NON MEASUREMENT SENSITIVE

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MILITARY SPECIFICATION

MISSILES, GUIDED, STRUCTURAL INTEGRITY GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification establishes the structural performance and verification requirements for guided missiles. The requirements of this specification are established to assure that guided missiles delivered to operational units have adequate structural integrity to accomplish their intended purposes.

1.2 Applicability. This specification is directly applicable to guided missiles. However, the degree of applicability may vary between types of guided missile systems. The extent of applicability shall be in accordance with the provisions of 1.3.

1.2.1 Guided missiles. The extent of applicability of "guided missiles" includes "cruise" missiles and may also by logical extension include other unmanned air-vehicles. However, "ballistic" missiles such as the "ICBM" are specifically excluded.

1.3 Modification and amplification. This specification may be modified and amplified in contracts for guided missiles by type, detail, design data, and test specifications, and addenda thereto.

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

AMSC N/A FSC 1410

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

1.4 Deviations. Deviations from contractually established requirements of this specification may be granted only by the contracting activity in written approval. Deviation requests shall be submitted to the contracting activity with sufficient engineering data to substantiate the need for and applicability of an alternate requirement.

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 document 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 (see 6.2).

SPECIFICATIONS

MILITARY

MIL-A-8591 - Airborne Stores, Suspension Equipment and Aircraft Store Interface (Carriage Phase); General Design Criteria for

STANDARDS

MILITARY

MIL-STD-167 - Mechanical Vibration of Shipboard Equipment
MIL-STD-210 - Climatic Extremes for Military Equipment
MIL-STD-1587- Material and Processes Requirements for Air Force Weapon Systems
MIL-STD-1763- Aircraft/Stores Certification Procedures

HANDBOOKS

MILITARY

MIL-HDBK-5 - Aerospace Vehicle Structures, Metallic Materials and Elements for
MIL-HDBK-17 - Polymer Matrix Composites

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Military Specifications and Standards, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this specification to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

PUBLICATIONS

NAVAL AIR SYSTEMS COMMAND

SD-24 - General Specification for Design and Construction of Aircraft Weapon Systems, Volume I - Fixed Wing Aircraft.

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

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents in the solicitation.

UNITED STATES COMMITTEE ON EXTENSION TO THE STANDARD ATMOSPHERE (COESA)

U.S. Standard Atmosphere

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

Test Method E399-83 - Test for Plane Strain Fracture Toughness of Metallic Materials

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Establishment of structural integrity program. The structural performance requirements of this specification reflect operational and maintenance requirements of the guided missile and are stated in terms of parameter values and conditions (3.2), and technical requirements (3.3 through 3.8). The airframe shall have sufficient structural integrity to meet these requirements, separately and in attainable combinations. Demonstration of compliance with each requirement of this specification shall be verified by an integrated program consisting of design analyses, laboratory and ground tests, structural demonstration tests and data documentation as specified in 4.2.

3.1.1 Missile and launch platform interface compatibility. The missile contractor shall coordinate with the launch platform contractor(s) and together shall perform analysis and tests necessary to ensure that the structural performance of the missile is compatible with the launch platform(s) throughout their common operational envelopes as specified in the system specification. The required structural integrity analyses and tests shall be proposed by the missile contractor and approved by the contracting activity prior to use in structural design.

The required analyses, tests, and documentation shall be consistent with the missile and launch platform(s) interface and may include, but are not limited to the following areas:

a. structural captive flight loads
b. missile launch dynamic response loads
c. missile dynamic response loads due to separation of an adjacent store
d. stress and fatigue
e. aircraft/missile aeroelastic stability
f. vibration and aeroacoustic environments
g. catapult and arrested landing tests
h. field landing, taxiing, and take-off tests
i. aircraft/missile ground vibration modal tests
j. aircraft/missile flight flutter tests
k. aircraft/missile flight loads tests

For the airborne carried missile, the requirements of MIL-A-8591 shall be met and the aircraft/stores certification procedures of MIL-STD-1763 shall be followed.

3.2 General parameters and conditions. The airframe shall have sufficient structural integrity to meet the required operational and maintenance capabilities reflected in the general parameters and conditions of the following subparagraphs and attainable combinations of these parameters and conditions. These parameters and conditions are to be used in conjunction with the detailed requirements contained in 3.3 through 3.8.

3.2.1 Limit loads. Unless otherwise specified, load factors and load formulas noted in any portion of this specification represent limit loads.

3.2.2 Free-flight load factors. The free-flight load factors used for structural design shall be the maximum and minimum load factors attainable for flight use commensurate with the attainable combinations of load factors including intermediate load factors, gross weights, speeds, altitudes, thrust, and rates of displacements of control surfaces.

3.2.3 Design weights and center of gravity (CG) positions. The maximum design gross weight, flight design gross weights, and CG positions shall be as specified by the contracting activity. In addition, the following provisions shall apply.

a. The design gross weights shall be all gross weights, from the maximum design gross weight to the minimum flying gross weight.

b. The weight distributions shall include all distributions that are critical as defined by all possible arrangements of variable and removable items, for which provisions are required, and for all combinations of remaining fuel.

c. For air launched missiles during captive flight, the CG positions employed for design shall be in accordance with the provisions of MIL-A-8591.

d. For free-flight, the CG positions employed for design shall include a tolerance beyond the actual maximum-forward and maximum-aft positions for the gross weights of 3.2.3a. This tolerance shall be 1.5 percent of mean aerodynamic chord or 15 percent of the distance between the actual maximum-forward and actual maximum-aft CG positions, whichever is greater. This tolerance shall be applied so as to move the design CG range forward of the actual maximum-forward position and aft of the actual maximum-aft position.

3.2.4 Atmospheric characteristics. The atmospheric characteristics used for the determination of loads shall be in accordance with the COESA U.S. Standard Atmosphere.

3.2.5 Airload distributions. The distributions of the airloads used in the structural design shall be those distributions determined by the use of acceptable analytical methods, wind tunnel tests, and aerodynamic data which are demonstrated to be applicable and approved by the contracting activity. These data shall include the effects of Mach number, deformation of the surface due to aeroelasticity and thermoelastic effects, and nonlinear effects such as buffet.

3.2.6 Positions of aerodynamic surfaces. The positions of aerodynamic surfaces for the flight loading conditions of this specification shall be the end attainable by all adjustments, including the maximum allowable tolerances specified for fabrication and assembly of the missile, and all critical intermediate positions.

3.2.7 Air speeds. The air speeds employed for design shall be the maximum speeds specified for both captive flight and free-flight and any attainable lesser or intermediate air speeds.

3.2.8 Altitudes. The altitudes used for design shall be all altitudes from sea level to those altitudes at which limit-equivalent air speed and Mach number are maximum.

3.2.9 Thrust. The thrust for the conditions of this specification shall be all values from the minimum to the maximum attainable commensurate with the propulsive system used.

3.2.10 Balance of forces. For conditions for which parameters or values of parameters are not completely specified to the extent necessary for the missile and its components to be in complete translational and rotational equilibrium, additional forces which are determined by a rational method and which are approved by the contracting activity shall be assumed to act in a manner such that the acceleration of the missile's component masses are balanced by externally applied forces.

3.2.11 Thermal criteria. The design of the missile shall provide for the cumulative heating effect from the internal and external thermal environment as defined in 3.2.11.1 and 3.2.11.2.

3.2.11.1 Internal thermal environment. The design of the missile shall provide for the heating effects from internal areas of the missile, such as but not limited to the propulsion and electronics systems during all phases of maintenance and operational use.

3.2.11.2 External thermal environment. The design of the missile shall provide for the heating effects from external areas of the missile, such as but not limited to aerodynamic heating and operation in ambient atmospheres consistent with both the cold and hot atmosphere-verses-altitude relationship defined in MIL-STD-210 extrapolated to cover operational altitudes.

3.2.12 Deformations. The cumulative effects of elastic, permanent or thermal deformations, acting singly or together, which result from application of design temperatures, fatigue loads, and yield loads shall not:

a. Inhibit or degrade the mechanical operation of the missile or of the aerodynamic characteristics of the launch platform.

b. Adversely affect the missile's aerodynamic characteristics or the aerodynamic characteristics of the launch platform.

c. Require repair or replacement of parts.

3.2.13 Load and temperature redistribution. The external load and temperature distributions shall include the effects of aeroelastic and thermoelastic structural deformations.

3.2.14 Transient response. The magnitudes and distributions of loads shall include the effects of the dynamic response of the structure resulting from the transient or sudden application of loads.

3.3 Design loads criteria and loads. Structural design loads criteria and loads shall be established for the structural loading conditions of the following subparagraphs as well as in conjunction with the general parameters and conditions of 3.2. Specific detail structural loading requirements, except as otherwise specified by the contracting activity, shall be as proposed by the contractor and approved by the contracting activity prior to use in the design.

3.3.1 Handling loads. Handling loads for the unpackaged missile shall include all loads required to meet operational use and maintenance requirements and shall incorporate the following limit load factors:

a. For hoisting, a limit load factor of 2.0 acting through the center of gravity within a 20 degree cone around the hoisting axis.

b. For jacking, the limit load factors of 2.0 vertical, 0.50 fore and aft, and 0.50 lateral.

c. For cradling and handling the limit load factor shall be 2.5 in all directions.

3.3.2 Transportation loads. Transportation loads shall include, but not be limited to those imposed due to railroad transportation, truck transportation, air transportation, shore to ship transfer, and ship to ship transfer. Static and transient transportation loads associated with each transportation mode, which shall include loads induced by pressure altitude changes during transportation, shall be evaluated and submitted to the contracting activity for acceptance. The vibration environment encountered by the vehicle in each transportation mode shall be evaluated, submitted to the contracting activity for acceptance, and included in the determination of fatigue loads.

3.3.3 Launch platform interface loads. Launch platform interface loads shall include all loads transmitted to the missile while retained on the launch platform. Analysis shall be made by the contractor based on criteria acceptable to the contracting activity which defines these launcher imposed loads and shall include the following:

3.3.3.1 Ground and ship launched missiles. For ground and ship launched missiles, the following interface load sources shall be evaluated.

a. Steady-state surface wind and gust loads shall be in accordance with MIL-STD-210 for a life expectancy as specified by the contracting activity. Surface wind vortex shedding loads and induced oscillations shall be defined. Shipboard steady state-surface winds shall be not less than 60 knots in all directions.

b. Shipboard loads shall include those imposed due to ship vibration as specified in MIL-STD-167 and for near-miss shock inputs. The various shipboard locations where the missile is normally positioned during service operations shall be included in determining the imposed loads.

