. For all cargo or personnel carrier airplanes, this report shall present a complete description of all structural design criteria used for troop and passenger seats, cargo tie downs, litters, cargo aerial delivery systems, cargo jettison systems, and other equipment and systems used to transport or deliver passengers or cargo. Where applicable, the structural design criteria used for substantiation of compatibility with the specified material handling system shall be provided.

3.4.4 Ground loads design criteria report. For field landings, arrested landings, Field Carrier Landing Practice (FCLP) landings, field takeoffs, catapult takeoffs, and taxiing and ground handling, this report shall present:

a. Derivation of design weights, CG positions, all practicable distributions of variable and removable mass items, including internal and external fuel that will be considered for design.

b. For each design weight, the maximum design loading for (1) internal fuel, (2) internal and external fuel, (3) each store station, (4) total store capacity per wing, (5) asymmetrical store carriage about the airplane plane of symmetry, and (6) bomb bay fuselage stores.

c. The variation of $V_{PA_{MIN}}$ with landing weight.

d. The range and derivation of takeoff speeds, approach speeds, engaging speeds, sinking speeds, airplane altitudes and combinations thereof.

e. The catapult tow forces and horizontal accelerations used for each type of catapult as a function of airplane weight.

f. The catapult holdback forces.

g. The arresting hook forces and horizontal accelerations used for each type of arresting gear as a function of airplane weight.

h. The range of ground roughness and soil conditions used for design takeoff and landing conditions.

i. The range of landing gear variation in servicing that will be used for design.

j. A summary of all ground handling, taxi, securing, and miscellaneous ground loading conditions.

k. The lift curve (C_L versus α with respect to Fuselage Refernce Line (FRL)) used to define the airplane design pitch angles.

l. Substantiating data, pertinent references, and amplifying data showing that the derivations of the required range of parameters comply with contract requirements.

m. Drawings showing required airplane attitudes with main landing gear, auxiliary landing gear, and tail bumper in the fully extended and fully compressed position relative to the fuselage reference line. Also, the arresting hook in the retracted and full down trail position, identifying the clearance angles between the tail/empennage structure and the main landing gear wheels for the condition of main landing gear shocks struts fully extended and tires undeflected and for the condition of main landing gear struts fully compressed and tires flat. The foregoing angles shall be shown for airplane roll angles of 0°, 2°, and 5°.

3.4.5 Repeated loads criteria report. This report shall present the repeated loads requirements in terms of specific design requirements and parameters, including:

a. Airplane weights and loading configurations in terms of fuel, stores, and other useful load items.

b. Mission and maneuver analyses.

c. Maneuver loads spectra and the derivation thereof.

d. Ground-air-ground cycles spectra.

e. Gust loads.

f. Cockpit and cabin pressurization loads.

g. Airplane weights and loading configurations, spotting positions, and winds-over-the deck for catapulting.

h. Airplane weights and loading configurations, sinking speeds, roll and pitch attitudes, engaging speeds, approach speeds, values of wing lift, landing gear servicing, and deck obstruction roll-over occurrences of main and nose gear wheels for all carrier landings.

i. Airplane weights and loading configurations, ground roughness parameters, and ground speeds for all takeoff, landing rollout and taxiing conditions.

j. Airplane weights and loading configurations, ground roughness parameters, touch down speeds, roll and pitch attitudes, and sinking speeds for all field landings.

k. Airplane weights and loading configurations, and design parameters for all ground braking, turning, taxiing, and pivoting conditions.

l. Airspeeds and maneuver load factors to be used for design of component parts of the airframe, such as flight control systems and landing gear retraction and extension systems.

m. Design parameters for folding, extending and sweeping of all movable surfaces while the airplane is on the ground or in flight, as applicable.

3.4.6 Dynamic loads and fatigue program and criteria report. This report shall include a list of actions and dates pertinent to the airframe structural dynamic loads and fatigue program consistent with the program set forth in the Schedule of Structural Work Report and discussion of environment prediction, structural dynamic response analysis and component tests, as follows:

3.4.6.1 Environment prediction section. This section shall include, but not be limited to, the following:

3.4.6.1.1. Aeroacoustic environments.

a. Three views of the airplane with major dimensions and surface areas. Also, geometric relationships between the jet blast deflector (JBD) and the airplane in battery position on the catapult and the positions of the airplane aft of the JBD that will be included for design.

b. A list of the significant aeroacoustic load sources (and those characteristics which are available) associated with engine and airplane operation on land, aboard ship, and in flight. This list shall include, but not be limited to, the following:

(1) Propeller/rotor induced noise if rotational tip velocities exceed 0.8 Mach number and minimum clearance between blade tip and structure is less than 20 inches.

(2) Efflux from jet propulsion systems of any type. For shipboard operations, the effect of this efflux on the emitting airplane, as well as an airplane in close proximity, shall be included.

(3) All other noise sources associated with the propulsion system, such as compressor or fan noise, combustion noise, and nozzle instability noise.

(4) Boundary layer pressure fluctuation noise.

(5) Wake noise.

(6) Cavity noise.

(7) Base pressure fluctuation noise.

(8) Noise caused by oscillating shocks.

(9) All other noise of aerodynamic origin that may be associated with unsteady flow phenomena.

(10) Gunfiring.

c. The temperature-humidity environment to be assumed in aeroacoustic loads calculation, and definition of regions of structure experiencing high temperatures because of jet exhaust impingement or aerodynamic heating.

d. A tabular enumeration and its derivation of time duration and associated temperatures of acoustic loads for the specified service life of the airplane. The tabulation shall show the important operating modes of the airplane in flight, on the ground, and aboard ship, including corresponding airspeed and altitudes, engine power settings, and other pertinent information required to determine the aeroacoustic design environment.

e. The methods of aeroacoustic loads predictions to be used and the bases for their selection.

f. Outline of development of any new or unconventional methods of predicting aeroacoustic loads. Any experimental work which will be undertaken to obtain data needed in predicting aeroacoustic loads (e.g., wind tunnel models, rocket models, etc.) shall be discussed in detail.

g. Plans for environmental measurements of airframe structural aeroacoustic loads during ground and flight operations.

3.4.6.1.2 Vibration environments.

a. A listing of sources of oscillatory exciting forces, and, if available, vibration level measurements applicable to the airframe structural design.

b. The total time duration for the specified service life of the airplane for each different vibration environment to be encountered during operation on the ground, aboard ship, and in flight.

c. Description and analysis, where applicable, of antivibration provisions (including antivibration mountings, special structures, and location of propulsion systems) to be applied to control the airframe structural vibration environment; and, if available, the measured effects of devices planned or required to control airframe structural vibration.

d. Proposed investigations for making accurate predictions of airframe structural vibration environments and prediction techniques to be used.

e. Plans for environmental measurements of airframe structural vibrations during ground and flight operations.

3.4.6.2 Structural dynamic response analysis section. This section shall include but not be limited to the following:

a. Discussion of methods to be used for identifying structural components that are susceptible to sonic-fatigue or dynamic-fatigue.

b. Discussion of methods to be used for determining the sonic-fatigue resistance of the structure and predicting its sonic-fatigue life.

c. Discussion of methods to be used for determining the dynamic-fatigue resistance of the structure and predicting its dynamic-fatigue life.

d. Techniques to be used for designing adequate sonic-fatigue or dynamic-fatigue strength into structural components. The bases for their proposed use shall also be stated.

e. The method in which combined environments (i.e., temperature, creep, corrosion, pressure differentials, nuclear radiation, load factor, etc.) effects will be accounted for shall be stated.

3.4.6.3 Component tests. This section shall include the following:

a. Rationale to be used for determining whether component testing will be performed on various sonic-fatigue or dynamic fatigue susceptible structural components.

b. Description and basis for selecting test methods for sonic-fatigue component tests.

c. Description and basis for selecting test method for the empennage dynamic fatigue test and any other dynamic-fatigue component test.

d. Description of the test facilities and test equipment that are available and their characteristics, capabilities and limitations.

3.4.7 Aeroelastic stability program report. This report shall contain a description of the technical approach to be used in substantiating the required flutter margins of safety, as follows:

a. Methods of representing the inertial and elastic characteristics of the airplane and determining vibration modes.

b. Methods of representing aerodynamic forces, including compressibility, control surface and tab gap effects, and aerodynamic interference effects for contiguous airfoils.

c. Methods of representing thermal effects.

d. Methods of flutter and divergence analyses to be followed and a description of the flutter modes to be investigated, including, but not limited to, airplane, engine, external stores and racks plus any Contract Furnished Equipment (CFE) or Government Furnished Equipment (GFE) appendages.

e. The substantiating and demonstration tests, such as structural model tests, flutter model tests, thermoelastic tests, rigidity tests, ground vibration surveys, and flight flutter tests, shall be described and discussed.

f. A list of actions and dates pertinent to the flutter and divergence program consistent with the program set forth in the Schedule of Structural Work Report.

3.4.8 Nuclear weapons delivery criteria report. This report shall present the methods and basis for defining weapons explosion fields, the airplane response and airframe resistance to the effects, and shall include a description of the following together with data pertinent to the solution of critical delivery and escape conditions.

a. A list of applicable documents to be used for a study of nuclear weapons capability and vulnerability.

b. Criteria for allowable and vulnerable levels of airplane structural response resulting from thermal radiation, nuclear radiation, overpressure and material velocity or "gust" effects.

c. Allowable and vulnerable overpressure and gust levels to which the airplane power plant may be subjected.

d. Allowable and vulnerable levels of thermal and nuclear radiation for the airplane crew and cockpit.

e. The applicable airplane weights, CG, and variable geometry component locations.

f. Mission profiles.

g. The delivery techniques or airplane flight paths and performance conditions at the delivery release point.

h. The escape maneuvers or airplane flight paths and performance conditions from the weapon delivery release point through shock arrival at the airplane.

i. The range of applicable environmental conditions, including such parameters as atmospheric conditions, ground albedo or reflection factors, and target elevations.

j. The applicable surface absorbability.

k. The applicable airplane dynamic response factors.

l. The degree of applicability of blast thermal interactions.

m. Allowable and vulnerable avionics levels.

n. The combinations of yield and burst height,the applicable weapon configurations and weapon flight trajectories, and the threat to the airplane from fratricide and enemy weapons.

3.4.9 Fracture control plan report. A fracture control plan shall be prepared outlining the provisions for damage tolerance to be incorporated into the design and construction of the airplane. The plan shall provide for the establishment of a fracture control board to provide an organizational focus to supervise the implementing of the plan's provisions. The fracture control plan will outline provisions for implementing a fracture critical parts program. The plan shall include the following major elements:

a. Redundant load path structure.

b. Damage tolerant material.

c. Critical component list.

d. Fracture mechanics test program.

e. Fracture mechanics analyses (metals).

f. Fracture control (advanced composites).

g. Material and process controls.

h. Nondestructive testing and inspection.

i. Guaranteed fracture properties of materials.

3.5 External loads reports. These reports shall present in detail the magnitudes and distributions of all applied external loads, such as flight loads, ground and deck reaction loads, catapult loads, fatigue loads, and repeated loads. The development of any new or unconventional methods of determining air or ground loads, or load distributions used in the structural design shall be explained in detail. Wherever possible, correlation of methods and assumptions with wind tunnel or flight test data, or both, shall be shown. Such explanation and data correlations shall be presented in appendices to the appropriate loads reports, or in separate reports.

3.5.1 Inertia loads report. This report shall include weight and balance analysis, moments of inertia, and distribution of inertia loads, shears, and moments for unit linear and angular accelerations and unit angular velocities.

3.5.2 Flight loads report. This report shall include references to detailed aerodynamic and other data used to determine the magnitude and distribution of aerodynamic loads. This report may be prepared as a separate report for each major structural component listed in 3.8.1. This report shall present at least the following information:

a. List of airplane weights, speeds, altitudes, load factors, variable geometry configurations, useful load distributions, and other pertinent conditions that were investigated with sufficient amplifying information to show that such investigations adequately covered all critical loads.

b. The basis for selection of the design load conditions, including discussion of design features affecting loads, parametric analyses, and loads trend data sufficient to provide a foundation for the validity of the selected conditions.

c. Comparative tabulated values or curves of loads, shears, bending moments, and torsions showing the more critical nature of one condition versus another.

d. Details of analyses methods with sample calculations, as appropriate.

3.5.3 Control system loads report. This report shall present the loads to be used for the design of the control system, including the components thereof. The source, derivations, magnitude, and analysis of system loads shall be presented. System components shall be listed and their functions and static and repeated operation shall be explained in sufficient detail to show clearly their operation.

3.5.4 Ground loads report. This report shall present those loads resulting from all static and dynamic ground loading conditions. For takeoff, landing, arresting, and landing gear sudden extension conditions, all externally applied ground loads and airframe response in the wing, fuselage, empennage, stores, pylons, and other significant airframe components shall be determined by dynamic analyses. All other ground loads shall be determined by static load analyses or by other rational methods. This report shall also contain the following:

a. For each of the specified takeoff, catapulting, arresting, landing impact, and ground handling conditions, list those airplane weights, distributions of useful load items, and conditions that were investigated, with sufficient amplifying information to show that such an investigation adequately covers all critically applied external static and dynamic loads as well as airframe response loads in all critically loaded airframe components.

b. Results of parametric studies in graphical form to show the variation on externally applied loads and airframe response loads caused by varying critical parameters, such as sinking speeds, airplane weight and weight distribution, airplane attitudes and angular velocities, arresting and catapulting forces, deck obstructions, rough terrain contours, coefficient of friction between the tire and landing surface, landing gear servicing, etc.

c. Time histories of external loads, airframe response loads, and motions for all critical dynamic loading conditions and tabulation of maximum dynamic and static loads.

d. Time histories of airframe response loads, such as bending moments, shears, and torsions for the wing, fuselage, empennage, and other appropriate airframe components, with tabulation of maximum response loads for each airframe component.

e. Amplifying information and discussion to substantiate the criticality of conditions presented in 3.5.4a, b, c, and d, above.

f. Equations used for determining static and dynamic loads. The dynamic analyses shall include the following:

(1) The critical elastic modes of vibration of the airframe and landing gear structure for all critical mass distributions,

including symmetrical and asymmetrical internal and external store loadings as well as symmetrical and asymmetrical loadings on multiple bomb racks.