3.3.3.2 Air-launched missiles. For air-launched missiles, the following interface load sources shall be evaluated.

a. Captive flight loads are to be based on applicable carrier-aircraft taxiing, take-off/catapulting, maneuvering, landing/arrested-landing, separation of adjacent stores, gun fire, and carrier aircraft engine induced aeroacoustic load conditions (including when the carrier aircraft is in launch position on shipboard catapult with the jet blast deflector (JBD) raised, and when behind the raised JBD in position for next launch.

b. Unless otherwise specified by the contracting activity, missile/carrier-aircraft aerodynamic and inertia interface loads shall be governed by the provisions of MIL-A-8591. Aerodynamic and inertia loads shall be determined from specifically applicable data. If such data are not available during preliminary design, MIL-A-8591 may be used in conjunction with aerodynamic coefficient and inertia load factor data of similar carrier-aircraft/missile combinations. However, final aerodynamic and inertia loads shall be from specifically applicable data.

c. Launching loads are to be based on the most critical flight conditions of the launch aircraft.

d. Combined jet-blast and overdeck winds for captive flight on carrier based aircraft shall be not less than 100 knots in all directions.

3.3.4 Launching loads. An analysis of launching loads, appropriate to the type of launch system used, shall include but not be limited to the effects of ejector impulse and tolerances, rail launch loads, static firing loads, and propulsion system loads.

3.3.5 Transition from launch to free-flight loads. An evaluation shall be made of the loading conditions for events occurring during the transition from the launch phase to the free-flight phase of flight. An analysis of transition loads shall include, but not be limited to the effects of:

a. Flight surface deployment including other deployable surfaces such as air scoops.

b. Staging and separation transient loading, including vibration and shock, occurring during the staging and separating sequence.

3.3.6 Free-flight loads. An analysis of the loading conditions during the free-flight phase of flight shall include, but not be limited to the following:

a. Maneuvering loads. The parameters defining the design maneuvering conditions shall include all those necessary to provide limit strength for the intended missions of the missile. Both steady-state and dynamic maneuvers for the prescribed mission shall be included in determining the maneuvering loads including the effects of launching and mid-course phase errors. The effect of cyclic or repeated maneuvering loads and the effect of load reversal due to missile roll shall be included.

b. Gust loads. The gust loads shall be those applicable to the design operational flight plan at appropriate speeds and altitudes. Unless otherwise specified by the contracting activity, the type of gust analysis, shall be proposed by the contractor and shall be acceptable to the contracting activity.

c. Combined gust and maneuver loads. Strength shall be provided for statistical combinations of maneuver and gust loads. These combined conditions shall apply to all phases of missile trajectory.

d. Wind shear loads. All missiles having vertical or nearly vertical flight paths, or portions thereof, shall be provided with strength to sustain wind shear loads. Operational type missiles shall withstand shear loadings resulting from wind profiles attainable 1 percent of the time. The contractor shall include shear layer thicknesses corresponding to the critical missile characteristics. Gust and wind shear effects shall act additively in proportions consistent with altitude variations.

e. Control system loads. The load investigation shall include the effects of weight, inertia, control stops, accelerations, and dynamic overshoot.

f. Fuel-slosh loads. The load investigation shall include the pressures and dynamic response associated with fuel-slosh and fuel-surge loads.

g. Internal pressures. The pressures resulting from the maximum anticipated rates of change of speed and altitude shall be established.

3.3.7 Recovery loads. An analysis of the recovery conditions, if applicable, shall be made to determine the recovery loads. The recovery system shall permit recovery of the missile or sections thereof with minimum damage as required in the detail specification.

3.3.8 Pressure vessel loads. An analysis of pressure vessels shall be made to establish the design nominal operating pressure and the maximum expected operating pressure (MEOP) loads. Upper and lower nominal operating pressure bounds shall be established in a rational manner when a range of pressure is possible for a particular structure. All pressure vessels shall withstand the maximum pressures attainable as limited only by pressure relief devices or the capacities of the pressure systems, whichever is less, in combination with the conditions specified in 3.2.11.

3.3.8.1 Nominal operating pressure. The range of nominal operating pressures shall be established by taking into account applicable combinations of the following items:

a. The maximum range of temperatures that will be encountered in all operating conditions.

b. The critical temperature limits specified for the particular operating conditions.

c. Fueling and storing conditions.
d. Propellant loading pressures.
e. The vapor pressure of the vessel contents.
f. The effects of head pressure, static and dynamic.
g. Atmospheric pressure at altitude.
h. Operating tolerances on pressure regulators, valves, instrumentation.
i. Instrumentation error.

3.3.8.2 Maximum expected operating pressure (MEOP). The MEOP shall be established as the maximum nominal operating pressure plus applicable combinations of maximum transient pressures including hydraulic shock.

3.3.8.3 Pressure vessels serving as primary structures. Design loading conditions for pressure vessels serving as primary structures (such as rocket motors and fuel tanks) shall be established and shall be the maximum forces or combinations of forces resulting from:

a. The static, vibratory, thermal, and repeated external loading conditions specified herein.

b. The minimum nominal operating pressure when pressure increases the load carrying capability of the structure.

c. The maximum nominal operating pressure when pressure decreases the load carrying capability of the structure.

d. The MEOP.

3.3.9 Overpressure, thermal, and gust response loads. Overpressure, thermal, and gust response load requirements shall be as specified by the contracting activity in the detailed specification.

3.4 Vibrations. Construction, materials, and design shall be such that there will be no airframe fatigue failures resulting from structural dynamic responses induced by aeroacoustic, mechanical, structural, or other oscillatory loadings. The requirements of 3.4.1 through 3.4.3 shall apply throughout the design range of altitudes, speeds, maneuvers, weights, fuel content, thermal conditions, and other loading conditions and configuration variables for the service life of the missile.

3.4.1 Oscillatory loads and fatigue. The design of the missile shall be demonstratably free from fatigue failures resulting from structural dynamic responses (vibrations) induced by the oscillatory loadings of 3.4.1.1 for the service life of 3.6.1. The design of the missile shall also satisfy the design factors and fail-safe requirements of 3.4.1.2 and 3.4.1.3 respectively, and the durability and damage tolerance requirements of 3.6 and 3.7 respectively.

3.4.1.1 Oscillatory loading sources. Structural oscillatory responses are caused by aeroacoustic energy or mechanical energy transmitted through either an air media (airborne) or solid media (structural borne). Oscillatory loading environments include, but are not limited to, those resulting from:

a. All sources that may be associated with the propulsion system such as rocket/jet exhaust turbulence noise, compressor or fan noise, combustion noise, nozzle instability noise, inlet instability noise, and vectored thrust propulsion.

b. All noise of aerodynamic origin that may be associated with unsteady flow operation such as boundary layer pressure fluctuation, wake noise, cavity noise, base pressure fluctuation, oscillating shocks, and shed vortices.

c. All mechanically induced phenomena such as launch platform induced loading and launching forces, unbalance of rotary components, and fuel slosh.

3.4.1.2 Design factors. The missile shall meet the following design requirements:

a. Design factors for oscillatory loads: The structure and structural components shall be designed with a design factors of 1.5 on aeroacoustic pressures and on oscillatory acceleration, G or Grms.

b. Damping: The total (aerodynamic plus structural) damping coefficient, g, for any significant airframe dynamic response mode shall be not less than three percent (g = 0.03).

3.4.1.3 Fail-safe structural integrity. The design of the missile shall provide multiple load path fail-safe features to eliminate critical single failures or, as a minimum, the design shall provide a safe life of critical elements. In the event of unexpected fatigue failure or partial failure of a principal structural element resulting from oscillatory loadings, at least limit strength required for flight loads shall remain.

3.4.2 Control of environment. Techniques to minimize excessive oscillations shall be applied in the early design stages. Such techniques include, but are not limited to relocation of oscillatory load sources, isolation from the oscillatory load, changing the structural stiffness locally to detune it from the known frequency spectrum of the oscillatory loads, avoidance of cavities and projections which produce local high-intensity turbulence, and the use of damping materials.

3.4.3 Component support structure. The design of missile component support structure shall be such as to prevent excessive oscillatory response of components due to amplification of structural responses of the support structure.

3.5 Design strength. The structure shall have sufficient strength such that material yield allowable stresses will not be exceeded at yield loads and material ultimate allowable stresses will not be exceeded at ultimate loads. For repeated load and fatigue conditions, strength shall be provided such that the fatigue life of the structure will equal or exceed the specified life, including specified scatter factors.

3.5.1 Missile construction. Unless otherwise specified by the contracting activity, the missile construction shall conform to the material, manufacturing, and process requirements of SD-24 Volume I.

3.5.2 Properties of materials for design strength. The selection of material physical properties used in structural design shall include a consideration of all factors which affect the allowable strength. Such factors include, but are not limited to the following:

a. Manufacturing processes.

1. For metallic materials, the allowable stresses used in the design shall not exceed those applicable to the grain directions resulting from fabrication. So far as is practical, structural members shall be so designed that the directions of the critical stresses are favorably related to the direction of the grain resulting from forging, rolling, extruding, and other fabrication processes.

b. The nature of static, transient, fatigue, and shock loads as well as the effects of sustained vibration and repeated loads.

c. Stress concentration areas.

d. Operating environments consistent with overall planned usage.
e. Effects of operating environment on residual physical properties.

f. Considerations of reductions of material strength, shall include the effects of expected longtime, short-time, and repeated exposure to elevated temperatures and to chemicals in combination with other applicable design loads. Applicable effects shall also include creep, thermal expansion, joint-fastener relaxation, elevated-temperature fatigue, and moisture absorption.

3.5.3 Metallic materials. The properties of metallic materials shall be commensurate with the operational and maintenance capability required of the airframe.