(2) The specified forcing functions for all arresting and catapulting gear for which the airplane is required to be designed.

(3) The dynamic response characteristics of the tire; the ground or soil for rough field design conditions; and the shock strut, including internal frictional characteristics, special load alleviating devices, and gas compression processes.

(4) Aerodynamic loads.

3.5.5 Repeated loads report. This report shall present the net shear, bending moment and torsion distributions for the various components of the airplane to be the basis for fatigue analyses and tests. These loads are based upon the fatigue loads spectra and operational environment defined in the fatigue criteria report. This report shall contain the following:

a. Distribution of applied in-flight loads at the wing, fuselage, empennage and ailerons, flaps, etc., including airplane weight, altitudes, speed, symmetrical and unsymmetrical load factors, variable geometry positions and configurations.

b. Distributions of applied ground loads at the landing gear, arresting hook, catapult launch bar, catapult holdback structure and airframe response loads for landing, taxiing, takeoff, and ground handling conditions.

c. Distribution of loads at all stores stations.

d. Details of analyses methods with sample calculations as appropriate.

3.6 Dynamic loads environment analysis report.

3.6.1 Initial dynamic loads environment analysis report. This initial submittal of the analyses for aeroacoustic and vibration environments of the airframe structure shall include the following:

3.6.1.1 Aeroacoustic loads environment.

a. A complete list of the important noise sources associated with engine and airplane operations.

b. A concise description of all aeroacoustic load prediction methods employed including testing of acoustic models.

c. The characteristics of the aeroacoustic loads, including but not limited to, the type of noise spectrum (i.e., continuous, discrete or mixed), the one-third octave-band pressure levels, and the frequencies of discrete components of the spectrum.

d. The effects of variation in engine thrust, airplane speeds, and other important operating variables on these aeroacoustic load characteristics.

e. Isobel (overall and one-third octave bands) contour plots of the aeroacoustic loads superimposed on the external surface configuration of the airplane for various important operating modes and engine-power conditions.

f. The aeroacoustic design loads for all of the various airframe structural components, including those located internally.

g. For structures that are heated by jet exhaust or aerodynamically, the structural temperatures associated with the aeroacoustic loads shall be included.

h. Exposure time at the various aeroacoustic load levels for the service life of the airplane. Incorporate the results from mission profile analysis.

3.6.1.2 Vibration and other oscillatory loads environments.

a. A description of the vibration prediction methods employed. Any vibration measurements made during the development program of the weapon system, or the propulsion system, or other sources of vibration shall be included in the analyses together with the measured effects of devices that are planned or required to control vibration of the airframe structure and crew stations.

b. A summary description of the vibration environment characteristics, including, but not limited to, the type of vibration spectrum, acceleration spectral densities (g^2/Hz vs frequencies), the one-third octave-band load levels, and the frequencies of discrete components of the spectrum, to be encountered by the airplane on the ground, aboard ship, and in flight at various locations on the airframe structure and at the crew stations.

c. The effects of variation in engine thrust, airplane speed, dynamic pressure, load factor, operation of armament systems, and other important operating variables on these vibration environment characteristics.

d. A description and analysis of the effect, where applicable, of the antivibration implementations (including but not limited to, anti-vibration mountings, special structure, and location of propulsion systems) to be applied to control the vibration of the airframe structure and the crew stations.

e. Exposure time at the various vibration levels for the service life of the airplane. Incorporate the results from mission profile analysis.

3.6.2 Intermediate dynamic loads environment analysis report. This report shall be based upon the initial report but updated to reflect at least the results of wind tunnel model tests and ground tests (3.9.1, 3.9.3, 3.9.4 and 3.9.6) that have been completed.

3.6.3 Final dynamic loads environment analysis report. This report shall revise the data of 3.6.1 and 3.6.2 to reflect the results of all airframe structural aeroacoustic and vibration environment tests, both ground and flight. An assessment on how the previously reported airframe's structural aeroacoustic loads and vibration environments shall be amplified in view of all test results. Correlation between analytical, ground test and flight test aeroacoustic and vibration results shall be performed and discussed. In addition, this revision shall contain data demonstrating that the required vibration level limits at the various airplane crew stations have not been exceeded, and that the minimum damping requirement for all significant airframe dynamic response modes exists. This report shall be submitted not later than 60 days after completion of the aeroacoustic and vibration flight tests.

3.7 Aeroelastic analysis reports.

3.7.1 Preliminary aeroelastic analysis report. As a minimum, this report shall include the flutter analyses results, divergence analyses results, basic data, and vibration modal analyses described in 3.7.1.1, 3.7.1.2, 3.7.1.3, and 3.7.1.4, respectively.

3.7.1.1 Flutter analyses section. The flutter analyses results shall be presented for the minimum altitude at which the maximum design Mach number can be obtained, the minimum altitude at which the maximum design dynamic pressure can be obtained, and the minimum altitude at which transonic effects begin to occur. In addition, the analyses results shall be presented for all other altitudes deemed necessary either by the contractor or the contracting activity. Compressible aerodynamics shall be used in the high subsonic and supersonic speed ranges. Analytical or empirical corrections, as are available, shall be applied for analyses in the transonic speed regime. Finite span effects shall be included in the analyses for lifting surfaces when these effects are significant. The effects of aerodynamic interference shall be included for surfaces where significant flow interaction occurs. The effects of transient and steady-state heating shall be included in all analyses for thermal considerations specified in MIL-A-8860. In cases where the results of the flutter analyses show the flutter stability to be marginal or where the flutter speeds are sensitive to variations in one or more parameters, the critical parameter(s) shall be varied to cover the expected range, where the range shall include, but not be limited to, the implications of wear due to service usage and changes in rigidity up to limit load conditions. The analyses may be based on calculated vibration modes or, if they are available, on measured vibration modes. Sufficient number of modes shall be used to present the important dynamic characteristics of the airplane. The report shall include, at least, the results of the three-dimensional flutter analyses described in 3.7.1.1.1 through 3.7.1.1.11. For a few selected critical conditions and configurations, matched point flutter analyses results shall be presented. The methods and notation used in the analyses shall be clearly described and defined unless standard flutter methods and notations are used and referenced. The reports and results of the analyses shall be complete and as concise as is practical and shall list the numerical values of the flutter parameters used. The results of all flutter analyses performed shall be presented as plots of the damping coefficient "g" and variation of frequency (Hz) for each mode versus equivalent airspeed (knots). Significant descriptive information shall be listed on each plot. The results of parametric studies shall be presented as plots of flutter speed versus the variation in significant parameters. A discussion of the mechanism of flutter for all critical flutter modes shall be included. A summary plot shall be included showing predicted flutter speed and airplane limit speed, V_L, versus Mach number for various altitudes. The predicted flutter speed boundary shall be given for structural modal damping coefficient "g" equal to zero and also for a g = +0.02 on the summary plot.

3.7.1.1.1 Wing flutter analyses. Both symmetrical and antisymmetrical modes shall be investigated for various internal fuel loadings, CG positions, and geometric variations. Significant fuselage, empennage, and control system modes shall also be included. Leading edge flap(s) rotation, torsion and bending modes (including chordwise bending) shall be included in all wing flutter analyses. Where external stores such as fuel tanks, rockets, bombs, mines, missiles, racks and pylons are carried, the flutter analyses shall cover the range of external store configurations (including single and multiple carriage, mixed loadings, standard and optional down-loadings, and hung stores) for which the airplane is designed and as specified by the contracting activity. The effects of the variations of the mass and the positions of the CG of variable mass items, such as fuel tanks, rockets pods, and bomb racks, shall be included. Analyses for external and outboard internal fuel tanks shall include at least the half-full forward and half-full aft CG conditions in addition to the empty and full fuel conditions. In addition, a full span airplane flutter analyses shall be performed to investigate the flutter characteristics of various asymmetric store loadings selected by the contractor and contracting activity.

3.7.1.1.2 Empennage flutter analyses. Both symmetrical and antisymmetrical modes shall be investigated and critical parameters shall be varied to cover the expected ranges of design values. Significant fuselage modes shall also be included. For T-tail type empennages, the effects of aerodynamic interference shall be included and variations in stabilizer roll and yaw frequencies shall be made.

3.7.1.1.3 All-movable-surface flutter analyses. Both symmetrical and antisymmetrical modes shall be investigated. All-movable-surface first and second bending, rotation, and torsion modes shall be included. Where the axis of rotation is not in the plane of the surface, the fore-and-aft motion of the surface shall be included. The rotational frequency of the surface shall be varied over the ranges to cover both normal and emergency operations.

3.7.1.1.4 Control surface flutter analyses. The rotational frequencies of all control surfaces shall be varied in the flutter analyses to cover the probable ranges of operation. The control surface torsional and bending degrees of freedom shall be included in the analyses.

3.7.1.1.5 Control surface tab flutter analyses. Flutter analyses shall be performed for all tabs. The flutter analyses shall include: tab rotation, bending and torsion degrees of freedom; control surface rotation, bending and torsion degrees of freedom; important modes of the main lifting surface; and control system modes. The effective inertia of the control column or pedals and of the pilot shall be varied to cover the probable range.

3.7.1.1.6 Other surfaces controls which are exposed to the air stream. Flutter investigations shall be performed for airplane components, other than control surfaces, which are exposed to the air stream. These include the following:

a. Flaps.

b. Dive brakes.

c. Spoilers.

d. Canard surfaces.

e. Scoops.

f. Booms.

g. Strakes.

h. Fixed, retractable, or jettisonable ventral fins.

i. Overwing fairings on airplane with variable sweep wings.

j. Weapon bay doors.

3.7.1.1.7 Aeroservoelastic analyses. The dynamic characteristics of control surfaces actuating systems such as servo boost, fully powered servo control, and other types, shall be included in the flutter analyses. Augmentation systems and other systems which may alter the dynamic response of the airplane shall also be included in the flutter analyses. The effect of high temperatures on the dynamic characteristics of the actuating systems, including the hydraulic fluid, shall be included.

3.7.1.1.8 Chordwise mode flutter. Evaluations based on existing experimental and theoretical data shall be made to determine that the required flutter margin of safety exists for those structural sections and surfaces on supersonic airplane which are deemed to be most susceptible to chordwise mode flutter.

3.7.1.1.9 Panel flutter. Evaluations based on existing panel flutter design criteria, such as that contained in AFFDL Technical Report 67-140 but not limited thereto, shall be made to determine that the required flutter margin of safety exists for those skin panels and fairings on a supersonic airplane deemed most susceptible to flutter. When panels may be subjected to in-plane compressive stresses due to airplane maneuvering or aerodynamic heating, a buckled or near buckled condition (whichever is more critical) shall be assumed unless an accurate prediction of the compressive stress and its effect on panel flutter can be made. The aerodynamic conditions used shall be the local conditions existing at the panel surface which may be altered from the free stream by airplane attitude or surface shape.

3.7.1.1.10 Whirl mode flutter. Whirl mode instability of the total and complete propulsion system plus the airplane system shall be analyzed and include the following:

a. Airframe and airplane modes including pylon pitch and yaw modes.

b. Engine modes including engine case modes and engine mount-isolator modes.

c. Power transmission system modes including drive shaft modes.

d. The modes of propellers, fans, or any other blades.

e. The propeller, fan, or all other blade aerodynamic and dynamic loads, such as gyroscopic loads.

f. All accessories for all systems that are considered important.

3.7.1.1.11 Fail safe. Analyses shall be made that assume failures of various components of the airplane that are significant from a flutter standpoint. At least the following failure, malfunction, or adverse conditions shall be analyzed:

a. Failure, malfunction, or disconnection of any single element of the main flight control system, augmentation systems, automatic flight control system, tab control system, or in any flutter damper connected to a control surface or tab.

b. Failure of any single element in the supporting structure of external fuel tanks, engine pods, or other external stores.

c. Failure of any single element of the structure supporting any engine, independently supported propeller shaft, or engine structure for airplane with turbopropeller or large turbofan engines if applicable.

d. Absence of propeller aerodynamic forces resulting from feathering of any single propeller both as a separate condition and in combination with (c). In addition, for airplane with four or more engines, the feathering of the critical combination of two propellers.

e. Any single propeller or fan of a large turbofan engine that is rotating at the highest possible overspeed (RPM).

3.7.1.2 Divergence analyses section. Divergence analyses shall be performed for all wings, stabilizers, fins and leading edge flaps. If external stores, such as wing tanks, are carried near the tip of a main surface, these analyses shall be made both with and without stores. The effects of tank fins shall be included in the analyses. Divergence analyses shall also be performed for pylon mounted engines and stores, long slender bodies having significant lift or forward located lifting surfaces, all-movable control surfaces and their actuating systems, and the leading edges of surfaces. The sectional aerodynamic derivatives used in the analyses shall be based on experimental data, insofar as is practicable. The analyses shall be performed for the same altitudes specified in 3.7.1.1. Compressibility corrections shall be made where applicable. The effects of transient and steady-state heating shall be included in all analyses for thermal considerations specified in MIL-A-8860. The results of the analyses shall be presented as plots of divergence speed in knots equivalent airspeed versus Mach number for various altitudes. In addition, these plots shall show the design limit speed, V_L, versus Mach number.