3.5.3.1 Design data and allowable materials properties. Design data and properties of metallic materials shall be obtained from the following sources, or from other sources subject to acceptance by the contracting activity.

a. The "A" and "S" values of MIL-HDBK-5 shall be used in the design of structural components whose failure would result in the loss of the missile, whose failure during captive flight would result in damage to or in the loss of the launching vehicle, or in the loss of launching vehicle control within the meaning of 3.2.12. These values shall also be used for design of structural components not subjected to structural tests. Where both "A" and "S" values exist and differ, the least value shall be used.

b. The "B" values of MIL-HDBK-5 may be used, subject to the approval of the contracting activity, for the design of multiple load path structural components where the redistribution of loads due to failure of a load path does not result in airframe catastrophic failure, loss of control of the missile, or otherwise an incomplete mission.

Minimum guaranteed properties obtained from the handbook shall be used for design purposes. For the substantiation of structural integrity by analytical calculations, the nominal thickness of material shall be used, except for mechanically or chemically milled pressure vessels where the design thickness shall be the minimum thickness. The nominal thickness shall be the average between tolerances.

When new materials are proposed for use in the design, design data and properties other than those contained in MIL-HDBK-5 shall be developed as necessary according to a material characterization and design allowable plan. This plan shall be in accordance with the guidelines presented in Chapter 9 of MIL-HDBK-5 or as specified by the contracting activity. Where it is necessary to develop data and properties for metallic materials, the test materials and processes shall be those intended for use in production missiles.

3.5.4 Nonmetallic materials. Nonmetallic materials shall be selected and used in compliance with the following requirements. Whenever materials are proposed for which only a limited amount of data is available, the contractor shall provide the contracting activity with sufficient background data so that a determination of the suitability of the material can be made.

a. Unless otherwise specified by the contracting activity, design data and properties for plastics and glass fiber reinforced plastics shall be obtained from MIL-HDBK-17B (Volume 1) or from other sources subject to the approval by the contracting activity. The material acquisition, qualification, and process specifications shall be in accordance with the procedures of MIL-STD-1587 (section 5.2.1.4.2).

b. Design data and properties other than those contained in MIL-HDBK-17B (Volume 1) shall be developed as necessary according to a material characterization and design allowable plan. This plan shall be in accordance with the guidelines of MIL-HDBK-17B (Volume 1) or as specified by the contracting activity. Where it is necessary to develop data and properties for non-metallic materials, the test materials and processes shall be those intended for use in production missiles.

3.5.5 Margins of safety. Margins of safety shall be positive and shall be determined at yield and ultimate allowable levels, when appropriate, at the temperatures expected for all critical conditions.

3.5.5.1 Margins of safety for castings.

a. Requirements for the use, classification, and inspection of castings is contained in SD-24 Volume I.

b. The margins of safety for class 1 castings, considering S property values, shall be not less than +0.33 and for class 4 castings shall be not less than +2.00 unless a lower value, acceptable to the contracting activity, can be substantiated empirically.

c. Fitting factors shall not be used in conjunction with casting margins of safety even though a part of the casting functions as a fitting.

d. At least one ultimate static test shall be conducted for all class 1 castings.

3.5.6 Design strength factors.

3.5.6.1 Factors of safety.

3.5.6.1.1 Yield factors of safety. Except for loading conditions for which specific yield loads are delineated, the yield loads are obtained by multiplying limit loads by the yield factor of safety. No permanent deformation shall remain after application and removal of yield loads. Unless otherwise specified by the contracting activity, the following yield factors of safety apply:

a. 1.15 for captive flight, launching, ejection, jettison, and initial free flight conditions. Initial free flight conditions shall be defined as within 5 seconds after separation from the launch platform/launcher or 250 feet clear of the launch platform/launcher, whichever yields the greater distance.

b. 1.00 for free flight conditions other than the initial free flight condition of 3.5.6.1.1a.

c. 1.15 for transportation, handling, and other non-flight conditions.

3.5.6.1.2 Ultimate factors of safety. Except for loading conditions for which specific ultimate loads are delineated, the ultimate loads are obtained by multiplying the limit loads by the ultimate factors of safety. Failure shall not occur at the design ultimate load. Unless otherwise specified by the contracting activity, the following ultimate factors of safety apply:

a. 1.50 for captive flight, launching, ejection, jettison, and initial free flight conditions. Initial free flight conditions shall be as defined in 3.5.6.1.1a.

b. 1.25 for free flight conditions other than the initial free flight condition of 3.5.6.1.1a.

c. 1.50 for transportation, handling, and other non-flight conditions.

d. In certain special cases, an ultimate factor of safety of greater than 1.50 may be specified for consideration of added safety, strength, rigidity, quality assurance, and wear.

3.5.6.2 Pressure vessel factors.

3.5.6.2.1 Proof pressurization factors. Except for conditions for which specific proof pressures are delineated, the proof pressure (at operating temperature) for pressure vessels shall be determined by multiplying the nominal operating pressure by the proof pressurization factor, plus the difference between nominal operating pressure and the MEOP. For pressure vessels serving as primary structure, the proof pressure (at operating temperature) shall be determined by multiplying the MEOP by the proof pressurization factor. Pressure vessels shall not yield at the design proof pressure. Unless otherwise specified by the contracting activity, the following proof pressurization factors apply:

a. 1.2 for pneumatic vessels, hermetically sealed units, and lines and fittings when non-hazardous to personnel.

a. 1.5 for pneumatic vessels, hermetically sealed units, and lines and fittings when hazardous to personnel.

c. 1.1 for solid rocket motor cases and gas generators.

Unless otherwise specified by the contracting activity, hazardous conditions exist when pressurization occurs at any time up to and during the initial free-flight conditions specified in 3.5.6.1.1a.

3.5.6.2.2 Burst pressurization factors. Except for conditions for which specific burst pressures are delineated, the burst pressure (at operating temperature) shall be determined by multiplying the nominal operating pressure by the burst pressurization factor, plus the difference between the nominal working pressure and the MEOP. Pressure vessels shall not fail at the design burst pressure. Unless otherwise specified by the contracting activity, the following burst pressurization factors apply:

a. 1.33 for pneumatic vessels, hermetically sealed units, and lines and fittings when non-hazardous to personnel.

b. 2.0 for pneumatic vessels, hermetically sealed units, and lines and fittings when hazardous to personnel.

c. 1.5 for solid rocket motor cases and gas generators.

Unless otherwise specified by the contracting activity, hazardous conditions exist when pressurization occurs at any time up to and during the initial free-flight conditions specified in 3.5.6.1.1a.

3.5.6.3 Other factors. Other factors shall be used to account for structural analysis, environmental, and material uncertainties which are not amenable to rational approaches.

a. Fitting factor: For each fitting and attachment whose strengths are not proven by limit and ultimate load tests, in which actual stress conditions are simulated in the fitting and surrounding structure, the stress fitting factor shall be not less than 1.15.

b. Bearing factor: When a bolted joint with clearance (free fit) is subjected to relative rotation under limit load or shock and vibration loads, the stress bearing factor shall be not less than 2.0.

c. Buckling factor: A buckling factor of 1.5 shall be used on all components loaded in a manner that can produce structural instability.

3.6 Durability. The design and construction of the airframe structure and the selection of materials to be used shall include provision for durability. The repeated loads environment shall not cause failure or permanent deformation of any part of the missile, interfere with its mechanical operation, or affect its aerodynamic characteristics. Further, the design shall not require repair, inspection, or replacement of components other than as specifically approved by the contracting activity. The above requirements apply to the planned service life of the missile for the repeated loads environment resulting from the requirements of the following subparagraphs.

3.6.1 Service life. The service life shall be the total life expectancy of the missile. The service life starts at the completion of assembly of the missile and continues through, as applicable, all acceptance testing, handling, storage, transportation, captive carriage (for ground and ship launched missiles), captive flight (for air launched missiles), carrier suitability (for air launched missiles mounted on carrier based aircraft), launch, ejection, free-flight, and refurbishment, retesting, and reuse that may be required or specified for the missile. The service life of the missile shall not be less than that specified by the contracting activity.

a. Unless otherwise specified by the contracting activity, the service life for air-launched missiles shall be not less than:

1. 300 hours of captive flight.

2. 100 catapult launches and arrested landings for missiles mounted on carrier based aircraft.

3. 100 takeoffs, landings, and taxiing (power spectral density (PSD) taxi analyses shall be performed) including other ground conditions such as braking and turning for missiles mounted on land based aircraft.

3.6.2 Fatigue spectra. The missile usage spectra for analysis and test shall include repeated loads from all types of anticipated operational environments and shall be supplemented, as required, to ensure that each missile component is designed and tested to the proper repeated loadings. Consideration shall be given to the effects of load sequence, load truncation, load induced residual stress, and other factors as appropriate to assure that usage spectra for analysis and test provide the most conservative fatigue life. Ordering and frequency of loads within the usage spectra shall be random, consistent with missile operation, load exceedance and occurrence rates, and planned service life values.

3.6.2.1 Compliance. Compliance with 3.6.2 shall be demonstrated by the fatigue analysis of Appendix C and the fatigue tests of Appendix A utilizing crack initiation as the primary failure criterion. Specifically the structural design of the missile shall be such that the usage spectra will not cause structural defects (cracks, deformations, loss of modulus, delaminations, disbonds, etc.) or failure, within four times service life based upon analysis and two times service life based upon full scale tests. If any part of the missile should fail to demonstrate compliance with the above requirements, that part shall be redesigned and then shown by analysis and test to be compliant. No inspections shall be required as a function of design within two service lifetimes. For both fatigue analysis and tests, the use of fatigue life-enhancing mechanical processes (such as shot peening, roller burnishing, etc.), other than split sleeve cold working and interference fit, are prohibited in demonstration compliance.

3.6.2.1.1 Analysis. For analysis purposes, substantiation of fatigue life shall be in accordance with prediction methods as approved by the contracting activity. For approved interference fit and cold working enhancements, fatigue analysis shall indicate the missile will be free from structural defect for not less than one service life without the benefit of interference fit or cold working.

3.6.2.1.2 Test. Testing shall continue beyond two times service life until catastrophic failure, or until four times service life has been sustained by the test article. At test conclusion, the test article shall be subjected to a complete destructive teardown inspection, including fractographic examination, to identify all failures. All repairs made to the test article prior to two times service life, and all repairs for cracks or failures concluded to have been initiated prior to two times service life, shall be incorporated into all forward and retrofit production missiles, provided the repairs have demonstrated compliance by analysis and test. For fatigue life certification of composite structure by test, accounting for variability and environmental factors shall be relatable to and confirmable by the results of the design development pre-production component and static tests of Appendix A.

3.6.3 Low frequency vibratory loads. The airframe shall be designed so that low frequency (not greater than 60 Hz) dynamic stresses, induced by vibratory loadings, are below the endurance limit of the material used. When these low frequency vibratory loadings are combined with the other various missile loading conditions, the vibratory loadings shall not cause the structural fatigue life to be degraded from that which results when separately applying the other various loading conditions to the airframe structure.

3.7 Damage tolerance. The design and construction of the airframe structure and the selection of materials to be used shall include provision for damage tolerance. Damage tolerant material shall be chosen on the basis of available, confident data. Damage tolerance shall be in addition to, rather than in lieu of provision for adequate structural fatigue characteristics, and shall serve as a means of preventing catastrophic structural failure after a predefined limit of structural damage has occurred.

3.7.1 Analysis. All areas of structural components established as primary or critical shall be analyzed using the methods of linear elastic fracture mechanics, as a minimum, to identify the character and dimensions of defects which could grow to critical size in time periods as limited by missile inspection periods. These analyses shall assume the presence of crack-like defects and delaminations placed in the most unfavorable orientation with respect to the material properties and applied stress consistent with the missile loads environment, and shall predict the growth behavior of the chemical, thermal, and sustained and repeated-loads environment to which the component will be subjected.

3.7.1.1 Compliance - metals. For all primary or critical structures, crack growth under sustained and repeated loads shall not occur at a rate such that initial flaws can reach critical size at the residual strength requirement load in one lifetime of expected service usage. For purposes of these analyses, the initial flaw size shall be not less than 0.01 inch in metals, and at failure not less than 0.25 inch (surface length). Critical flaw sizes shall be determined using the appropriate critical fracture toughness values determined on a valid statistical basis in accordance with the procedures of the ASTM Test Method E399-83. The analysis shall identify plane strain, plane stress, or mixed mode conditions at the onset of rapid crack propagation, and shall include all crack growth rate and critical crack length data on which the analysis was based. The effect of sheet thickness on fracture resistance shall be proposed by the contractor and submitted for acceptance by the contracting activity.

3.7.1.2 Compliance - composites. Damaged structure (such as delamination) at or below the threshold of being clearly visible, shall be capable of fully compensated ultimate load statically with no damage growth under sustained and repeated loads for not less than one service lifetime. Demonstration of requirement shall be by test, or as proposed by the contractor and specifically approved by the contracting activity, accounting for the effects of variability and environment as relatable to and confirmable by the results of the design development, pre-production component, and static tests of Appendix A.

3.8 Aeroelastic stability. Construction, materials, and design shall be such that there will be no flutter, buzz, divergence, aeroelastic, aerothermoelastic, aeroservoelastic, or other related static or dynamic instabilities, including sustained limit amplitude instabilities, of the missile or of its components. The missile structure shall meet the requirements specified in 3.8.1 through 3.8.6. These requirements shall apply throughout the design range of altitudes, speeds, maneuvers, weights, fuel content, thermal conditions, maneuvers where losses in stiffness may occur, and other loading conditions and configuration variables for the service life of the missile.

3.8.1 Aeroelastic stability margins. Analysis, wind tunnel and laboratory tests, and missile flight tests (up to design limit speeds) shall demonstrate that the missile meets the following aeroelastic stability design requirements:

a. Speed margin: Fifteen percent equivalent airspeed, V_E, margin on the applicable design limit speed envelope, both at constant altitude and constant Mach number, M, (see Figure 1).

b. Damping: The total (aerodynamic plus structural) damping coefficient, g, for any critical flutter mode shall be at least three percent (g = 0.03) for all altitudes and flight speeds up to design limit speed (see Figure 2).

3.8.2 Aeroservoelastic stability. Interaction of the control system with the missile structural modes shall be controlled to preclude any aeroservoelastic instability. The equivalent airspeed margin and damping requirements of 3.8.1 shall be met for all operating states and for the range of operating temperatures of the control system. In addition, for any single flight control system feedback loop, the missile shall have the stability margins listed below at speeds up to V_L.

a. A gain margin of at least 6dB.
b. And separately, a phase margin of at least ±45 degrees.

3.8.3 Control surfaces. Control surfaces shall be designed to contain either sufficient static and dynamic mass balance, or sufficient bending, torsional and rotational rigidity, or a combination of these means, to preclude flutter of all critical modes under all flight conditions.

3.8.3.1 Mass balance of control surfaces. If static mass balance or dynamic mass balance or both are used on control surfaces to prevent any aeroelastic instability, the following requirements specified in 3.8.3.1.1 through 3.8.3.1.4 shall be met:

3.8.3.1.1 Location of balance weights. Balance weights in control surfaces shall be located so that flutter safety of both control surface and main surface are assured. In addition, the following shall apply:

a. Insofar as is practical, balance weights shall be located in regions where deflections of critical mode shapes are a maximum.

b. Whenever possible, balance weights shall be distributed so that each third of the span of each control surface shall be statically balanced.

c. Balance weights shall not be located externally with respect to the planes of the control surface.

d. Balance weights and actuating systems for control surfaces shall be designed to prevent control surface rotations resulting from inertia loads acting on the balance weights and actuating systems due to high acceleration environments.

3.8.3.1.2 Rigidity of balance weight attachment. The natural frequencies of the balance weights, as installed, shall be at least twice the highest frequency of the flutter mode for which the balance weight is required to be effective.

3.8.3.1.3 Design loads for balance weight attachment. Balance weights and adjacent supporting structure shall be designed, as a minimum, to the following conditions.

a. A limit inertial load factor of ±100g and repeated inertial load factor of ±60g for 500 kilocycles in a direction normal to the plane of the control surface.

b. A limit inertial load factor of ±50g and repeated inertial load factor of ±30g for 500 kilocycles in the other two mutually perpendicular directions of the control surface.

3.8.3.1.4 Static balance tolerance. The maximum allowable static unbalance of each control surface and the manufacturing tolerances (in inch-pounds), as approved by the contracting activity, shall be established and included in all control surface assembly drawings.

3.8.3.2 Rigidity and frequency of control surfaces. If bending, torsional, and rotational rigidity criteria are used for control surfaces to prevent any aeroelastic instability, the following requirements shall apply:

a. The adequacy of control surface bending, torsional, and rotational rigidity about the hinge line and frequency of the actuating system shall be established together with the maximum allowable changes in inertia properties (from nominal) of the control surface.

b. The bending, torsional, and rotational rigidity shall include the rigidity of all actuating elements, rigidity of the structure to which the elements are attached, and the rigidity of the control surface.

c. The actuators shall be located as close as practicable to the control surface and hinge to minimize the flexibility caused by connecting elements.

3.8.3.3 Freeplay of control surfaces. Detail design shall assure that normal wear of components, of control surfaces, and actuating systems shall not result in values of freeplay exceeding those specified below throughout the service life of the missile.

a. For an all-moveable control surface, the total freeplay shall be not greater than 0.10 degrees.

b. For a trailing edge control surface which extends outboard of the 75 percent span station of main surface, the total freeplay shall be not greater than 0.13 degrees.

c. For a trailing edge control surface which extends outboard of the 50 percent but inboard of the 75 percent span station of main surface, the total freeplay shall be not greater than 0.57 degrees.

d. For a trailing edge control surface which is inboard of the 50 percent span station of main surface, the total freeplay shall be not greater than 1.15 degrees.

3.8.3.4 Single-degree-of-freedom flutter of control surfaces. Single-degree-of-freedom flutter, such as control surface buzz, shall be prevented by providing adequate control surface torsional and rotational rigidity, or by use of aerodynamic configurations which are not susceptible to this phenomenon.

3.8.3.5 Hydraulic dampers. In the event that mass balance or rigidity criteria are impracticable, hydraulic dampers may be used for flutter prevention of control surfaces. The rigidities of the damper element and the supporting structure to which the elements are attached shall be sufficiently high to preclude loss of damper effectiveness by structural deformation at the flutter frequencies. The freeplay of the damper shall be not greater than applicable values specified in 3.8.3.3. The dampers shall be effective to prevent flutter throughout the range of temperatures experienced during operational usage.

3.8.3.6 Environmental effects on mass properties. The design of all control surfaces shall preclude detrimental changes in physical characteristics and mass properties (that is mass, static balance, and mass moment of inertia) due to any natural or man-made environments throughout the service life of the missile. Water absorption and water entrapment shall be prevented.

3.8.4 Fail-safe stability. Detail design shall provide multiple load paths to eliminate critical single failures or, as a minimum, the design shall provide a safe life of critical elements to preclude all aeroelastic instabilities. In the event that a single failure of a multiple load design does occur, the stability margins of 3.8.1 shall be met.

3.8.5 Panel and chordwise mode flutter. External, inlet, transparency and other aerodynamically loaded panels shall be designed to preclude flutter and sustained limit amplitude instabilities. The stiffness and damping properties of skin panels and supporting structure shall be sufficiently high to preclude panel and chordwise flutter. The effects of midplane stresses caused by pressure differential across the panel, temperature differential between the panel and the supporting structure, and maneuvering loads shall be included in determining the required stiffness. In addition, the local flow aerodynamics (i.e., Mach number, dynamic pressure, flow angularity, etc) at the panel surface shall be used to establish panel stiffness criteria.

3.8.6 Transonic aeroelastic phenomena. Lifting surfaces or other missile components shall be designed to meet the equivalent airspeed margin and damping requirements of 3.8.1 when exposed to shock induced oscillations or other related aeroelastic instability phenomena peculiar to the transonic flight regime.