3.7.1.3 Basic data section. All data necessary to perform the detailed vibration modal analyses, flutter analyses, divergence analyses and aeroservoelastic analyses shall include, but not be limited to, the following:

a. Plots of airplane design limit speed in knots equivalent airspeed and Mach number versus altitude.

b. A three-view drawing, to scale, of the complete airplane general arrangement showing major dimensions and locations of non-structural mass items, control surfaces hinges and balance weights.

c. Blow-up drawing of airplane components.

d. Planview drawings, to scale, with major dimensions, showing locations of balance weights, dampers, hinges, axes of rotation and actuators of all control system surfaces. A description of the type, weight, and final assembly and installation of balance weights and their natural frequencies when installed in the airplane shall be included.

e. For flutter dampers, a description of the method of operation, installation in the airplane, design values intended to meet damping versus frequency, and results of laboratory qualification tests of the flutter dampers shall be included.

f. If the NASTRAN computer program is used for the finite element model and vibration modal analyses, a copy of the input data shall be provided.

g. For the main lifting surfaces, if an elastic axis theory is used: Plots of chord length, weight per unit span, CG location, mass moments of inertia per unit span, static unbalance about elastic axis per unit span elastic axis location, EI and GJ versus span and root stiffnesses.

h. For control surfaces, tabs, flaps, and other controls exposed to the free stream: Plots of leading and trailing edge locations, hinge line location, weight per unit span, CG location, static unbalance about hinge axis per unit span, mass moments of inertia about hinge axis per unit span, EI and GJ, versus span and rotational stiffness.

i. For fuselage: plots of weight, mass moments of inertia, elastic axis, EI and GJ versus length.

j. Design stiffnesses of all actuators.

k. Schematic diagram of the airplane entire flight control systems, (longitudinal control system, lateral control system, directional control system etc.). Also, detailed explanation of how the hydraulic power supply (including redundancy) is used to actuate these various control systems shall be included.

l. Mass properties (weight, CG location, mass unbalance about hinge line, and mass moments of inertia) of all control surfaces and tabs.

m. For concentrated masses such as engines, pylons and pods: weight, CG location, mass moments of inertia and stiffnesses of the supporting structure.

n. For external stores such as fuel tanks, bombs, missiles, rockets, mines, etc.: weight, CG location, and mass moments of inertia.

o. Dimensional analyses of all actuating system parts for each control surface and tab showing minimum and maximum freeplay values due to manufacturing tolerances.

3.7.1.4 Vibrational modal analyses section. Dynamic characteristics of the entire airplane which are required to perform aeroelastic stability and dynamic response analyses shall include, but not limited to, the following:

a. A description and figures of the symmetric and antisymmetric complete airplane idealized dynamic mathematical model. A table showing the dynamic degrees-of-freedom and their location in airplane coordinates.

b. A description and figures of the full-span complete airplane idealized dynamic mathematical model. A table showing the dynamic degrees-of-freedom and their location in airplane coordinates.

c. Plots of calculated normal modes (mode shapes and node lines), frequencies and generalized masses of the fully coupled airplane. These data shall be provided for various selected airplane/external store configurations, in addition to the basic airplane.

d. Microfiche copies of computer input/output listings of various selected airplane/store(s) configuration(s) shall be provided.

3.7.2 Initial aeroelastic analysis report. This report shall update the preliminary report based on a dynamic mathematical model which was modified to simulate the final airplane design prior to first flight. The analyses shall also be updated based on results obtained from ground tests and wind tunnel flutter model tests that have been completed. The report shall also include, but not limited to, the following:

a. A tabular summary of all flutter analyses performed indicating for each analysis the modes used, the flutter speed obtained, and the minimum value of the damping coefficient, "g", obtained for speeds from minimum up to 1.15 times the limit speed.

b. The flutter summary plot(s) shall be updated showing predicted flutter speed boundaries and airplane limit speed, V_L, versus Mach number for various altitudes. Indicate by shaded areas within the flight speed envelope where, if any, the minimum flutter margins exist for various airplane lifting surfaces.

c. The updated divergence analyses results shall be presented as plots showing predicted divergence speeds and airplane limit speed, V_L, versus Mach number for various altitudes.

d. All flutter analyses results shall be presented as plots of the damping coefficient "g" and variation of frequency (H_z) for each mode versus equivalent airspeeds (knots). Results of modal deletion flutter analyses and match point flutter analyses shall also be presented.

e. All aeroservoelastic analyses results shall be presented as plots of gain (dB) and phase (degrees) versus frequency (H_z) for various Mach numbers and altitudes.

f. The flutter characteristics of the airplane with wing and fuselage mounted internal and external pylon-ejector-rack-store loading configurations shall be presented in sets of graphical summary plots. Contour plots of flutter speed isolines (in 25 KEAS increments up to 1.50 V_L) versus rack-store configuration radius of gyration and rack-store configuration weight shall be presented for a given value of rack-store configuration center of gravity position relative to the rack-to-pylon suspension lugs midpoint. Variations in center of gravity position shall be chosen in suitable increments (about 5 inches) to generate these sets of curves over the CG range which would result from loading the entire store inventory and from loading a multiple ejector rack with various combinations of forward and aft store loadings on the rack's store stations. These sets of contour plots shall be prepared for each store station and in combination with each other.

g. The static aeroelastic divergence characteristics of wing and fuselage mounted external pylon-ejector-rack-store loading configurations shall be presented in graphical summary plots. Plots of external rack-store configuration projected side area forward of the rack-to-pylon suspension lugs' mid-point versus external rack-store configuration center of pressure location forward this mid-point with isolines of divergence speed (in suitable incrments up to 1.5 V_L) shall be shown.

h. Recommended airplane configurations (with and without stores) to be evaluated during the aeroelastic stability flight test demonstration.

3.7.3 Intermediate aeroelastic analysis report. This report shall be based on the initial report but updated based on the results of the ground tests of the aeroelastic stability substantion program such as ground vibration modal tests, compliance tests, wind tunnel flutter model tests, and other tests that have been completed. Corrections shall be included which account for all significant differences between measured and calculated mass properties, stiffnesses, and freeplay, and modification of aerodynamics based on wind tunnel tests (both flutter model and steady aerodynamics model). The dynamic mathematical model used in the analyses shall reflect modifications made which are based on correlation studies between experimental and analytical modal parameters (mode shapes and frequencies). The report shall also include, but not limited to, the following:

a. A tabular summary of all flutter analyses performed indicating for each analysis the modes used, the flutter speed obtained, and the minimum value of the damping coefficient, "g", obtained for speeds from minimum up to 1.15 times the limit speed.

b. The flutter summary plot(s) of 3.7.2b shall be updated. In addition, flutter summary plot(s) shall be presented for ten of the more flutter critical airplane-store configurations, including the most critical. These plots shall show predicted flutter speed boundaries and airplane limit speed, V_L, versus Mach number for various altitudes. Indicate by shaded areas within the the flight speed envelope where, if any, the minimum flutter margin exist for the various flutter mechanism.

c. The divergence analyses summary plots of 3.7.2c shall be updated. In addition, a tabular summary shall be presented for all divergence analyses performed for pylon-ejector-rack-store configurations.

d. All flutter analyses results shall be presented as plots of the damping coefficient "g" and variation of frequency (H_z) for each mode versus equivalent airspeeds (knots). Results of modal deletion flutter analyses and match point flutter analyses shall also be presented.

e. The aeroservoelastic analyses of 3.7.2e shall be updated. In addition, aeroservoelastic analyses results shall be presented for ten of the more flutter critical airplane-store-configurations, including the configuration having the lowest structural modal frequencies. The results shall be presented as plots of gain (dB) and phase (degrees) versus frequency (H_z) for various Mach numbers and altitudes.

f. Addenda to this report shall be submitted to update the analyses based on the results of ground tests that have been completed after initial submittal, such as when limit load rigidity tests show reductions in structural stiffness under load, flutter analyses shall be updated which include the lower stiffness levels at compatible flight conditions where flutter margins are minimum.

g. Addenda to this report shall be submitted for parametric variation flutter analyses performed to determine sensitivity of the flutter speed margins of the airplane due to variation of mass properties of control surfaces, tabs and flaps. These parametric study results shall be presented for all control surfaces, tabs, flaps and other controls exposed to the airstream. Based on these parametric studies, the maximum structural repair mass properties (weight, location, etc.) allowable without degradation in flutter speed margin shall be established.

3.7.4 Final aeroelastic analysis report. This report shall contain data demonstrating flutter and divergence safety requirements up to 1.15 V_L for the weapon system. It shall include the summarized results of all the required flight flutter and divergence tests. Final plots of damping coefficient, "g", and frequency of oscillation of the critical modes versus knots equivalent airspeed and Mach number for various altitudes shall be presented. A discussion of the correlation between the flight flutter and divergence test data and the results of the analyses and tests performed during the flutter and divergence program shall be included. The objective of this discussion shall be to substantiate that the required MIL-A-8870 damping coefficient, "g", margin exists up to V_L and to substantiate that the required MIL-A-8870 flutter and divergence margins of safety beyond V_L exist. The report shall also include the following:

a. Final flutter characteristics of the airplane with wing and fuselage mounted internal and external pylon-ejector-rack-store loading configurations shall be presented in sets of graphical summary plots. Contour plots of flutter speed isolines (in 25 KEAS increments up to $1.50V_L$) versus rack-store configurations radius of gyration and rack-store configuration weight shall be presented for a given value of rack-store configuration center of gravity position relative to the rack-to-pylon suspension lugs' mid-point. Variations in center of gravity position shall be chosen in suitable increments (about 5 inches) to generate these sets of curves over the CG range which would result from loading the entire store inventory and from loading a mulitiple ejector rack with various combinations of forward and aft store loadings on the rack's store stations. These sets of contour plots shall be prepared for each store station and in combination with each other.

b. Final static aeroelastic divergence characteristics of the wing and fuselage mounted external pylon-ejector-rack-store loading configurations shall be presented in graphical summary plots. Plots of external rack-store configuration projected side area forward of the rack-to-pylon suspension lugs' midpoint versus external rack-store configuration center of pressure location forward of this midpoint with isolines of divergence speed (in suitable increments up to $1.50V_L$) shall be shown.

c. Recommended maximum carriage airspeed limits for all stores to be carried on the airplane including mixed loading. Provide detail rational.

d. A final vibration and flutter analyses computer program shall be made available in an operational, ready to use form, along with user's manuals, to the contracting activity at a government facility such as Naval Air Development Center (NADC), Naval Air Test Center (NATC), Naval Research Laboratory (NRL) or Naval Sea Research & Development Center (NSRDC).

3.8 Internal loads analysis reports.

3.8.1 Internal loads methodology report. The methodology to be used for determining the internal load distribution shall be prepared for NAVAIR acceptance. The report shall contain all data required to substantiate the input to the analysis program being used. It shall include but not be limited to:

a. The math models of the structure: both the model developed by the analyst and the one drawn by the computer.

b. Structural arrangement drawings in such detail that the model can be compared to them.

c. Program input and output in a presentable form, including computer plots of the output where practicable.

3.8.2 Stress analysis reports. Stress analysis reports shall consist of those data that relate to the analytical determination of the ability of the airplane structure to support critical loads and meet the specified strength requirements. These reports shall include, in the first few pages, curves, tables, or both, giving for the particular component the detail resultant loads, shears, bending moments, and torsional moments. In general, stress analysis reports shall contain detailed analyses of the major components of the structure and summaries of stress calculations of other components. Emphasis shall be given to presentation of the stress analysis in a manner that will allow rapid interpretation of the significant results. The stress analysis shall include a description of the structural components analyzed, giving the type of construction, arrangement, material, location by coordinates of load carrying members, and other pertinent data. Adequate sketches shall be provided throughout the analysis to minimize the necessity of referring to drawings of the airplane. The presentation of detailed loads shall be complete and show clearly the steps considered in their development. Detailed loads shall be identified as limit or design ultimate loads, or in the case of landing loads, defined as design loads. Identification of special factors used shall be included. Stresses shall be calculated for the maximum loading conditions of components or members, chosen in each case to afford an adequate check of the structure. Unorthodox methods of stress analysis shall be substantiated for accuracy and application. The derivation or source of unusual stress analysis formulas shall be shown. Computations in the stress analysis shall be made on the basis of design ultimate loads; however, where computations based on yield strength of materials indicate yielding, they shall also be included. For landing loads analysis, the "allowable" used shall be identified. Computed margins of safety shall be clearly indicated. A summary table of minimum margins of safety and a table listing all castings and their margins of safety shall be included in each report. Wherever measurements obtained during structural tests permit, the stress distributions of the major components, as determined by analysis, shall be correlated with those determined from test data. Stress analysis shall be prepared as separate reports for the following major structural groups:

a. Wing, including all attachments and actuating structure, movable control surfaces, wing mounted speed-reduction devices, engine mounts, pylon and external store mountings, nacelles, and auxiliary lift devices that are wing mounted.

b. Fuselage, including canopy, engine mount, pylon and external store mountings, fuselage mounted speed-reduction devices, seat, litter and cargo tie downs, and all attachment and actuating structure, except wing and tail attachment.

c. Empennage, including horizontal and vertical fixed and movable surfaces, their attachments, and actuating structure.

d. Control system, including manual, power, and automatic parts, devices, or actuators. (The analysis may be included in reports of control-system loads).

e. Landing and takeoff gear, including actuators and attachments, and catapult and arresting gear.

f. Miscellaneous structure, including seats, hoisting gear, armament attachments, auxiliary and wingtip tank attachments, and fittings, attachments and actuators not otherwise analyzed.

g. Aerial refueling system.

3.8.3 Fatigue analysis reports. Fatigue analysis reports shall provide verification of the ability of the airframe to withstand the fatigue design load spectra of MIL-A-8866 for the required life. All data necessary for this determination is to be included in the report or supplied in conjunction with other reports. The analysis of structural sections of all load carrying assemblies of the airframe, selected as fatigue sensitive, shall be presented in detail in a comprehensive manner. Data supporting the selection of the sections analyzed shall be included with sketches depicting the structural detail, section location and geometry, and the applied loading. All stress calculations shall be included or referenced. References are limited to formally submitted loads or stress reports. Include the supporting data and justification of the fatigue allowable (S-N) curves used and identify the wing 1-g stress levels for the design conditions. The method and procedure used for computing fatigue damage will be clearly specified. The analysis shall provide plots of damage by stress level, loading source, usage or other parametric relationship.