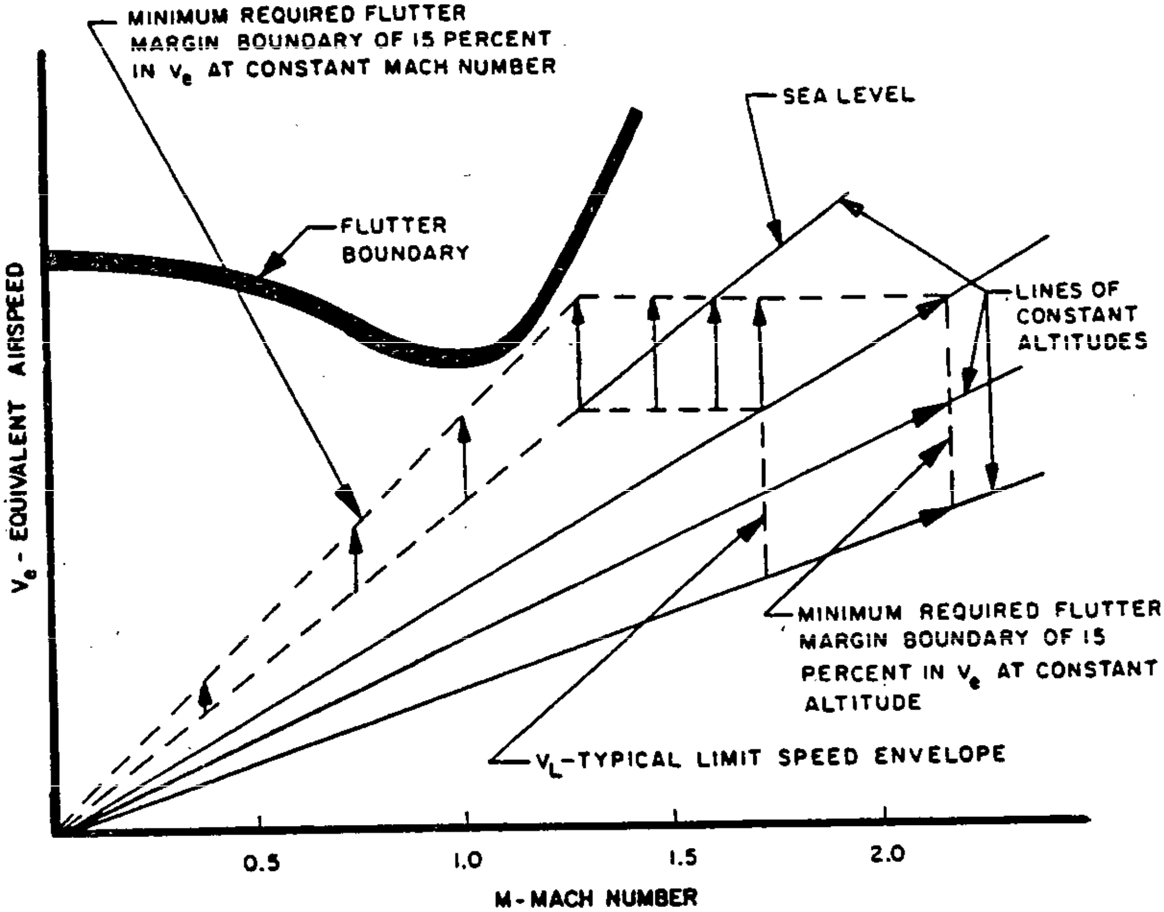

FIGURE 1. Graphical representation of minimum required flutter margin.

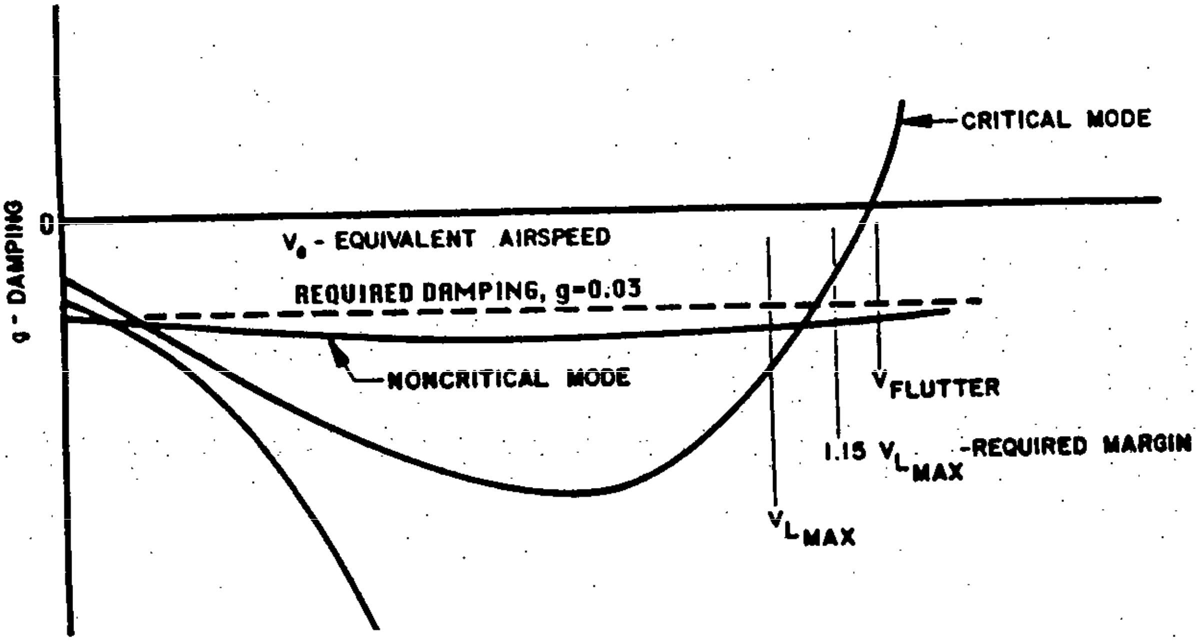

FIGURE 2. Graphical representation of required damping.

4. QUALITY ASSURANCE PROVISIONS

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

4.1.1 Responsibility for compliance. All items shall meet all requirements of section 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, and does not commit the Government to accept defective material.

4.2 Demonstration of compliance. Demonstration of compliance with each design requirement of this specification shall be verified by an integrated program consisting of design analysis, laboratory and ground tests, structural demonstration testing and data documentation.

4.2.1 Laboratory and ground tests. The static, dynamic, repeated load, environmental, wind tunnel, and other laboratory and ground tests required for proof of structural design shall be as specified in Appendix A.

4.2.2 Structural demonstration tests. The launch platform captive, free flight, and other structural demonstration test requirements for proof of structural design shall be as specified in Appendix B.

4.2.3 Analyses, data, and reports. The structural analyses, data, and reports required to substantiate the structural integrity of the missile shall be as specified in Appendix C.

4.2.3.1 Documentation. Appendix C establishes the basic inputs and requirements for documentation of structural integrity analyses and tests for the guided missile. The contracting activity acceptance or disapproval criteria of these documents shall be based on legibility, accuracy, correctness, completeness, validation, traceability, and requirement deviation approvals. The contracting activity approval of contractor analyses, test plans or procedures, and test reports that incorporate deviations from contractually established requirements does not, in itself, constitute approval of the deviation. Deviations shall be in accordance with 1.4.

5. PACKAGING. This paragraph is not applicable to this specification.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The requirements of this specification are intended for use in establishing the structural performance and verification of guided missiles.

6.2 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of the specification.

b. Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.).

6.3 Data requirements. The Data Item Descriptions (DID's) contained in Appendix C Table I must be listed, as applicable, on the Contract Data Requirement List (DD Form 1423) when this specification is applied on a contract, in order to obtain the data, except where DOD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423. The DID's listed were those cleared as of the date of this specification. The current issue of DOD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

6.4 Definitions of terms. The following terms are defined for use or reference herein.

6.4.1 Acoustic environment. The acoustic environment is the pattern of sound pressure levels within specified boundaries.

6.4.2 Aeroacoustic load. The aeroacoustic load is the acoustic-noise, turbulent or separated boundary layer pressure fluctuations, or oscillating shock pressures acting on the surface of the structure.

6.4.3 Aeroelasticity. Aeroelasticity is interaction of inertial, elastic and aerodynamic forces.

6.4.4 Aeroelastic flight tests. Aeroelastic flight tests are the experimental means used to determine the aeroelastic, including flutter, safety of a missile. The dynamic response data from strategically located transducers are carefully analyzed to ensure stability throughout the missile's flight envelope.

6.4.5 Aeroservoelasticity. Aeroservoelasticity is the interaction of inertial, elastic and aerodynamic forces and the dynamics of the control system of the missile.

6.4.6 Aerothermoelasticity. Aerothermoelasticity is the interaction of inertial, elastic and aerodynamic forces and stresses and reduction in material mechanical properties induced by high temperature environments.

6.4.7 Airframe. The assembled structural and aerodynamic components of a missile that support the different systems and subsystems integral to the vehicle.

6.4.8 Air launch. To launch from an aircraft in the air, as to "air launch a missile."

6.4.9 Ballistic missile. A missile designed to operate primarily in accordance with the laws of ballistics, such as a self-propelled missile guided in the ascent of a high-arch trajectory and freely falling in the descent.

6.4.10 Booster rocket. A rocket motor, either solid or liquid, used to set a vehicle in motion before another engine takes over.

6.4.11 Broad-band random vibration. Broad-band random vibration is random vibration having its frequency components distributed over a broad frequency band.

6.4.12 Buzz. Buzz is usually evidenced by a pure rotational oscillation of a control surface or, when support rigidities are such as to restrain the motion of the surface near one end, by a torsional windup oscillation. Buzz can lead to damage or destruction of the surface either by fatigue or by inducing greater than yield loads when the amplitude is sufficiently large.

6.4.13 Captive flight. Captive flight is the condition in which the missile is attached to the aircraft and the aircraft is on the surface or in flight.

6.4.14 Critical loading condition. The design loading condition for which margins of safety indicate the structural component is most likely to fail.

6.4.15 Cruise missile. A ground target guided missile designed to operate most of the time at a predetermined speed and altitude and deriving its lift primarily from wings.

6.4.16 Damage tolerance. The ability of the airframe to resist failure due to the presence of flaws, cracks, or other damage for a specified period of unrepaired usage.

6.4.17 Damping coefficient (g). Damping coefficient, g, is expressed by the equation

$$g = (1/\pi N)\ \ln(A_i / A_j)$$

where: $N = (j-i)$
A_i = amplitude of the i^{th} cycle
A_j = amplitude of the j^{th} cycle

6.4.18 Divergence. Divergence is a static aeroelastic instability of a lifting surface that occurs when the structural restoring moment of the surface is exceeded by the applied aerodynamic moment.