3.8.4 Damage tolerance analysis report. The damage tolerance report shall contain the analytical verification of the damage tolerance characteristics of the airframe in accordance with the requirements of SD-24. The report shall contain a classification of the structure as to the choice of damage tolerance concepts to be employed. Allowable initial flaw sizes, inspection intervals, classification of inspectability, and inspection details required to support the analysis shall be as agreed to by the contracting activity and shall be specified in the report. The report shall substantiate the ability of primary structural components to meet the residual strength, rigidity, and life requirements in the presence of initial flaws, battle damage, and fatigue cracks. Calculations shall be included that show the growth behavior of initial damage in a structure subjected to operational environments, thermal profiles, and critical combined static and dynamic loads. The analysis shall cover the time from initial damage to complete failure of the component. The calculation of critical flaw sizes, flaw growth rates, and residual strength shall utilize the damage tolerance test data generated during the design development (DD) and pre-production verification (PDV) test programs. The report shall include consideration of the method of spectrum ordering including flight-by-flight application of stresses. Also included shall be estimates of the variability of flaw growth due to environment, stress levels, etc. The report shall be a complete document in itself and shall contain all pertinent data required to determine the damage tolerance of the critical areas selected for analysis. Data supporting the selection of critical structure to be analyzed shall be included depicting the structural function and detail, section location and geometry, material, initial defects, applied loading, environment, thermal profile, and other pertinent information. The methods and procedures used throughout the analysis shall be specified, and a complete list of references shall be included.

3.8.5 Dynamic fatigue analysis reports.

3.8.5.1 Sonic fatigue analysis report. This report shall include the following:

a. Analysis of all structure that may be sonic fatigue critical.

b. Fatigue properties (S-N curves) of new or uncommon materials.

c. Sample design calculations to show compliance with fail safe and minimum maintenance and repair requirements.

d. Discussion of how the following factors have been accounted for:

(1) Random amplitude distribution of stress response of structures excited by broadband random sonic load.

(2) Non-linearity of structural response.

(3) Structural damping.

(4) Multi-mode structural response.

(5) Combined environments - elevated or low temperature, creep, corrosion, pressure differentials, nuclear radiation, and non-aeroacoustic vibrations, in addition to the aeroacoustic load.

e. A list showing the estimated sonic fatigue life for each structural component analyzed.

3.8.5.2 Dynamic loads fatigue analysis report. This report shall include the following:

a. Dynamic response analyses of all structure and structural components that may be fatigue-critical due to vibration and oscillatory loads excitation.

b. Fatigue properties (S-N curves) of new or uncommon materials.

c. Sample design calculations to show compliance with fail safe and minimum maintenance and repair requirements.

d. Discussion of how the following factors have been accounted for:

(1) Random amplitude distribution of stress response of structure excited by narrow band or broad band random vibration and oscillatory load.

(2) Non-linearity of structural response.

(3) Structural damping.

(4) Multi-mode structural response.

(5) Combined environments: elevated or low temperature, creep, corrosion, pressure differentials, nuclear radiation, flight and ground loads, aeroacoustic induced vibrations, in addition to the vibration and oscillatory load.

e. A list showing the estimated dynamic load fatigue life for each structural component analyzed.

3.8.5.3 Empennage dynamic fatigue analysis report. This report shall include the following:

a. Description and figures of the empennage idealized dynamic mathematical model used in the analyses. A table showing the dynamic degrees-of-freedom and their location in airplane coordinates.

b. Dynamic response analysis of the empennage due to vibration and oscillatory loads excitation.

c. Fatigue properties (S-N curves) used in analyses.

d. Discussion of how the following factors have been accounted for:

(1) Random amplitude distribution of stress response of empennage excited by narrow band or broad band random vibration and oscillatory loads.

(2) Non-linearity of structural response.

(3) Structural damping.

(4) Multi-mode structural response.

(5) Combined environments: elevated or low temperature, creep, corrosion, nuclear radiation, flight and ground loads, aeroacoustic induced vibrations, in addition to the vibration and oscillatory load.

(6) A list showing the estimated dynamic load fatigue life for structural components of the empennage analyzed.

3.8.5.4 Final dynamic fatigue analysis reports. The data of 3.8.5.1, 3.8.5.2 and 3.8.5.3 shall be revised to reflect the final dynamic loads environment analyses of 3.6.3 based on all the ground tests, laboratory tests, and flight tests compiled during the dynamic loads program including data measured on the flight article.

3.9 Reports of laboratory and ground tests to define environments and characteristics.

3.9.1 Air loads model wind tunnel test report. The report on the air loads wind tunnel test results shall contain the dates and place of the tests, comparisons of model and full scale airplane parameters, drawings and photographs of representative models and their supports, test conditions, plots and tabulation of data acquired (labeled as to parameters measured and units of measurement), and plots showing the wind tunnel characteristics. Comparisons of test results with theoretical results, if available, shall be included. All data shall be presented in terms of both model and airplane parameters.

3.9.2 Flutter model wind tunnel test report. The report on the flutter model test results shall contain the date and place of tests, the model flutter parameters as compared with similar parameters of the full scale airplane, drawings and photographs of representative models, and of the model support. The report shall contain the results of tests used to determine that the model does simulate the airplane. The report shall also include the test conditions, the mode and frequency of flutter encountered if flutter occurs, plots of the damping coefficient and frequency versus velocity if transients are measured, plots of the flutter speed and frequency versus the variation in important parameters if a parametric study is performed, and comparisons of test results with the results of theoretical flutter analyses on the model. The method of correcting for compressibility shall be included. Plots showing the wind tunnel characteristics and indicating the flutter boundary that must be attained (including the flutter margin) shall also be included. All data shall be presented in terms of both model parameters and airplane parameters.

3.9.3 Flutter compliance data report. This report shall contain the results of tests performed to demonstrate compliance with the detailed requirements, as specified in MIL-A-8870, for:

a. Total weight, CG location, static unbalance about hinge line and mass moments of inertia of all control surface, tabs and other controls and surfaces. A comparison of test data with calculated values shall be included.

b. Location and tolerance of balance weights, provision for rebalancing, and the protection installed to prevent changes in mass balance of control surfaces and tabs due to atmospheric effects.

c. Frequencies of installed mass balance weight installation and comparison with calculated values.

d. Test results of balance weights, attachments, linkages, and supporting structure that substantiate that these components can withstand, without failure, the specified static and repeated inertial load factors.

e. Freeplay of all control surfaces, tabs, leading and trailing edge flaps, and wingfolds and comparison with specified values. Dimensional analyses of all actuating system parts for each control surface tab, flap and wingfold showing minimum and maximum freeplay values due to manufacturing tolerances shall be included.

f. Test results of control surfaces, tabs, leading and trailing edge flaps, and wingfolds and on their supporting structure that substantiate that normal wear does not result in freeplay values in excess of specified values.

g. Rotational stiffness of control surfaces, tabs, leading and trailing edge flaps, and wingfolds and comparison with theoretical values.

h. Component vibration modal test data including natural frequencies, damping, mode shapes and node lines. Comparison of vibration modal test data with calculated modal data shall be included.

i. Hydraulic dampers: damping versus frequency, freeplay and service life.

j. Results and summary of all ground tests on all fail-safe features to substantiate fail-safe design requirements.

3.9.4 Ground vibration modal test report. This report shall contain the results of the ground vibration tests, as follows:

a. Description and photographs of the airplane suspension system, the excitation system, instrumentation, procedures, data reduction procedures, and the airplane configuration.

b. Plots of the amplitude versus frequency and frequency response function for several suitably located vibration pickups monitoring the frequency sweeps.

c. The natural frequency, damping, and mode shape and node line locations for all modes that are important with respect to flutter. A comparison of the airplane experimental vibration modal data, calculated vibration modal data and flutter or vibration model data shall be included.

d. The quality of the experimental mode shapes shall be evaluated by examination of the modal data orthogonality. The generalized mass matrix obtained from an integrated triple matrix product of the experimental orthonormalized mode shapes and the theoretical mass matrix of the dynamic system shall not have off-diagonal elements greater than 10 percent of the unit diagonal elements.

e. Results of all vibration tests (including tests with temperature effects simulated) performed to determine the dynamic characteristics of actuating systems of control surfaces and tabs shall be included. The data shall include the impedance of the control systems as determined both from the input and output sides of the control surfaces.

f. A supplement shall be submitted presenting the test results (3.9.4a, b, and c above) for the jig-mounted pylon vibration modal tests.

g. A supplement shall be submitted presenting the ground vibration modal test results (3.9.4a, b, and c above) for each airplane/external store configuration tested.

h. A supplement shall be submitted presenting the investigations performed to correlate the experimental modal parameters (frequencies and mode shapes) with the analytical modal parameters. Discussion of criteria and rationale on procedures used to evaluate the differences between experimental and analytical modal parameters. Discussion and rationale of methods used to modify or fine tune the analytical dynamic mathematical model which has physical relevance so that correlation between experimental and analytical modal parameters is achieved.

3.9.4.1 Thermoelastic test report. This report shall include the results of full scale component vibration tests with simulated in-flight thermal environment. The predicted and measured temperature distributions on the component and in important internal members, and the natural frequency and mode shape of each important vibratory mode shall be presented as a function of time. A description and photographs of the test specimens, test setup, test equipment and instrumentation, procedures, and method of data reduction shall be included.

3.9.5 Rigidity test report. This report shall contain the results of those static tests performed to substantiate rigidity characteristics applicable to flutter, divergence, and vibration. The report shall contain a description and photographs of the tests, instrumentation, test procedures, data reduction procedures, and plots or tables showing the applied load distributions for the simulated critical flight conditions and the incremental loads used. The deflections of the structure to incremental loads at limit load shall be presented and compared with data obtained for similar incremental loads for the low-load and intermediate-load conditions. A comparison of the stiffness distributions or influence coefficients obtained from the tests shall be made with data used in the theoretical analyses and obtained from similar measurements on the flutter models or other types of models.

3.9.6 Component endurance and wear test report. This report shall contain the results of endurance and wear tests performed on control surfaces, tabs, wingfolds, leading and trailing edge flaps and on their supporting structure and other components which are aeroelastically critical. The report shall include:

a. Dates and place of tests.

b. Detailed discussion of test results.

c. Description (including drawings, and photographs of test equipment, fixtures and setup).

d. Method of data interpretation.

e. List showing the test or deduced freeplay and stiffness deterioration versus service life for each component that was tested.

f. Recommended course of action regarding possible redesign or required measurement interval for production airplanes during their service life.

3.9.7 Aeroacoustic environment ground test report. This report shall include the results of the aeroacoustic environmental ground tests as follows:

a. An outline of the testing performed.

b. A description of the methods of aeroacoustic and thermal measurements employed for the test determination of the aeroacoustic environment of the airplane.

c. Date and place of test.

d. Test conditions.

e. The types of instrumentation and data processing systems employed and their calibration characteristics and all pertinent data analysis processing parameters.

f. Test results in terms of one-third octave band sound pressure levels at various important locations both internal and external and related surface temperatures.

g. Discrete frequencies and amplitude.

h. Temperature and humidity corrections for use in data reduction and interpretation.

i. Aeroacoustic contours on the airplane surface for each octave band of the excitation and for the overall sound pressure level for the takeoff power condition.

3.9.8 Catapult aeroacoustic and thermal environment test report. This report shall include the results of the catapult aeroacoustic and thermal environmental ground tests as follows:

a. An outline of testing performed.

b. A description of the methods of aeroacoustic and thermal measurements employed for the test determination of the aeroacoustic environment of the airplane.

c. Date and place of test.

d. Test conditions.

e. The types of instrumentation and data processing systems employed and their calibration characteristics and all pertinent data analysis processing parameters.

f. Test results in terms of one-third octave-band sound pressure levels at various important locations both internal and external, with the airplane forward of and aft of the JBD and related surface temperatures.

g. Discrete frequencies and amplitude.

h. Temperature and humidity corrections for use in data reduction and interpretation.

i. Aeroacoustic contours on the airplane surface for each octave band of the excitation and for the overall sound pressure level for intermediate thrust and maximum thrust of all engines on the airplane forward of the JBD.

3.10 Reports of laboratory tests to define static and fatigue strength. The following reports are required describing the static and fatigue test programs.

3.10.1 Test plans and program reports.

3.10.1.1 Description of test articles report. This report shall contain a description of all test articles including differences between test and flight articles such as dummy installations (e.g., engine mass), items proposed for omission (e.g., fairings, doors), a list of all items not identical with flight or production parts, and all other detailed information pertinent to the static and fatigue test articles. Modifications to the test articles subsequent to the issuance of this report and prior to the start of tests shall be described in appendices to this report. Modifications during static and fatigue testing to permit achievement of test loads shall be described in the appropriate test progress and final reports.

3.10.1.2 Static test plan report. This report shall contain in detail for each static test loads data, thermal data, computational methods, summaries of critical conditions, load envelope curves, physical dimensions of the test article, test article component weights as delivered for test, and applicable instrumentation data. The report shall include:

a. Discussion of the bases for the critical conditions selected for test including plots of test loads, shears, and moments for all conditions described. Comparisons with corresponding plots in design or analyses reports shall be shown; if test plots are identical to design or analytical plots, reference to the appropriate design or analyses reports may be made provided such reports have been submitted previously.

1. Loads.

(a) Intermediate and maximum test loads to be attained, including loading sequence. Estimated dates for attainment of intermediate test loads if such loads are significant check points during the tests and the maximum loads are not to be attained as an initial goal of the tests.

(b) Where the test article is a full-scale complete airplane, all loads shall be referenced about a standard location on the structure and be balanced about this reference location.

(c) Complete airplane loads shall be represented for all major test conditions. These loads shall be rational in all cases except for component tests where arbitrary balancing loads may be used with sufficient justification. It is not necessary to present balancing loads for small component static tests; however, the contractor will be free to make recommendations as to such loads.

(d) All major component static loads shall be presented separately in tabular and graphical form. Shear, moment and torsion data are required. If loads are presented in the form of artificial panel point applied loads, these panel point loads shall be in addition to the above requirements.

(e) The report shall include unit inertia tables and air load distributions in addition to the net test loads. Air loads distributions will be used primarily for backup data and to help derive the most rational possible test load distribution.

(f) All major concentrated inertia loads shall not be included with distributed test loads. These include landing gear, engine mount and store loads. If it is not possible to exclude these loads from the distributed load tables, their magnitude and location shall be clearly stated or referenced.

(g) Each test condition shall be prefaced with a summary page which presents all applicable test parameters such as airplane weight, load factor, speed, altitude, etc. In addition, the critical areas for that particular condition shall be noted.

2. Thermal data.

(a) Sufficient data shall be presented so that the following information may be obtained:

(1) Total power input to the specimen (kilowatts).

(2) Heat flow diagrams, heat sinks, heat concentrations, etc.

(3) Number of control areas desired and size of each.

(4) Physical properties of the specimen such as specific heat and coefficient of thermal expansion. Material properties should be based upon the temperatures to be used.

(b) Time versus temperature or heat flux input profiles shall be presented for all elevated temperature test conditions.

(c) In areas where the necessity for elevated temperature testing is questionable, data supporting reasons for or against hot tests shall be presented.

b. Descriptions of test articles, setups and procedures. A description of the test apparatus, the strain gage locations, the deflection and deformation measuring equipment, loading platforms, wing lift simulation, instrumentation, and tension pad locations are to be included. Such information may be included in a single report covering the static test program in which case the description of each test setup and procedure is not required in each test plan report.

1. Instrumentation.

(a) Drawings and tabular data indicating exact transducer locations and orientation shall be included in the test manual. For tests conducted by the contracting activity, photographs shall accompany this information when indicating location or orientation of inaccessible transducers.

(b) Predicted and allowable parameters (stress or strain, deflection, temperature, pressure, load, etc.) shall be supplied for all critical structural areas or components for each test condition. When possible, these data should be included with the preface for each load condition.

(c) For tests conducted by the contracting activity:

(1) Prior to commencing instrumentation, the contractor shall furnish a listing of the general measurement requirements.

(2) Instrumentation details (types of transducers, size and gage of wire, etc.) shall be coordinated with the contracting activity before transducer installation is initiated.

(3) All instrumentation wiring and outputs shall be compatible with the data acquisition and processing system of the Government facility at which the tests are to be conducted.

(4) Suggested data sampling rates shall be presented.

(5) Manufacturer's specifications for all installed transducers shall be presented; e.g., calibration data, transducer type, resistance, gage factor, bridge voltage, etc.

c. Each test shall be identified by applicable MIL-A-8867 paragraph number.

3.10.1.3 Fatigue test plan report. This report shall contain the general plan for each fatigue test, including a detailed description of the test article, test equipments, test loads, thermal data, computational methods, instrumentation data, inspection techniques, and test procedures in such detail as necessary for conducting the test. The report shall include:

a. Discussion of the bases for the selection of test conditions, development of the test loading spectra, and all other information pertinent to the establishment of fatigue test conditions. The methods and techniques used for derivation of the test loads and spectrum shall be described in detail.

1. Loads data - Test damage versus design damage shall be presented at all critical points of structure. The following requirements pertain to the presentation of loads data:

(a) For tests of the complete airframe, all loads shall be referenced about a standard location on the structure and all loads balanced about this reference location.

(b) Complete airframe test loads shall be represented for all major test conditions. These loads shall be rational in all cases except for component tests where arbitrary balancing loads may be used with sufficient justification.

(c) Fatigue test loads shall be represented in tabular and graphical form. Shear, moment, and torsional data are required. If loads are presented in the form of artificial panel point applied loads, these panel point loads shall be in addition to the above requirements.

(d) Test loads comparison with desired loading including shear, moment, and torsion for each load level.

(e) Major concentrated inertial loads shall not be included with distributed test loads. If it is impossible to exclude these loads from the distributed-load tables, their magnitude and location shall be clearly stated or referenced.

2. Thermal data.

(a) Sufficient data shall be presented to directly obtain the following information:

(1) Total power input to the specimen (kilowatts).

(2) Heat flow diagrams, heat sinks and concentrations, etc.

(3) Desired number of control areas and size of each.

(4) Thermal properties of the material in operating environment.

(b) Times versus temperature or heat flux input profiles shall be presented for all elevated temperature test conditions. Where heat flux profiles are to be programmed, recovery factors and adiabatic wall temperatures must be supplied.

b. Description of all test articles, a detailed description of test setups, facilities, test methods, loading equipment, method and sequence of load appication and instrumentation equipment and capabilities shall be included. This description may be included in a single report, but must include all information for specific fatigue tests as appropriate.

c. A description of crack detection techniques, instrumentation, inspection techniques, and plan for detailed inspection.

1. Instrumentation data - Instrumentation details shall be coordinated with the contracting activity prior to transducer installation.

(a) Drawings, and tabular data indicating exact transducer locations and orientation shall be presented. Photographs will accompany this information when indicating location or orientation of inaccessible transducers.

(b) Predicted and allowable parameters (stress or strain, deflection, temperature, pressure, load, etc.) shall be supplied for all critical structural areas or control points for each test condition.

(c) Suggested data sampling rates shall be presented.

(d) Manufacturers specifications shall be presented for all transducers installed on the test article (i.e., calibration data, transducer type, resistance, gage factor, bridge voltage, etc.).

2. Inspections - The methods of inspection, the number of inspections, and the specific area to be inspected shall be presented.

d. A plan for the disposition of test failures, repair of test articles, design changes for production and retrofit, and substantiation of design changes. This plan shall appropriately take into account significant failures as opposed to failures of a minor nature.

3.10.1.3.1. Sonic fatigue component test plan report. This report shall contain the general plan for each sonic fatigue component test including the following:

a. Discussion of and the bases for the selection of test conditions, development of the applied acoustic test spectra and duration, derivation of time compression factor, and all other information pertinent to the establishment of sonic fatigue test conditions. The methods and techniques used for derivation of the test spectra shall be described in detail.

b. Description of all sonic fatigue component test articles.

c. Detailed description of facilities, test fixtures and setups, test methods and procedures, acoustic excitation equipment, method and sequence of acoustic load application, and instrumentation equipment and capabilities. This description may be included in a single report, but must include all information for each specific sonic fatigue component test as appropriate.

d. Description of crack detection techniques, delamination detection techniques, instrumentation, inspection techniques, and plans for detailed inspection.

e. Drawings, and tabular data indicating exact transducer locations and orientation shall be presented.

f. A plan for the disposition of test failures, repair of test articles, design changes for production and retrofit, and substantiation of design changes.

3.10.1.3.2 Dynamic fatigue component test plan report. This report shall contain the general plan for each dynamic fatigue component test including the following:

a. Discussion of and the bases for the selection of test conditions, development of the applied vibration test spectra and duration, derivation of time compression factor, and all other information pertinent to the establishment of dynamic fatigue test conditions. The methods and techniques used for derivation of the test spectra shall be desribed in detail.

b. Description of all dynamic fatigue component test articles.

c. Detailed description of facilities, test fixtures and setups, test methods and procedures, vibration excitation equipment, method and sequence of vibration spectra application, and instrumentation equipment and capabilities. This description may be included in a single report, but must include all information for each specific dynamic fatigue component test as appropriate.

d. Description of crack detection techniques, delamination detection techniques, instrumentation, inspection techniques, and plans for detailed inspection.

e. Drawings, and tabular data indicating exact transducer locations and orientation shall be presented.

f. A plan for the disposition of test failures, repair of test articles, design changes for production and retrofit, and substantiation of design changes.

3.10.1.3.3 Empannage dynamic fatigue test plan report. This report shall contain the plan for the empennage dynamic fatigue test including the following:

a. Discussion of and bases for the selection of test conditions, development of the applied dynamic test spectra and duration, derivation of time compression factor, and all other information pertinent to the establishment of dynamic fatigue test conditions. The methods and techniques used for derivation of the test spectra shall be described in detail.

b. Description of test article.

c. Detailed description of facilities, test fixtures and setups, test methods and procedures, dynamic excitation equipment, method and sequence of dynamic spectra application and instrumentation equipment and capabilities.

d. Description of crack detection techniques, delamination detection techniques, instrumentation, inspection techniques, and plans for detailed inspection.

e. Drawings, and tabular data indicating exact transducer locations and orientation shall be presented.

f. A plan for disposition of test failures, repair of test articles, design changes for production and retrofit, and substantiation of design changes.

3.10.1.4 Structural design, development and preproduction verification test plan report.

a. This report shall contain an outline and schedule of all static, fatigue, sonic fatigue component, dynamic-fatigue component, and empennage dynamic fatigue tests to be performed prior to full scale production tests. Types of component tests identified are as follows:

1. Design development tests.

(a) Element tests.

(1) Materials selection.

(2) Process evaluation.

(3) Fastener evaluation.

(4) Manufacturing methods evaluation.

(b) Structural configuration development tests.

(1) Splices and joints.

(2) Panels (basic section).

(3) Panels with cutouts.

(4) Fittings.

(5) Assemblies.

2. Pre-production component design verification tests.

(a) Splices and joints.

(b) Fittings.

(c) Panels.

(d) Assemblies including (a), (b) and (c) above.

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

3. Any other structural tests performed prior to full scale production tests.

b. This report shall include a discussion of each component test which shall include the following information:

1. Complete justification for selection of tests, including a discussion of why that component was selected for testing, and how the test results will be used in the design development and/or design verification program. Documentation to support the proposed test shall also include analyses directed at establishing the cost and schedule trade-offs involved in decision concerning early tests of major structural elements and components.

2. Test schedule.

3. Description of component to be tested.

4. Number of components to be tested.

5. Description of the test setup and test procedure.

6. Type and magnitude of test loads.

7. Description of instrumentation.

3.10.2 Test status reports.

3.10.2.1 Static test progress reports. The initial submittal of static test progress reports shall be made in accordance with Table I and shall include the information of 3.10.2.1a. with as much information required by 3.10.2.1b. through 3.10.2.1i. as is available. Subsequent submittals with revised 3.10.2.1a. information and latest new information shall be submitted at 30 day intervals through completion of the static tests. These reports shall contain for all static tests the following information:

a. A list of all test articles with a schedule and list of tests including test sequence, and submittal date of the plan for each test in tabular form. Specific applicable paragraph numbers in MIL-A-8867 shall be shown for all tests described. Planned submittal dates for the remaining information of items 3.10.2.1b. through i. shall be included. A summary in bar chart form shall be included.

b. Actual test date for each test including dates for intermediate loads if test is not scheduled to be performed immediately to specified maximum load.

c. Design conditions and maximum loads to be attained.

d. Submittal date of final report for each test.

e. Test loads sustained to date.

f. Test summaries: The summary, consisting of supplemental pages, shall include a discussion of test results, conclusions, discussion of compliance with specification requirements, deficiencies disclosed, reinforcements, the flight or production articles in which reinforcements will or will not be incorporated, and the effect of the test on the test program, flight program, evaluation of the weapon system, and delivery of the airplane.

g. Failure to meet specification: As soon as possible, the contractor shall report to the Naval Air Systems Command, Attention: AIR-5302, events which affect the progress of a test program. Premature deformations, premature failures under static, dynamic, and fatigue loads, inability to sustain load, or delays in the program are such events and shall be considered as automatic evidence of the existence of a failure to meet specifications. The cognizant plant representative will record such evidence of the existence of a deficiency by making an official report to this effect to the contractor and to the Naval Air Systems Command, Attention: AIR-5302.

h. Significant achievements: The attainment of significant achievements, goals, or milestones during the static test program shall be described.

i. Modifications to test articles: All structural modifications to the test articles to permit attainment of test loads, not previously covered in the description of test articles report, shall be described, including photographs and sketches as appropriate.

3.10.2.2 Fatigue test progress reports. The initial submittal of fatigue test progress reports shall be made in accordance with Table I and shall include the information of 3.10.2.2a. Subsequent submittals with revised 3.10.2.2a. Information shall be made at 30 day intervals through the completion of the fatigue tests. These reports shall contain for all fatigue tests the following information:

a. All test articles shall be listed with a schedule and list of tests including test sequence, and submittal date of the plan for each test in tabular form. Specific applicable paragraph numbers in MIL-A-8867 shall be shown for all tests described. A summary in bar chart form shall be included.

b. Monthly reports. These reports shall include spectrum progress at the time of report and all failures on primary and secondary structure since the last monthly report, giving particulars such as extent of failure and a definition of the location such as fuselage station, wing station, water line, buttock line, and distances from spars. Description of failure shall include direction, size, and point of origin of damage. Other particulars shall include:

1. Test article repair details including schedule information such as cycling time lost for repairs.

2. Time of test failure in terms of flight hours, landing, arrestments, catapult launches, or pressurizations demonstrated.

3. Reference to engineering change proposal (ECP) containing design changes for production or retrofit.

4. Reference to applicable Technical Orders for inspection and rework of fleet airplane.

c. Special reports. Special reports shall be submitted each time a failure occurs of such a magnitude that the safety of the fleet may be in immediate jeopardy, or the test is stopped by the contractor because of the safety of the test specimen, or the contractor feels a failure will necessitate a major fleet repair in the future. Special reports shall also be submitted because of any accident to the cyclic test equipment or jig structure. These special reports shall contain data such as date of incident, spectrum or layer when incident occurred, detailed account of damage and all other details pertaining to the incident. This report shall be transmitted not later than one working day after occurrence of the incident; in the case of a major emergency, the Navy office of primary responsibility shall be contacted by telephone within 2 hours of the incident. The attainment of significant achievements, goals, or milestones during the fatigue test program shall be reported.

d. Inspection data. Such data shall be submitted for all test failures of significance. The time of submittal shall be dependent upon the urgency of the inspection but not later than two weeks after discovery of the test failure. The inspection data shall be submitted in letter report form with the following information:

1. Recommended inspection period.

2. Urgency for inspection.

3. Man-hours to inspect.

4. Inspection techniques, including access information, and recommended nondestructive testing methods if other than visual inspection is required.