6.4.19 Durability. The ability of the airframe to resist cracking (including stress corrosion and hydrogen induced cracking), corrosion, thermal degradation, delamination, wear, and the effects of foreign object damage for a specified period of time.

6.4.20 Excessive vibration. Excessive vibration are those structural oscillatory accelerations, displacements, or stresses in structural or other components, which result in the component not being fully functional.

6.4.21 Failing load. Load at which failure occurs.

6.4.22 Fail-safe crack arrest structure. Fail-safe crack arrest structure is structure designed and fabricated such that unstable rapid propagation will be stopped within a contained area of the structure prior to complete failure. Safety is assured through slow crack growth of the remaining structure and detection of the damage at subsequent inspections. Strength of the remaining undamaged structure will not be degraded below a specified level for the specified period of unrepaired service usage.

6.4.23 Factor of safety. Factor of safety is a multiplying constant that is applied to the limit load to arrive at an appropriate design load.

6.4.24 Flutter. Flutter is a self-excited oscillation of an aerodynamic surface and its associated structure caused by a combination of the aerodynamic, inertia, and elastic characteristics of the components involved. At speeds below the flutter speed, oscillations will be damped; at the flutter speed, oscillation will persist with constant amplitude; and at speeds above the flutter speed, oscillations will, in most cases, diverge and result in damage or destruction of the surface. Flutter is a subtopic of aeroelasticity.

6.4.25 Fracture critical structure. Safety of flight structural components or regions of safety or flight structural components which are either sized by the requirements of this specification (category I fracture critical parts), or could be sized by the requirements of this specification if fracture control procedures are not employed (category II fracture critical parts).

6.4.26 Free-flight. Free-flight is the condition in which the missile is in flight and separated from the launch platform.

6.4.27 Guided missile. Broadly, any missile that is subject to, or capable of some degree of guidance or direction after having been launched, fired, or otherwise set in motion. Specifically, an unmanned, self-propelled flight vehicle (such as a pilotless aircraft) carrying a destructive load and capable of being directed or of directing itself after launching or take-off, responding either to external direction or to direction originating from devices within the missile itself. Loosely, by extension, any steerable projectile. See ballistic missile.

6.4.28 Launcher. Broadly, a structure, machine, or device, including the catapult, by means of which missiles are directed, hurled, or sent forth. Specifically, a structure or device, often incorporating a tube, a group of tubes, or a set of tracks from which missiles are sent forth and by means of which the missiles usually are aimed or imparted initial guidance - distinguished in this specific sense from a catapult.

6.4.28.1 Ejection launcher. A launcher which provides an initial source of energy to adequately displace the missile from the launch platform prior to the initiation of the missile's self propulsion system.

6.4.28.2 Rail launcher. A launcher containing rails on which the missile is carried, and along which the missile travels after initiation of the missile's self-propulsion system.

6.4.29 Limit load. Limit load is the maximum load which the airframe is expected to encounter.

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

6.4.30.1 Limit load or limit load factor. A load or load factor which establishes a strength level for missile design.

6.4.30.2 Ultimate load or ultimate load factor. Limit load or limit load factor multiplied by an ultimate factor of safety.

6.4.30.3 Load amplification factor. The ratio of load with aeroelastic effects to that for a rigid structure.

6.4.31 Margin of safety. The margin of safety is the relative measure of the material allowable stress to the maximum working stress. The working stress is based on the appropriate load condition, yield or ultimate load. The allowable stress is based on the material properties including temperature effects.

6.4.32 Maximum expected operating pressure (MEOP). The maximum expected operating pressure is the highest pressure at which a pressure vessel is expected to operate, and it includes the effects of temperature, transient peaks, variations in pressure, and vehicle acceleration.

6.4.33 Mode. The spatial distribution of amplitude and phase characterizing the displacement pattern of a vibrating body undergoing free undamped oscillations and associated frequency.

6.4.34 Narrow-band random vibration. Narrow-band random vibration is random vibration having frequency components only within a narrow band. It has the appearance of a sine wave whose amplitude varies in an unpredictable manner.

6.4.35 Nominal operating pressure. The maximum pressure to which an item is subjected under steady state conditions.

6.4.36 Octave. The interval between two sounds or signals having a basic frequency ratio of two.

6.4.37 Octave band analysis. An analysis made with an array of filters, the center frequencies of which are separated by one octave and the effective bandwidth of which is one octave.

6.4.38 One-third octave. The interval between two sounds or signals having a basic frequency ratio of $2^{1/3}$ (1.26).

6.4.39 One-third octave band analysis. An analysis made with an array of filters, the center frequencies of which are separated by one-third octave and the effective bandwidth of which is one-third octave.

6.4.40 Oscillation. Oscillation is the variation, with time, of the magnitude of a quantity with respect to a specified reference when the magnitude is alternately greater and smaller than the reference.

6.4.41 Panel Flutter. Panel flutter is a self-excited, aeroelastic instability that may occur when a panel is exposed to a supersonic airstream. During flutter the panel oscillates in a direction normal to its plane and the amplitude of motion usually increases until limited by inplane stresses.

6.4.42 Periodic. The recurrence of an oscillation at equal increments of the independent variable.

6.4.43 Power spectral density. Power spectral density is the limiting mean-square value (e.g., of acceleration, velocity, displacement, pressure, stress etc.) of a random variable per unit bandwidth (i.e., the limit of the mean-square value in a rectangular bandwidth divided by the bandwidth, as the bandwidth approaches zero).

6.4.44 Pressure vessels. Pressure vessels are defined as containers that must sustain an internal pressure and include solid rocket motor cases, nozzles, thrust chambers, liquid or gas storage bottles, plumbing, tubing and piping.

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

6.4.46 Random vibrations. Random vibration is vibration whose instantaneous magnitude is not specified for any given instant of time. The instantaneous magnitude of a random vibration is specified only by probability distribution functions giving the probable fraction of the total time that the magnitude (or some sequence of magnitudes) lies within a specified range. Random vibrations contain no periodic or quasi-periodic constituents.

6.4.47 Response. The response of a system is the motion (or other output quantity) resulting from an excitation (stimulus) under specified conditions.

6.4.48 Sonic fatigue. Sonic fatigue is the material fracture caused by the rapid reversal of stresses in the structure which in turn is caused by the fluctuating pressures associated with the acoustic noise.

6.4.49 Sound pressure level. The sound pressure level is 20 times the common logarithm of the ratio of the pressure of the sound to the reference pressure and is expressed in decibels, dB. For air, the reference pressure is 2×10^{-5} N/m^2.

6.4.50 Speeds. Speeds are in knots based upon the international nautical mile.

6.4.50.1 Level flight maximum speed (V_H). The maximum speed attainable in level flight with maximum available thrust.

6.4.50.2 Limit speed (V_L). The maximum attainable speed of the missile commensurate with the operational use of the missile considering shallow and steep dive angles, thrust, and inadvertent upsets from gusts.

6.4.51 Stationary. A statistical term that describes a random process whose spectrum and amplitude distribution do not change with time.

6.4.52 Structural integrity. Structural integrity is the ability airframe to meet structural performance requirements which include strength, durability, damage tolerance and aeroelastic stability.

6.4.53 Transducer. A device capable of converting one form of energy to another. It transduces a mechanical or physical quantity or movement into an analog signal which can be transmitted to a remotely located recorder.

6.4.54 Transient vibration. A temporary vibration of a structural dynamic system, caused by an impulse.

6.4.55 Vibration. Vibration is the oscillation of a body or a particle about a point of equilibrium. A parameter that defines the motion of a dynamic system.

6.5 Subject term (key word) listing.

Aeroelastic stability
Control system tests
Fatigue criteria
Fatigue tests
Ground tests
Load criteria
Missile reports
Missile strength
Missile tests
Repeated load tests
Static tests
Vibration criteria

6.6 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:
Navy - AS
Army - MI

Preparing Activity:
Navy - AS
(Project No. 1410-0113)

APPENDIX A

LABORATORY AND GROUND TESTS

10. SCOPE

10.1 Scope. This appendix contains the requirements which define the laboratory and ground tests required for structural evaluation of guided missiles. The types of testing include, but are not limited to:

a. Design development tests.
b. Pre-production component tests.
c. Static tests-complete airframe.
d. Durability tests-complete airframe.
e. Leakage tests of integral fuel tanks.
f. Structural dynamic tests.
g. Proof tests for flight articles.

This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

10.2 Purpose. The purpose of this appendix is to define the requirements for laboratory and ground structural tests for development and proof-of-design of structural integrity of guided missiles.

20. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

30. REQUIREMENTS

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

30.1.1 Terminology. Definitions and symbols are in accordance with 6.4.

30.1.2 Location of tests. The contract will specify whether the tests are to be performed at Government facilities or at contractor facilities.

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

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

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

30.2.1 Design development tests. These tests are to establish design concepts, and to provide design information and early design validation. Design development, static, and fatigue tests include but are not limited to:

a. Element tests for:

1. Materials selection, including crack propagation, fracture mechanics, and structural allowables.
2. Fatigue spectrum variation effects.
3. Process evaluation, including assessment of finish.
4. Fastener and bonding evaluation.
5. Manufacturing methods evaluation.

b. Structural configuration development tests for:

1. Splices and joints.
2. Panels (basic section).
3. Panels with cutout.
4. Fittings.
5. Critical structural areas which are difficult to analyze due to complexity of design.

30.2.1.1 Design development tests for composites. These tests are used to establish design allowables, verify analysis, and evaluate design details. Additionally, the design development tests are a part of the overall structural certification procedure in that the test results are used in the interpretation of the full-scale airframe static and fatigue test results. Design development tests range in complexity from coupon tests that are used to evaluate material and fastener behavior to full-scale components. Both static and fatigue tests are required in the design development test program.

The actual number and types of tests required will depend upon the missile design. A design development test plan shall be prepared by the contractor and shall require approval by the contracting activity.

30.2.1.2 Design development testing approach for composites. Composite materials exhibit a high degree of mechanical properties variability, an inherent sensitivity to out-of-plane loads, and a multiplicity of potential failure modes. Therefore, a building block approach to design development testing is essential for composite structures. The essence of the building block approach for composites is as follows:

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

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

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

30.2.2 Pre-production component design verification tests. These tests are to allow early verification of the static and fatigue strength capability of final or near-final structural designs of critical structural areas. The pre-production component test program shall be proposed by the contractor and conducted as approved by the contracting activity. These tests shall include but not be limited to splices and joints, fittings, panels, assemblies and full-scale components.