5. Recommended repair, rework, or replacement procedures in the event that inspections reveal structural damage.

6. Identification of airplanes by Bureau Numbers (BUNOS) that are to be affected.

7. Sketches and photographs, marked-up if necessary to show appropriate areas of structural damage and repair.

3.10.3 Final test reports.

3.10.3.1 Static test reports. These reports shall describe fully each test and all significant data obtained. The data shall include:

a. A detailed discussion of test results, conclusions, reinforcements, modifications and necessary changes to flight or production articles. The airplanes in which changes will be incorporated and number of backfitted airplanes shall be indicated. For drop tests, a discussion of changes in tire pressures, shock strut servicing, and metering pins shall be included.

b. Plots of percent limit, ultimate, or design load, as appropriate, versus deflections showing points of permanent set and any large differences between predicted and actual deflections. For major components, stress measurements obtained during structural tests shall be correlated with the stress distributions determined by analysis. Plots of stress versus percent load must be shown for the locations of maximum stresses and the critical locations.

c. Photographs showing elastic buckles, permanent buckles, significant failures.

d. Load stroke curves for each drop test condition for each gear at sinking speeds above 8 feet per second (land based) or 18 feet per second (carrier based).

e. Vertical, drag, and side loads versus sinking speed.

f. Vertical and drag loads versus time at sinking speeds above 8 feet per second (land based) or 18 feet per second (carrier based), effects of touchdown speed on loads.

g. Envelope of design or ultimate strength for vertical, drag, and side loads and combinations thereof.

h. Data for landing gear servicing tests including a discussion of the time required for servicing and all problems encountered in completing tests including problems of air entrapment if strut does not comply with venting provisions of MIL-L-8552.

3.10.3.1.1 <u>Static design development and preproduction component design verification test report</u>. This report shall describe fully each test and all significant data obtained. The data shall include:

a. Date and place of tests.

b. A detailed discussion of test results.

c. Plots of load versus deflection, stresses, etc.

d. Photographs showing significant failures and other pertinent information.

The report also shall include a complete discussion of how the test results will be used in the design development and design verification program.

3.10.3.2 Fatigue test report. This report shall include a detailed discussion of all test results, conclusions, reinforcements, modifications, and necessary changes to flight test and production articles. Areas on the test article where loadings were found to be unrealistic and all areas where structural modifications have been made shall be identified. Each particular failure shall be discussed. Such discussion shall include the type of failure, area of failure, percent of life expended in terms of spectrum block when failure occurred, and action taken on each failure. Liberal use shall be made of isometric sketches and photographs. All data necessary to maintain constant surveillance of the Fleet shall be submitted.

3.10.3.2.1 Fatigue development test reports. These reports shall describe in detail the specimens and components that were tested and shall contain the following data:

a. Description of each specimen. In addition, the structural function of the components shall be described.

b. Load and stress (magnitude, direction, frequency) environment applied to specimens.

c. Frequency and type of inspections.

d. Description (including drawing and/or photographs) of loading equipment.

e. Instrumentation (type, location).

f. Results of test (description and photograph, discussion, time, and mode of failure; metallurgical, strength property and dimensional analyses; instrumentation data and analysis; teardown inspection).

g. Recommended changes to structural configurations.

3.10.3.2.2 Fatigue test teardown inspection report. This report shall record the areas inspected and the results of the full-scale fatigue test teardown inspection. It shall show the location of any failures by use of sketches and photographs. The structural damage report shall also include the method of inspection, location and description of damage, results of metallurgical examination and investigation, and instrumentation data review.

3.10.3.3 Sonic fatigue component test report. This report shall include the results of the component tests, as follows:

a. An outline of the work performed.

b. A description of the test methods employed in determining the sonic fatigue life of the various structural components.

c. Data and place of tests.

d. Test conditions.

e. The type of noise source employed and their characteristics.

f. A description of the instrumentation and data processing used, its characteristics, and its limitations.

g. Techniques of specimen arrangement.

h. A description of the dynamic properties of representative components.

i. Methods of data interpretation.

j. A comparison of test results with theoretical or expected results.

k. A description of the cumulative damage theories employed.

l. A list showing the test or deduced service life for each structural component that was tested. For those components that were found by test to have fatigue lives less than that required, the course of action taken for redesign and retest must be described in the report.

m. The recommended course of action regarding possible redesign and retest of certain components if other tests indicate necessary revisions in the sonic loads environment used for design purposes.

3.10.3.4 Dynamic fatigue component test report. This report shall include the results of the component tests as follows:

a. An outline of the work performed.

b. A description of the test methods employed in determining the dynamic fatigue life of the various structural components.

c. Date and place of tests.

d. Test conditions.

e. The type of mechanical excitation sources used and their characteristics.

f. A description of the instrumentation and data processing used, their characteristics and their limitations.

g. Specimen installation on test fixtures.

h. A description of the dynamic properties of representative structural components.

i. Method of data interpretation.

j. A comparison of test results with theoretical or expected results.

k. A description of the cummulative damage theories employed.

l. A list showing the test or deduced service life for each structural component that was tested. For those components that were found by test to have fatigue lives less than that required, the course of action taken for redesign and retest must be described in the report.

m. The recommended course of action regarding possible redesign and retest of certain components if other tests indicate necessary revisions in the oscillatory loads environment used for design purposes.

3.10.3.5 Empennage dynamic fatigue test report. This report shall include the results of the empennage dynamic fatigue test as follows:

a. An outline of the work performed.

b. A description of the test methods employed in determining the dynamic fatigue life of the empennage.

c. Date and place of tests.

d. Test conditions.

e. The type of mechanical and acoustic excitation sources used and their characteristics.

f. A description of the instrumentation and data processing used, its characteristics and limitations.

g. Specimen installation on test fixture.

h. A description of the empennage dynamic properties.

i. Method of data interpretation.

j. A comparison of test results with theoretical or expected results.

k. A description of the cumulative damage theories employed.

l. A list showing the test or deduced service life for the empennage tested. For those components of the empennage that were found to have fatigue lives less than that required, the course of action taken for redesign and retest must be described in the report.

m. The recommended course of action regarding possible redesign and retest of certain components if other tests indicate necessary revisions in the oscillatory loads environment used for design purposes.

3.10.4 Material substantiating data and analysis report. This report shall include data and analyses to substantiate the use of material property values from sources other than MIL-HDBK-5 and MIL-HDBK-23, as specified in MIL-A-8860, and to substantiate compliance with applicable design requirements. The data shall be presented in a manner similar to the presentation in MIL-HDBK-5.

3.10.4.1 Fibrous composites.

a. Mechanical properties. Minimum mechanical properties for use as structural design allowables shall be furnished for fibrous composites. Such properties shall be for room temperature conditions, and for all combinations of fiber and stress directions determined as critical or the intended operating environment. As a minimum, the following mechanical properties shall be included:

(1) Tensile ultimate strength-longitudinal (0°) and transverse (90°) including attendant elongation.

(2) Tensile yield strength-longitudinal and transverse.

(3) Compressive ultimate strength-longitudinal and transverse including attendant deformation.

(4) Compressive yield strength-longitudinal and transverse.

(5) Shear ultimate strength-membrane and interlaminar.

(6) Core shear strength.

(7) Flexural strength.

(8) Bearing ultimate strength-tensile and compressive.

(9) Bearing yield strength-tensile and compressive.

(10) Modulus of elasticity.

(11) Poisson's ratio.

(12) Density.

b. Typical properties. Physical properties and certain other properties of the fibrous composite materials intended for use in the design and construction of airplane shall be developed as typical (average) values. For such properties, information on data scatter shall be furnished based on all test values obtained. As a minimum, such properties shall be the following:

(1) Full range tensile stress-strain curves with tabulated modulus data.

(2) Full range compressive stress-strain and tangent modulus curves.

(3) Shear stress-strain and tangent modulus curves.

(4) Flexural stress-strain curves.

(5) Fatigue data-tension/tension and tension/compression stress-life curves.

(6) Reduced and elevated temperature effects-temperature range from -65°F to a maximum of +160°F or to the maximum elevated temperature to be encountered by the vehicle under acquisition, whichever is greater.

(7) Directional variation of mechanical properties including 360° polar plots, as appropriate.

(8) Pullout strength of material where mechanical fasteners are used.

(9) Variation of mechanical properties with laminate thickness and with test specimen width.

(10) Creep rupture curves.

(11) Effects of fatigue loads on mechanical properties.

(12) Notch sensitivity.

(13) Climatic effects.

(14) Effects of cyclic rate of load on fatigue strength.

(15) Fire resistance.

(16) Material repairability.

(17) Thermal coefficients.

c. Special definition of properties. As appropriate, the mechanical and physical properties developed shall be specially defined to accommodate unique failure characteristics of fibrous composites. Such definitions shall include, but are not limited to, yield strength in terms of ultimate stress or secondary modulus, bearing strength associated with hole elongation and shear tear-out criteria, compression strength associated with stability criteria, specimen type, failure mode, and fatigue strength associated with failure criteria such as crazing or other matrix properties degradation when such degradation is sufficient to result in incipient fatigue failure. Where wet and dry properties differ, wet properties also shall be established.

3.11 <u>Flight test reports</u>.

3.11.1 <u>Aeroelastic stability, vibration and aeroacoustic flight test planning report</u>. This report shall contain a detailed description of the aeroelastic stability, vibration and aeroacoustic flight test programs. The report shall also include the following:

a. Installation drawings and photographs showing location of transducers (accelerometers, microphones, strain gages, and motion sensors for control surfaces and tabs).

b. Description of instrumentation and methods of data acquisition, recording, telemetry, data reduction and analyses.

c. For aeroelastic stability flight tests - Method of modal excitation, speed range and speed increment, altitudes and expected modes of vibration to be investigated.

d. For vibration and aeroacoustic flight tests - A summary table of flight test points in terms of pertinent flight parameters i.e., speed, Mach number, altitude, dynamic pressure, load factor, angle of attack, etc. Maneuvers expected to produce the most severe vibration and aeroacoustic environments and structural dynamic responses shall be identified.

3.11.2 Structural flight and ground operations test planning report. This report shall outline, in general terms, the scope of the proposed structural flight load survey, flight demonstration and ground test programs, the proposed schedule for flight and ground loads airplane including phase-in with static test and full-scale cyclic fatigue load tests and the proposed type of instrumentation.

3.11.3 Flight and ground load survey instrumentation calibration planning report. This report shall present a description of the instrumentation and calibration procedures to be employed for accomplishment of the flight and ground load survey. The report shall encompass sufficient details showing sensing element locations selected, calibration loading conditions, a discussion of the calibration procedures, proposed development of loads equations, and the expected accuracy to be achieved.

3.11.4 Structural flight and ground operations test program report. This report shall include a detailed description of the instrumentation, approximate locations of instrumentation in the airplane, and the maneuvering and dynamic response test program to be conducted. If the complete series of structural loads reports has not been forwarded to the contracting activity prior to submittal of the flight test program proposal, or if any questions exist concerning interpretation of the requirements for this airplane, the contractor shall discuss the proposed program with the contracting activity prior to submittal for approval. A summary table of the structural maneuvers in terms of the pertinent flight parameters shall be listed. The design maneuvers expected to produce the most severe structural loads shall be identified along with the critical structural members. This report shall be revised by the contractor as necessary during the course of the test program to reflect the latest design, analysis, or test information.

3.11.5 Structural dynamic flight test reports.

3.11.5.1 Aeroelastic stability flight test letter reports. These bi-weekly letter reports shall contain the results of aeroelastic stability flight tests performed during the preceding two weeks and shall include the following:

a. Airplane configuration, altitudes, Mach numbers, equivalent airspeed (knots), load factor, damping coefficient "g" and frequency of each mode being investigated.

b. Unexpurgated comments of contractor's pilots and an evaluation of test results by structural dynamic engineers.

c. Plot of altitude versus Mach number with curves of constant equivalent airspeed (knots) and the design limit speed envelope of the airplane. The portion of the flight speed envelope for which aeroelastic stability tests have been completed prior to the reporting period, and the aeroelastic stability test points investigated during the reporting period.

d. Summary table of the various airplane configurations tested to date. Indicate the maximum equivalent airspeed (knots), highest Mach number at the lowest altitude and the highest Mach number with identified altitude tested to date for each respective airplane configuration.

e. Cumulative number of flights and flight hours of testing.

3.11.5.2 Vibration and aeroacoustic flight test letter reports. These bi-weekly letter reports shall contain the results of vibration and aeroacoustic flight tests performed during preceding two weeks and shall include the following:

a. Airplane configuration, altitudes, Mach numbers, equivalent airspeed (knots), load factor, fuel content, dynamic pressure, angle of attack, and engine power settings.

b. Unexpurgated comments of contractor's pilots and an evaluation of test results by structural dynamic engineers.

c. Plot of altitude versus Mach number with curves of constant equivalent airspeed (knots) and the design limit speed envelope of the airplane. The portion of the flight speed envelope for which vibration and aeroacoustic tests have been completed prior to the reporting period and the test points investigated during the reporting period.

d. The microphone measured data shall be reduced and presented on appropriate plots by one-third octave band analysis of sound pressure levels in dB (ref: 2×10^{-5} N/M^2) versus frequency and, if required, power spectral density analysis (psi^2/Hz versus frequency).

e. The vibration measured data shall be reduced and presented on appropriate plots by spectral analysis of acceleration (g) versus frequency, acceleration spectral density analysis (g^2/Hz versus frequency), one-third octave band analysis or combination analyses, where applicable, depending on predominant characteristics of amplitude time history.

f. Cumulative number of flights and flight hours of testing.

3.11.5.3 Aeroelastic instability, vibration or sonic fatigue occurrence report. The contracting activity shall be notified immediately by message or letter report of any aeroelastic instability, vibration or sonic fatigue failures or excessive vibrations that may occur or be observed during or as a result of any ground or flight tests by the contractor. The message or letter shall describe in detail any damage or malfunction which has occurred.

3.11.5.4 Vibration environment measurement report. This report shall include:

a. Outline of testing performed.

b. Description of the methods of vibration measurement employed for test determination of the vibration environment of the airplane

c. Dates and place of tests.

d. Test conditions.

e. Types of instrumentation and data processing systems employed and their calibration characteristics, and all pertinent data analysis processing parameters.

f. Ground test and flight test results at all measured locations both internal and external. Data shall be reduced and plotted in appropriate form by spectral analysis (acceleration (g) versus frequency), acceleration spectral density analysis (g^2/Hz versus frequency), one-third octave band analysis or combination analyses, where applicable, depending on predominant characteristics of amplitude time history. Similar data reduction and presentation for strain or stress data shall be provided.

g. Discrete frequencies and amplitude.

h. Identification vibration sources.

i. Comparison of test results with predicted design environments.

j. Assessment of whether the design vibration environment should be modified in view of flight and ground test results.

k. Recommended course of action regarding possible redesign and retest of certain components because of revisions to the design vibration environments.

l. An addendum shall be provided, including items a. through k. above, for the empennage environment measurements.

m. An addendum shall be provided, including items a. through g above, for the crew and passenger stations environment measurements. Comparison of test results with design requirements of 3.1.3 of MIL-A-8870 shall be provided.

3.11.5.5 Aeroacoustic environment measurement report. This report shall include:

a. Outline of testing performed.

b. Description of the methods of aeroacoustic measurement employed for the test determination of the aeroacoustic environment of the airplane.

c. Date and place of test.

d. Test conditions.

e. Types of instrumentation and data processing systems employed and their calibration characteristics and all pertinent data analysis processing parameters.

f. Ground test and flight test results of aeroacoustic loads in terms of one-third octave band sound pressure levels of various important locations both internal and external.

g. Discrete frequencies and amplitude.

h. Identification of internal and external aeroacoustic sources.

i. Comparison of test results with predicted design environments.

j. Assessment of whether the design aeroacoustic environments should be modified in view of test results.

k. Recommended course of action regarding possible redesign and retest of certain components because of revisions to the design aeroacoustic environments.

3.11.5.6 Gun fire vibration and aeroacoustic environment measurement report. This report shall include:

a. Outline of testing performed.

b. Description of methods of vibration and aeroacoustic measurements employed for test determination of the vibration and aeroacoustic environment of the aircraft.

c. Date and place of test.

d. Test conditions.

e. Types of instrumentation and data processing systems employed and their calibration characteristics and all pertinent data analysis processing parameters.

f. Ground test and flight test vibration results at all measured locations. Data shall be reduced and plotted in appropriate form by spectral analysis (acceleration (g) versus frequency), acceleration spectral density analysis (g^2/Hz versus frequency), one-third octave band analysis or combination analyses, where applicable, depending on predominant characteristics of amplitude time history. Similar data reduction and presentation for strain or stress data shall be provided.

g. Ground test and flight test results of aeroacoustic loads in terms of one-third octave band sound pressure levels of various important locations.

h. Discrete frequencies and amplitude.

i. Assessment of whether the design vibration and aeroacoustic environments should be modified in view of test results.

j. Recommended course of action regarding possible redesign and retest of certain components because of revisions to the design vibration and aeroacoustic environments.

3.11.5.7 Missile vibration and aeroacoustic environment measurement report. This report shall include:

a. Outline of testing performed.

b. Description of the methods of vibration and aeroacoustic measurements employed for test determination of the vibration and aeroacoustic environments of the missile.

c. Dates and place of tests.

d. Test conditions.

e. Types of instrumentation and data processing systems employed and their calibration characteristics and all pertinent data analysis processing parameters.

f. Ground test and flight test results at missile locations both internal and external. Data shall be reduced and plotted in appropriate form by spectral analysis (acceleration (g) versus frequency), acceleration spectral density analysis (g^2/Hz versus frequency), one-third octave band analysis or combination analyses, where applicable, depending on predominant characteristics of amplitude time history.

g. Ground test and flight test results of aeroacoustic loads in terms of one-third octave band sound pressure levels of various missile locations both internal and external.

h. Discrete frequencies and amplitude.

i. Comparison of test results with predicted design environments.

j. Duplicated data tapes shall be provided when requested by the contracting activity.

3.11.6 Flight and ground load survey instrumentation and calibration progress reports. Brief summary type progress reports reflecting the progress being made in instrumenting and calibration the flight load airplane shall be submitted. Any difficulties encountered which are delaying or expected to delay the program shall be pointed out immediately in order to expedite any necessary procuring service action.

3.11.7 Flight and ground load survey instrumentation and calibration reports. A summary type report covering the calibration of the instrumentation and expected accuracy of the flight measurements shall be submitted. The report shall contain sensing element locations finally selected, calibration loading conditions, a discussion of the calibration procedures, flight load equations, and the expected accuracy to be achieved in each flight measurement.

3.11.8 Flight load and ground operations survey data report. The recorded data shall constitute proof of the test condition attained, and for flight load surveys, the aerodynamic loads applied to the airplane during the structural flight test. The contractor shall submit an initial (80 percent flight conditions) and a final phase (100 percent flight conditions) report containing the following:

a. The information on the operational airplane shall include: three-view drawings; V-n diagrams; dimensions; weights; armament and external store configurations; and any other significant items of a structural loads nature. The test airplane description shall be included only if there are significant structural or aerodynamic differences, e.g., use of built-up structure in place of honeycomb structure, different wing camber, installation of external instrumentation equipment of significant size, and inability to carry internal or external armament, or fuel tanks.

b. Historical information on the tests shall include: dates of start and finish of instrumentation; first flight for instrumentation check-out; start of survey or demonstration; any important periods that affected the flight program; the final test; and completion of data reduction. Information comparing flight test with static test scheduling shall also be included.

c. The comparison of attained maneuvers versus specified maneuvers in the structural flight test program shall be represented in tabular form. Information shall include: airplane configuration; test altitude; airspeed or Mach number; weight; CG location; and load factor.

d. The brief account of difficulties encountered during the program shall include comments on: structural difficulties, aerodynamic difficulties, maneuvering difficulties and instrumentation and data reduction difficulties. These comments shall encompass descriptions of: reinforcement required or parts damaged or showing unobjectionable permanent set, aerodynamic modifications required to attain test conditions or deviations granted from unattained requirements, control surface trim deviations or power control difficulties, and instrumentation failures or other instrumentation and data reduction difficulties.

3.11.8.1 Eighty-percent phase. The flight load and test condition data obtained during the flight tests shall be reduced, analyzed, and evaluated on a continuing basis throughout this phase of the test program and submitted in report form. In instances where a flight demonstration is scheduled, the report need only contain the applicable portions (mostly condition data) of the requirements (see MIL-A-8871).

a. The data obtained from the structural flight tests are of two general types: loads data and condition data. The term loads data includes air load (from pressure or strain gage instrumentation), temperature stress (air load or thermal), and inertia data. The term condition data includes airspeed, Mach number, altitude, airplane altitude, rate of change in altitude, control forces, control surface positions and hinge moments, and load factor data.

b. The loads data describe the external aerodynamic or thermal loads acting on the structure, the internal effects on the structure, and the inertia response of the structure. The data from the maneuvering grid portion of the initial phase structural flight program are used to define the load trends as a function of airspeed, altitude, and load factor. The data from the design criteria maneuvers contain the additional effects of abruptness of control application, and gust. The data from maneuvering grids shall be shown versus span, load factor, Mach number or speed, and altitude, with the data from the design criteria maneuvers (and additional maneuvers that may have been performed) shown as a function of load factor, as well as superimposed on the maneuvering grid plots. These data shall be extra-pointed to design load factors and compared with design loads. Air loads data from the fuselage external tanks and vertical fin and rudder shall be shown as a function of maneuver or side-slip, lateral load factor or rudder deflection instead of normal load factor except where crosscoupling takes place. The air loads data shall be corrected for weight and CG whenever the data is significantly affected by these conditions. The decision to apply the necessary correction and the methods of correction shall be decided between the contractor and the contracting activity. Whenever air loads are shown as a function of Mach number and altitude, they shall be corrected to the design load factor. The design loads shall be shown with the air loads whenever possible.

c. Temperature, stress and additional measurements shall be prepared in a similar fashion to the air loads presentations to show levels and trends.

d. The condition data describes the position and attitude of the airplane, the control positions and forces. All of the condition data shall be shown in time history form for the final approved maneuvers. The condition data from the other maneuvers shall appear in the reports in the form of cross-reference with the loads data or as peak data points. There may be maneuvers performed in the initial phase which exhibit unusual loads or conditions, and so require time history presentation of the data for more detailed description of the maneuver.

e. The condition data, in time history form, shall be presented in related groups such as: (1) accelerations at CG and at fuselage nose and tail, airspeed, Mach number, stagnation temperature, and pressure altitude; (2) elevator position, hinge moment, longitudinal stick force, angle of attack, and rate of pitch; (3) aileron position, hinge moment, lateral stick force, angle of bank, and rate of roll; and (4) rudder position, hinge moment, pedal force, and angle of sideslip, and rate of yaw. The time history shall be made complete for a symmetrical maneuver by adding wing, horizontal stabilizer, elevator, and fuselage vertical loads to group no. 2. For a directional maneuver, the vertical tail, rudder, horizontal stabilizer, and fuselage side loads shall be added to group no. 4. The unsymmetrical maneuvers require the addition of horizontal stabilizer, elevator, and fuselage vertical loads to group no. 2, wing and aileron loads to group no. 3, and vertical tail, rudder, and fuselage side loads to group no. 4. The data shall be presented to show that the test requirements have been met. Each time history sheet shall contain information: on airplane configuration, test condition, airspeed or Mach number, and altitude.

3.11.8.2 One-hundred-percent phase. The report shall be prepared in a similar manner to the initial phase data report except that the final phase data shall replace the initial phase design criteria maneuver data on the summary plots plus the additional data from tank and other store or demonstration tests and ground operations tests. Particular emphasis shall be directed toward establishing that the airplane is satisfactory for all critical flight conditions existing within its design operational flight or ground envelopes or, if necessary, provide suitable flight or ground restrictions for any conditions that cannot be safety attained. Immediately upon completion of the preliminary draft of the report, the contractor shall confer with the contracting activity to present and discuss the test results and proposed structural flight limits for service airplane. In instances where a flight demonstration is scheduled, the report need contain only the applicable portions (mostly condition data) of the requirements in MIL-A-8871.

3.11.9 Dynamic response test report. A report presenting the data and analysis from the dynamic response tests shall be submitted for approval. The report shall include transfer functions between the internal structural loads and accelerations at various locations throughout the airframe and the gust, landing, and taxi load inputs. Both discrete and power spectral density methods of analysis shall be considered and utilized to compare the load inputs, structural responses, and transfer functions with the dynamic loads analysis. Transfer functions shall also be provided between vertical CG accelerations and the load frequency distribution for the range of weights, airplane configurations, speeds, and altitudes being flown by service airplanes. Flight or ground handling conditions which result in significant dynamic over-stressing of the structure shall be identified and the effects on fatigue life estimated. Methods used for the reductions and analysis of the test data shall be presented. Suitable discussions shall be provided for all material presented. Immediately upon completion of the preliminary draft of the report, the contractor shall confer with the contracting activity to present and discuss the test results.

3.11.10 Structural flight test anomaly and failure report. A report shall be submitted to the contracting activity not later than 30 days after a structural flight test anomaly or failure has occurred during flight testing, such as overload, fatigue (including vibration or aeroacoustically induced), aeroelastic instability and aeroservoelastic instability. The report shall include the following:

a. Date and place of incident.

b. Flight test conditions and airplane configuration.

c. Description of anomaly or failure, mode of failure, metallurgical test results, dimensional analysis, and instrumentation data and analysis. Photographs showing structural member failure.

d. Detailed discussion and recommended course of action regarding reinforcement, modification, redesign, and other changes to Full Scale Development (FSD) flight test airplane. The effect on flight test program schedule and any recommended flight restrictions until FSD flight test airplane are modified.

e. Recommended course of action for redesign of production airplane and aircraft in which design changes will be incorporated and number of airplane to be back-fitted.

3.12 Nuclear weapons delivery capability report. This report shall present the methods and basis for defining escape envelopes and flight profiles, and for determining airplane response to weapons effects and the selection of airplane limits. It shall include, but not be limited to, the following:

a. Escape envelopes for the specified nuclear weapons based upon deliveries which may be repeated without incurring permanent structural deformation or other adverse effects.

b. For all possible delivery techniques, a graphical presentation of airplane and weapon flight profiles suitable for the development and evaluation of delivery tactics. Airplane flight profiles shall contain time histories of airplane positions and velocity. Weapon trajectories shall contain time histories of weapon position at altitudes of interest. These profiles shall be based on actual flight test data for the airplane and weapon where possible.

c. The methods of determining the airplane response to weapons effects and for selection of airplane limits shall be suitably defined and conclusions justified. Experimentally determined dynamic characteristics of the airplane structure shall be employed in response calculations where possible. Sample calculations shall be included in the report illustrating the application of methods to a typical set of conditions studied. These sample calculations shall be thorough enough to permit checking all results presented in this report.

3.13 Strength summary and operating restriction report. A strength summary and operating restriction report shall summarize the strength of the airplane for all design conditions at the specified and other critical weights, by showing a comparison of strength required by applicable specifications to the strength determined by analysis and test the report shall recommend restrictions for service operation of the airplane and afford a basis for determining the practicability of modifying restrictions of varying useful loads, and making structural modifications. The initial submittal of this report need not be complete and need not present final data; it shall present sufficient data and information to substantiate the structural strength and operating restrictions applicable to the flight envelope and operating conditions authorized for the initial flight of the airplane. Bi-monthly revisions shall be submitted to keep the data current. The final report shall include the following information:

a. A brief description of the airplane. If the airplane is a modification of a previous model, the significant differences between the models shall be described and the effects of these differences on operating restrictions shall be included.

b. A summary of basic data including design and actual weights, CG positions, principal dimensions, and principal surface areas.

c. V-n diagrams depicting the required and available strength of the airplane in terms of load factor, airspeed, and altitude. Load factors developed by specified symmetrical gusts and maximum speeds for which limit strength exists for specified side gusts shall be shown on these V-n diagrams. Values of static and dynamic airplane normal force coefficients on which V-n diagrams are based shall be shown.

d. When it is known or anticipated that adverse phenomena such as buffeting, pitch up to pitch down, abnormal control characteristics, control surface or tab buzz, and flutter or divergence will limit permissible speeds, load factors, or both, at any altitudes below service ceiling to values less than design limits, a discussion of these phenomena and the limits they may impose in terms of airspeed, Mach number, load factor, or altitude, or collectively, airspeed, Mach number, load factor, and altitude shall be included.

e. The effects of variations in weight on flight strength and flutter characteristics. In those cases in which the amount, distribution, or both, of fuel carried in internal or external wing tanks significantly affects flight strength and flutter characteristics, a discussion of the variations of flight strength and flutter characteristics with amount and distribution of such fuel shall be included.

f. Maximum design sinking speeds at the various design weights.

g. A table of recommended authorized combinations of the airplane, racks, and stores. For each combination listed, the following limits and configurations shall be stated:

(1) The maximum carriage limits (airspeed, acceleration and altitude).