30.3 Full-scale tests. The contractor shall perform tests in accordance with the requirements specified herein, as modified and amplified by the contract or supporting contractual documents, unless the contract specifies that tests will be performed by the Government. Not less than three full-scale laboratory test articles shall be used: one for the static tests, one for the fatigue tests, and one for the dynamic environmental tests.

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

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

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

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

30.3.2 Strength-test structures.

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

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

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

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

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

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

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

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

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

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

30.3.2.4 Test instrumentation.

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

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

30.3.2.4.3 Government tests. If and when tests by the government are required under terms of the contract , the contractor shall consult with the designated test activity to determine the kind and amount of instrumentation required. All such required instrumentation shall be installed by the contractor as contractor furnished equipment and calibrated in accordance with the requirements of 30.3.2.4.2. A detailed description of all instruments and recording devices, methods of calibration, location of instruments, and calibration data for these tests shall be documented in accordance with the provisions of Appendix C.

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

30.3.3 Support during test. Subject to the qualifications of 30.3.4.3, the actual interaction between the component being tested and its adjacent components shall be existent or simulated to the satisfaction of the contracting activity. Structural components may be tested in a jig and loaded by dummy structure only when there is no possibility of interference or deflection that would result in improper loading of the component under test, or adjacent components, and only when the loads and reactions that act on the component being tested are statically determinant or the reactions may be rendered statically determinant by neglecting redundant reactions that do not have a significant effect on loads in the component being tested.

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

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

30.3.4 Simulation requirements.

30.3.4.1 Test loads to be used. Initial static testing shall be performed using analytically derived loads and available wind tunnel data. Loads measured in the flight load surveys program shall be incorporated into the static test program at a suitable time if these loads are higher than the analytical loads to the degree specified by the contracting activity.

30.3.4.2 Distribution of loads. The distribution of loads during the test shall duplicate the actual distribution as closely as possible, except as provided in 30.3.4.3.

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

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

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

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

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

b. Select the critical test conditions based upon consideration of potential failure modes and quantitative "compensation" or "knockdown" factors derived from the environmental compensation design allowables and development test results.

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

30.3.4.6 Effects of internal pressurization. Critical loads resulting from the pressure differentials on pressurized portions of the structure, such as fuel tanks or cells, shall be simulated.

30.3.4.7 Deformation of fairings, covers, locks, and fasteners. During structural tests for flight conditions, the deflection, deformation and operation of movable and removable fairings and covers, and movable mechanical equipment shall be determined with respect to retention in their intended positions without gaping, and operate as intended.

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

30.3.5 Test measurements. All measurements recorded during static and fatigue tests shall be consistent with the test program objectives. Strain, deflection, temperature, and applied load data are generally the required measurements, except for specific deviations requested by the contractor and approved by the contracting activity. Measurements shall be made at representative points and of sufficient quantity and accuracy to verify the assumed load distributions, stress analysis, thermal analysis, and deflections. For static tests conducted in discrete load increments (see 30.3.4.4), measurements shall be made at each increment. For true time flight profile testing, the test data will be recorded on a time basis and with a data sampling rate sufficient to accomplish the above required measurement objectives.

30.3.6 Miscellaneous.

30.3.6.1 Determination of deformation load. Compliance with deformation load requirements of this specification for each structural component shall be demonstrated during each test of that component.

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

30.3.6.3 Test-correction factor. Test-correction factors shall be determined and the test results shall be corrected to represent a structure having mechanical properties in accordance with this specification, and having minimum dimensions.

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

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

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

a. Inability to sustain the applied ultimate test load.

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

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

d. Initiation of a crack in metallic structure or delamination of composite structure in a primary load carrying structural component.

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

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

g. Any event which creates a condition which will not satisfy fatigue, crack growth, or stiffness requirements of 3.6.

h. Any structural anomaly that during a normal service operating condition would necessitate a structural repair to critical safety of flight components.

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

30.4 Static tests.

30.4.1 Test conditions. Static tests shall be performed in accordance with Table I.

TABLE I. Static tests.

Test	Component	Loading condition	Magnitude of load and special requirements
1.	Wing	Most critical bending with associated torsion	Failure: +g
2.	Wing	Most critical bending with associated torsion	Design ultimate: -g (for cruise missiles)
3.	Wing deploying mechanism and supporting structure	Most critical	Failure
4.	Tail fin and supporting structure	Most critical	Failure
5.	Tail fin and supporting structure	Next most critical	Design ultimate
6.	Tail fin deploying mechanism and supporting structure	Most critical	Failure
7.	Canard and supporting structure	Most critical	Failure
8.	Canard and supporting structure	Next most critical	Design ultimate
9.	Canard deploying mechanism and supporting structure	Most critical	Failure
10.	Control system	Most critical	Failure: Test each control subsystem
11.	Control system	Ultimate	Demonstrate that each control subsystem will operate under ultimate load
12.	Body	Most critical vertical bending incl. torsion	Body failure

APPENDIX A

TABLE I. Static tests - Continued.

Test	Component	Loading condition	Magnitude of load and special requirements
13.	Body	Most critical vertical bending incl. torsion in opp. direction to 13	Design ultimate
14.	Body	Most critical lateral bending incl. torsion	Design Ultimate
15.	Body	Critical wing support structure flight load	Body failure
16.	Body	Maximum total tail load	Design ultimate
17.	Body	Most critical launcher imposed load	Design ultimate
18.	Msl launch platform interface structure	Most critical	Failure
19.	Msl launch platform interface structure	Next most critical	Design ultimate
20.	Body fuel tanks	Most critical	Design ultimate
21.	Engine installation	Most critical	Mount failure
22.	Engine installation	Next most critical	Design ultimate
23.	Engine installation	Critical nonflight	Design ultimate
24.	Ducts, ramps, inlets	Critical	Failure
25.	Elements	Test to failure, each structural element for which the allowable stresses are not known and cannot be calculated with reasonable accuracy.	
26.	Fittings	Test to failure, each principal fitting for which the design ultimate strength is not known and cannot be calc. with reasonable accuracy.	
27.	Miscellaneous	Test to failure, miscellaneous assemblies for which the allowable loads are not known and cannot be calculated with reasonable accuracy.	
28.	Hoisting points	Critical	Design ultimate
29.	Jacking points	Critical	Design ultimate

30.4.2 Overpressure, thermal, and gust response. The contractor shall substantiate overpressure, thermal, and gust response limits on critical components by laboratory tests.

30.4.3 Proof tests.

30.4.3.1 Proof tests prior to first flight. Design limit load shall be applied to each control subsystem up to the control surface attach points. Each control subsystem shall be operated through its full travel while supporting design-limit hinge moment. These tests shall be conducted on the first flight article. The primary flight control surfaces shall be tested to design limit load and may be conducted on a flight article, on the static test article, or on appropriate test jigs. Yielding shall not be permitted for captive flight articles.

30.5 Miscellaneous tests.

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

30.5.2 Air loads model wind tunnel tests. Air loads model wind tunnel tests shall be performed early in the design stage to determine external component loads within the missile maneuvering envelope. Loads (shears, bending moments, and torques), hinge moments, and pressure shall be measured. Wind tunnel tests shall also be performed to investigate the characteristics of the oscillatory pressures on critical parts of the missile which will experience aeroacoustic loads.

30.6 Fatigue tests.

30.6.1 Fatigue tests. Unless otherwise specified by the contracting activity, all fatigue tests shall be performed on the fatigue article. Tests shall be continued until the service life with a scatter factor of two is demonstrated, and thence until major, nonrepairable failure occurs, or until a scatter factor of four is demonstrated. The loads shall be increased during the fourth lifetime, if required, to bring on a major failure. Inspections shall be made to detect cracks and to track crack progression. Any crack, delamination or similar defect occurring during the first two lifetimes shall be considered a failure and shall require redesign and retest.

30.6.1.1 Test rigs. The test rig and associated equipment shall be capable of applying not less than 150 percent of design limit load plus environmental factors for the maximum wing deflection condition. This is to provide for possible increases in initial loading requirements and for failing load test capability.

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

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

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

30.6.1.5 Wing and body tests. The wing, body, and wing-carry-through structures shall be tested for captive and flight loads in accordance with the fatigue spectra of 3.6.2. Loads shall be applied to the tail fins, body, and canards to balance the wing loads. The spectra shall be applied in a flight--by-flight sequence. The ground-air-ground cycle shall be accounted for in as realistic a manner as possible. The test loadings for flight conditions shall be those which result in the greatest wing root bending moments and shall include a realistic combination of symmetric and rolling pull-out conditions subject to the approval of the contracting activity.

30.6.1.6 Control fins, canards, and body tests. Additional cycles over and above those applied to balance the wing loads of 30.6.1.5 shall be applied to the control fins, canards, and body, as necessary, to produce a spectrum of control fins, canard, and aft body loads for which the missile is designed. The CG position shall be that which will produce critical loads in control fins, canard, and body.

30.6.1.7 Control system tests. The lateral, directional, and longitudinal control systems which are subject to aerodynamic loads shall be repeat-load tested. An approved rational loading schedule shall be sustained without failure. Particular attention shall be paid to the provisions of 30.3 during these tests.

30.6.1.8 Control system reliability tests. Control surface components and controls shall be fatigue tested to assure structural reliability.

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

30.6.1.9.1 Leakage inspection tests. The contractor shall propose, for contracting activity approval, leakage, repair, and inspection criteria. A method for readily detecting leaks, such as, the use of special dyes in the test fluid, shall be used and accurate records of all leakage, repairs, and inspections shall be kept. The use of a test fluid other than the standard missile fuel shall be contingent upon the results of investigations made by the contractor relative to the deteriorating effects of actual fuel and the test fluid upon the tank sealant. The test fluid shall simulate the viscosity and surface tension of the standard fuel. For purposes of qualification, one service life of fatigue spectrum of 30.6.1.5 shall be sustained without disqualifying leakage or disqualifying repair. No scatter factor is required for this test. If the leakage exceeds the limits specified in the approved criteria or if other normal servicing procedures and repairs become necessary, the qualification portion of the test shall be repeated after redesign of the critical leakage area.