(2) The release, launch, and jettison limits (airspeed, acceleration, altitude, dive angle, and attitude).

(3) Takeoff and catapult launch configurations.

(4) Field landing and arrested landing configurations.

(5) The critical design condition and the critical component

h. Recommendations for operational restrictions including:

(1) Maximum weights for field takeoff, field landing, and when applicable, catapulting, arrested landing, and rough field takeoff and landing.

(2) Maximum permissible speeds and load factors for flight with and without external stores.

(3) Restrictions on use of lateral and directional controls.

(4) Maximum permissible speeds with devices, such as flaps, spoilers, cockpit enclosures, landing gear, speed brakes, and bomb bay doors in partially extended, fully extended or open positions, and for combinations of devices when a combination results in adverse aerodynamic effects, such as buffet.

(5) Maximum permissible airplane CG accelerations for arresting and catapulting versus weight.

(6) Maximum permissible drag load components for arresting and catapulting.

(7) Maximum permissible drag load factor as a function of weight for both catapulting and arresting.

i. List of critical margins of safety for each major component of the airplane including margins of safety for supporting structure for stores listed in g. of this paragraph. This list shall include, for each margin of safety listed, the design condition that is critical and reference to the report and page wherein the margin of safety was determined. These critical margins of safety shall be based on test results in those instances in which applicable test results are available, and should reflect the test-correction factors required in MIL-A-8867. Diagrams or reduced-size drawings of the airplane or of major components, such as a wing, fuselage, landing gear, etc., shall be included which show the most critical and second most critical design loading conditions for specific areas or regions of the airframe. The diagrams or text shall indicate those areas or regions which are almost equally critically loaded by specific flight and non-flight conditions.

3.14 Structural redesign report. This report shall provide engineering data for all production changes which in any manner affect the strength and fatigue life of the airframe, and for all production and retrofit redesigns resulting from static and fatigue tests. The data shall consist of description, justification, and verification of adequacy of the change. Detail description shall consist of adequate sketches, nomenclature, location, and discussion of the function of the items concerned. Justification for and verification of adequacy of the redesign shall be as comprehensive as necessary in order for the appropriate activity to grant engineering acceptance of the change. Necessary loads, stress, and fatigue analysis calculations and test data shall be submitted as revisions to the appropriate reports. A compendium of such calculations and data shall be included in the redesign report.

3.15 Service life analysis report. The service life analysis report shall selectively combine the phases of the structural integrity program into the following service life information:

a. All necessary information from service loads programs, flight loads survey, flight dynamic response test, static test, full scale fatigue test, and component fatigue tests. The above input data shall be used to develop unit damage calculations which will permit the service life analysis to be continually revised as data is received from the life history program.

b. Format of the analysis shall include the necessary methodology and formulas to automatically incorporate life-history data. Computer processing shall be used for this purpose. The nature of the reduced data could require the initial use of a simplified methodology with sophistication to be added after the accumulation of sufficient data from the life history program and from operational experience with the airframe.

c. Life calculations of primary and basic structure determined to be fatigue critical. The exclusion of any airframe structural elements shall be substantiated with lifecheck calculations.

d. Fatigue unit-damage calculations shall be prepared covering significant fatigue damage for all mission segments and load sources of the operational mission profiles. Examples of mission segments and load sources are taxi, takeoff, ascent, cruise, low level, landing, kneeling, braking, turning, gust, etc. The fatigue unit damage calculations will be presented as functions of airplane operational parameters such as velocity, weight, cargo, or fuel weight, external configuration, etc. A computer program tape or other suitable format shall be generated for use in developing reports of an assessment of the fatigue damage, damage rate and damage trends of each individuel airplane. Additional, graphic plots of damage rates versus significant operational parameters (such as various mission segments) shall be published in report form. Parametric calculations shall be provided for all locations of the airframe which are determined by analysis, test, or service experience to be fatigue critical. Input to these calculations shall be derived from all currently available data from analyses, test, flight tests, operational usage recorder programs and service experience. Revisions and updating of the parametric calculations shall be made if any of the following changes occur:

(1) Structural performance changes resulting from static test.

(2) Load changes resulting from flight (and ground) loads survey.

(3) Load changes resulting from dynamic response testing.

(4) Changes in load environment as determined by data from the VGH, multichannel, or exceedance operational usage programs.

(5) Changes in structural fatigue performance of the airframe as derived from results of cyclic testing.

3.16 Service airplane fatigue estimate reports. These reports shall provide the contracting activity with a periodic assessment of the structural fatigue damage accumulated on each individual airplane of the fleet. These reports shall contain the following minimum data:

a. Fatigue damage accumulation figures on each and every operational airplane by tail number. Service airplane fatigue estimates shall be furnished for the fatigue sensitive structural areas of the airframe. These estimates will cover fatigue damage locations on all major air-frame assemblies. Service airplane fatigue estimate reports shall be self-contained in that a structural description of the location reported shall be included. Included also shall be sufficient discussion to understand the basis of the figures presented. The report shall call attention to fatigue problems which could affect safe operational usage of an airplane within a period of twelve months subsequent to report date. Such extrapolation shall be made based upon the latest calculated damage rate.

b. As revisions to the parametric calculations become available the accumulated damage figures based on this revised data will reflect all previous service usage. All accumulated damage figures issued in reports after a parametric calculation revision incorporation shall reflect the effects of this revision.

c. Service airplane fatigue estimate reports are to be published at regular intervals to be agreed upon; but not to exceed a frequency of once every 30 days.

d. In conjunction with the production of these reports the contractor will maintain, for record, the operational usage parameter data from which service airplane fatigue estimate report was derived.

e. For those airplanes utilizing counting accelerometer data for the individual airplane fatigue tracking function, the contractor shall maintain and report on a system of surveillance of counting accelerometer data by airplane serial number and shall make periodic comparisons of the expenditure of fatigue life with that experienced in fatigue test. Expenditure of fatigue life for catapulting and arrested landings, including Expeditionary Airfields (EAF) operations, shall also be monitored. The analysis shall be made on a 30-day basis. The initial submittal of this report shall describe the methods of analysis to be used to show fatigue life expended. Subsequent submittals shall be at 90-day intervals as recurring status reports, throughout the lifetime of the airplane, showing the expenditure of fatigue life by airplane serial number.

3.17 Life history recording program reports. Life history program reports shall contain, but not be limited to, exceedance curves and histograms presenting comparison by base of assignment of all recorder data accumulated up to the date of the report with the design spectra. Each report shall be self-contained, and reference to other reports for further clarification should not be required.

3.18 Structural integrity methodology report. The methodology report shall present all aspects of the program for accomplishing the operational phase of the structural integrity program. The procedures, methodology, assumptions, limitations, and controls shall be provided utilizing detailed flow diagrams, discussions, and examples for each step to illustrate the flow of the operational data (recorder and mission) from its receipt until submittal of the fatigue service life monitoring reports, service loads and life history recording program reports. The effect of interfaces and revised inputs from the other (nonoperational) phases shall also be shown.

3.19 Sonic fatigue inspection and repair schedule report. This report shall recommend a plan of inspection and repair maintenance that can be employed by the using services for preventive maintenance of sonic fatigue failures. Such a plan must include schedules and techniques of inspection and maintenance, locations for inspection, and estimation of time and cost of inspection and maintenance. Additionally, recommendations for design fixes and retrofit of components during the service life must be made.

3.20 Airplane structural integrity program (ASIP) master plan report. This report shall depict the integration of the required ASIP elements into a logical sequence for design development and qualification of the airplane structure. The required elements of the ASIP are defined in MIL-STD-1530. The format and instructions for the preparation of the report are contained in Air Force Regulation 80-13.

3.21 Fatigue life monitoring systems report. A fatigue life monitoring system report shall be prepared which provides the overall program plan and the hardware/software development results necessary for the comprehensive structural appraisal of fatigue effects for the airplane and its dynamic components. This program shall be compatible with the Navy's SAFE (Structural Appraisal of Fatigue Effects) program operated by NADC. Included shall be information concerning the parameters to be tracked, the type and location of data sensors, the on-board state-of-the-art recording and micro-processor systems, the methodology for transmitting the required data to NADC and the methodology for analyzing the data. Parameters to be tracked shall include, among others, the longitudinal and vertical acceleration, roll acceleration, airspeed, altitude, wing fuselage and empennage critical strains, and airplane flight time. Parameters or flight condition information to track fatigue-critical rotating components shall also be included. The program shall be implemented on the FSD vehicle and all production vehicles. The final revision of the report and delivery of the life monitoring program to NADC shall be made after the following conditions have been satisfied:

a. All life monitoring data obtained during the contractor's FSD flight demonstration program have been analyzed and published.

b. All flights, takeoffs, catapults, landings, and arrestments completed by the Navy during Technical Evaluation (TECHEVAL), Operation Evaluation (OPEVAL) and Inservice (INSURV) acceptance trials have been analyzed and published.

c. Sufficient data has been analyzed and published during fleet operations to assure a smooth transition to continued fleet monitoring by Navy personnel and equipment.

d. All problems encountered during the monitoring system development are resolved to NADC satisfaction.

e. A user's manual has been made an appendix to the final report.

f. A maintenance diagnostic test and user's manual for ground transfer unit and ground based equipment has been made an appendix to the final report.

g. Algorithms have been developed to produce fatigue index accumulations for components such as wings, fuselage, empennage, landing gear and catapult and arresting gear.

3.22 Structural manual. This document shall consist of all the data and procedures normally used by the contractor in the structural analysis of airplanes including data and procedures used in fatigue analysis. Only the revisions and additions need be submitted if a structures manual has been previously submitted to the contracting activity within the previous five years.

3.23 Structural dynamic manual. This document shall consist of a detailed description of all the procedures and computer programs normally used by the contractor in the structural dynamic analyses of airplanes, including procedures used in flutter and divergence analyses, aeroservoelastic analyses and other aeroelastic analyses and dynamic response analyses. Data and detailed description of procedures used in sonic loads, dynamic loads, sonic fatigue and dynamic loads fatigue analyses shall be included. Only the revisions and additions need be submitted if a structural dynamic manual has been previously submitted to the contracting activity within the previous five years.

3.24 Maintenance instructions for control surfaces and tabs. Maintenance instructions for each control surface, tabs, leading and trailing edge flaps, and wingfolds shall be prepared in accordance with MIL-M-81260. These instructions shall include, but not be limited to, the following:

a. Description and illustration of procedure for measuring freeplay.

b. The maximum allowable freeplay not to be exceeded during the service life of the airplane.

c. Scheduled service life interval when freeplay measurements must be performed to assure that specified freeplay limits are not exceeded in service.

d. Procedure to be followed and parts to be inspected and replaced in the event that freeplay exceeds specified limits.

e. Description and illustration of procedure for measuring mass properties, i.e., weight, CG location, static unbalance about hinge line, dynamic mass balance, and mass moments of inertia.

f. For control surfaces, tabs and flaps which are designed with mass balance, the maximum allowable static and dynamic unbalance not to be exceeded. Description and illustration of procedure for increasing and decreasing mass balance required to compensate for effects of repairs, painting, etc.

g. The maximum allowable mass properties, i.e., weight, CG location, static unbalance about hinge line, dynamic mass balance, and mass moments of inertia. Description and illustration of permissible repairs and limitations.

h. Description and illustration of inspection and maintenance procedure for hydraulic dampers.

The contractor's structural dynamic engineering department shall coordinate with the logistic engineering department to assure that the required data are included in these maintenance instructions.

4. QUALITY ASSURANCE PROVISIONS

This section is not applicable to this specification.

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.

6.2.1 Acquisition requirements.

This paragraph is not applicable to this specification.

6.2.2 Data requirements. When this specification is used in an acquisition, and data are required to be delivered, the data requirements specified in Table I should be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (CDRL). When the provisions of DOD FAR Supplement, Part 27, Sub-Part 27.410-6 (DD Form 1423) are invoked and the DD Form 1423 is not used, the data specified in Table I should be delivered by the contractor in accordance with the contract or purchase order requirements.

(Copies of data item descriptions required by contractors in connection with specific functions should be obtained from the Naval Publications and Forms Center directed by the contracting officer.)

6.3 Definitions. For definitions of terms used in this specification see section 6 of MIL-A-8860.

6.4 Subject term (key word) listing.

Airplane
Airplane data
Airplane reports
Airplane strength
Data requirements
Design criteria
Fatigue criteria
Flight test reports
Laboratory tests
Load criteria
Methodology
Nuclear weapons criteria
Rigidity tests
Service life analysis reports
Structural design reports
Structural manual
Test procedures
Vibration criteria

6.5 Changes from previous issue. Asterisks or vertical lines are not used in this revision to indicate changes from the previous issue due to the extensiveness of these changes.

Preparing activity:
Navy - AS
(Project 1510-N027)

INDEX

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-A-8868B(AS)	Airplane Strength and Rigidity Data And Reports

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

b. WORK TELEPHONE NUMBER (Include Area Code) – Optional

c. MAILING ADDRESS (Street, City, State, ZIP Code) – Optional

8. DATE OF SUBMISSION (YYMMDD)

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

DD FORM 1426, 82 MAR — PREVIOUS EDITION IS OBSOLETE.