30.6.1.10 Teardown inspection. A complete detailed teardown inspection, including fractographic examination, of test article(s) of 30.6.1.5 through 30.6.1.9 and 30.8.2 shall be accomplished for occurrence of the following events:

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

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

30.7 Structural dynamic tests.

30.7.1 Flutter model wind tunnel tests. Flutter model wind tunnel tests shall be performed early in the design stage to substantiate the specified flutter margins or to substantiate flutter analysis used to perform parameter variation investigations. Transonic models shall be used when limit speed, V_L, is greater than 0.7 Mach number. These tests shall be performed for a sufficient range of design variables to include the design flight envelope, a complete range of weights, and the reduction of stiffness due to maneuvers and thermal environments. As a minimum, the investigation shall include the flutter characteristics of the wing, body, control fins, and control surfaces. Where the flutter speeds are sensitive to variations in one or more parameters, the critical parameters shall be varied to cover the expected range. It shall be demonstrated by suitable analysis and tests that the model dynamically simulates the full-scale missile. If it is determined by analysis, static tests, or ground vibration tests that significant discrepancies exist between the flutter parameters of the model and the missile, additional tests on modified models shall be performed. Before the flutter models are installed inthe wind tunnel,the following testsshall be performedto validate the models:

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

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

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

30.7.2 Compliance tests. These tests shall be made on a flight article prior to first flight of any article. When a change is made that is likely to affect the flutter characteristics of the missile, the tests shall be performed on a flight article incorporating the change prior to flight of any changed article. Tests of 30.7.2.1 through 30.7.2.3 shall be repeated on the last full-scale development (FSD) or first production missile.

30.7.2.1 Mass measurements of control surfaces. The total weight, static unbalance, and mass moment of inertia of all control surfaces about their hinge lines shall be accurately measured and recorded.

30.7.2.2 Free play measurements of control surfaces. The contractor shall demonstrate that the free play for control surfaces are within the limits specified in 3.8.3.3 by making measurements. Incremental loads shall be applied first in one direction, normal to the mean plane of the surface, and then in the opposite direction. Corresponding deflection measurements shall be taken. The total free play shall be determined from a plot of applied load vs measured deflection for both directions of loading. The loads used in the tests shall not cause appreciable structural deformations. These shall be performed prior to or during the ground vibration modal tests.

30.7.2.3 Rigidity tests for control surfaces. Rotational rigidity tests shall be performed on all control surfaces to determine the rigid-body rotation of the surface as a function of applied torque. These tests may be combined with the free play tests specified in 30.7.2.2. The data obtained, together with the measured mass moment of inertia, shall be used to calculate the uncoupled control surface rotational frequency. Both clockwise and counterclockwise moments shall be applied to determine rotational rigidity data. Both symmetrical and antisymmetrical loading conditions shall be employed if the actuating system is such that the frequencies for the symmetrical and antisymmetrical rotational modes differ, as in the case where the left-hand and right-hand elevators are connected by a torque tube. Applied moments to all control surfaces shall be as large as practicable, but shall not cause structural deformations; for horizontal surfaces, the applied moment shall be at least large enough to overcome gravitational effects.

30.7.2.4 Balance weight attachment tests. Tests shall be performed on balance weights, attachments, linkages, and supporting structure to demonstrate that these components can withstand, without failure, the static and repeated inertia load factors specified in 3.8.3.1.3.

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

30.7.2.6 Actuator stiffness tests. Unless specified in the contractor's procurement specification for the actuator's, tests shall be performed to determine the following:

a. Static stiffness and freeplay of the actuator(s) prior to and subsequent to life cycle testing.

b. Actuators(s)' dynamic stiffness over the range of frequencies for all operating modes, including failure modes, of the system.

30.7.3 Missile ground vibration modal tests. Missile ground vibration modal tests shall be performed on the first FSD missile prior to its first flight and on the FSD missile to be used for aeroelastic stability flight tests prior to its first flight. These tests shall determine modal frequencies, mode shapes and node lines and modal damping coefficient for the assembled missile and main missile components. The objective of the test shall be to obtain modal data to verify, and update if required, the analytical modal data which were used in the structural dynamic analyses (flutter analyses, dynamic analyses, flutter models). Where applicable, these tests shall be used to demonstrate that resonant vibrations of the missile components have been avoided when actual missile periodic vibratory excitation loading has been applied. In addition to the conventional ground vibration modal tests on the missile and main missile components, component vibration modal tests for control surfaces, actuating systems, and linkages for balance weights shall also be performed. The pitching and yawing frequencies and mode shapes of the powerplant system, including propeller, rotor, or fan if applicable, shall be measured for use in whirl flutter calculations. These tests shall be repeated on the last FSD or first production missile. The contractor shall notify the contracting activity at least three weeks prior to commencement of these tests, so that the contracting activity representative can witness the tests.

30.7.3.1 Vibration test apparatus.

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

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

30.7.3.2 Missile configuration. The missile shall be equipped with all items having appreciable mass. Whenever practicable, fuel in partially full tanks shall be simulated by a non-flammable liquid. Tests shall be performed for several weight configurations if variable gross weight conditions are possible and if they cause significant changes in the vibration modes and frequencies of the missile.

30.7.3.3 Support of missile. The missile shall be supported so that the rigid body frequencies of the missile on its support are less than one-half the frequency of the lowest elastic wing or body mode to be excited.

30.7.3.4 General vibration test procedure. A vibration pickup shall be placed at an appropriate location and an amplitude-frequency response curve shall be obtained to determine the natural frequencies. The frequency increments selected shall be sufficiently small so that no important resonant peaks are overlooked. The frequency range covered during the vibration tests shall include all modes that may be important with respect to flutter. Alternate pickup and vibrator locations shall be employed as a check since node lines may have passed through the first selected vibrator and pickup locations. At each resonant frequency, amplitude and phase measurements shall be carefully taken at a sufficient number of positions to define the mode of vibration. A complete missile modal survey shall be made. At least 6 spanwise stations and 3 chordwise stations shall be selected in making amplitude measurements perpendicular to the plane of the wing, fin, or stabilizer. Additional chordwise locations will probably be necessary for low-aspect-ratio surfaces. At least six fore-and-aft stations shall be selected in making amplitude measurements in the plane of the wing, fin, or stabilizer. The mode shape measurements obtained shall be plotted as tests progress so that the vibration modes can be evaluated. In addition, the relative orthogonality of the modal data shall be determined as each successive mode is obtained. The single or multiple point random test method may be used to measure the missile vibration modes.

30.7.3.4.1 Correlation of analytical to experimental modes. Analysis shall be performed to validate or modify the dynamic mathematical model such that correlation is achieved between analytical modal parameters (frequencies and mode shapes) and the experimental modal parameters. In addition, orthogonality checks shall be performed to indicate acceptable normal modes whereby the generalized mass matrix obtained from an integrated triple matrix product of the experimental orthonormalized mode shapes and the theoretical or modified mass matrix of the system have off-diagonal elements less than 10 percent of the unit diagonal elements.

30.7.3.5 Missile structural modes usually encountered. The modes excited during ground vibration tests depend on the type of configuration being tested. The vibration modes of a missile that carries heavy masses on the wing, has the stabilizer located near the top of the fin, or in general carries heavy masses on the outer span locations of its main components, will be highly coupled and generally cannot be described except by diagrams which show the vibratory deflection shapes and relative motion and phase of each part of the missile. Missiles that do not carry these masses usually have relatively uncoupled vibration modes which can be described by naming the type of motion which is predominant, such as, wing bending, wing torsion, stabilizer bending, or some other uncoupled mode. In general, the predominant vibration modes of 30.7.3.5.1 through 30.7.3.5.9 shall be obtained.

30.7.3.5.1 Wing group.

30.7.3.5.1.1 Wings.

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

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

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

30.7.3.5.1.2 Wing mounted control surfaces. For all control surfaces on wings:

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

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

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

30.7.3.5.2 Whirl mode flutter. When applicable to the propulsive system used, the engine with propeller/fan blades shall be mounted to a rigid structure. With the exciting equipment attached to the hub, propeller/fan plane natural frequencies in pitch and yaw shall be obtained. Propeller /fan bending and torsion modes shall be obtained.

30.7.3.5.3 Tail group.

a. Body torsion and body side bending, fundamental and higher modes.

b. Body vertical bending, fundamental and higher modes.

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

d. Stabilizer torsion, symmetric and antisymmetric modes.

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

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

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

h. Stabilizer fore-and-aft bending, symmetric and antisymmetric.
i. Elevator rotation about its hinge line, symmetric and antisymmetric.

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

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

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

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

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

o. Rudder spanwise and chordwise bending and torsion.

30.7.3.5.4 Canards.

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

b. Canard torsion, symmetric and antisymmetric modes.

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

d. Canard rocking about its attachment to the body.
e. Canard yawing.
f. Canard fore-and-aft bending, symmetric and antisymmetric modes.

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

30.7.3.5.6 Concentrated balance weights and attachments. The frequencies of mass balance assemblies shall be obtained in both lateral and vertical missile directions.

30.7.3.5.7 Missile rigid body modes on low-frequency suspensions. Missile rigid body modes shall include:

a. Vertical, side, and fore-and-aft translations.
b. Pitching, rolling, and yawing.

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

30.7.3.5.9 Skin panels. The modes and frequencies of skin panels which have been determined to be flutter critical by analysis shall be measured on the missile or in laboratory tests for flutter safety evaluation required by 3.7. The effects of inplane stresses on panel modes and frequencies due to maneuvering loads or aerodynamic heating shall be determined when they are of sufficient magnitude to affect panel flutter speeds. Laboratory vibration tests shall accurately simulate the edge conditions, substructure, and cavity depth of the panel as mounted in the missile.

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

30.7.5 Thermoelastic tests. Thermoelastic tests shall be performed on missile components fabricated from fibrous composites. Thermoelastic tests of components from material other than fibrous composites shall be performed unless the results of analysis required by 30.6 of Appendix C indicate that a critical problem does not exist. Full-scale components of the missile shall be heated and cooled in a manner to simulate the most critical heating and cooling rates and temperatures to be encountered in flight. The components shall be vibrated in their natural modes as the heat is applied and removed so that time histories of the changes in natural frequencies are obtained. These tests shall be performed on fully instrumented components or partial components of a test article having restraint or boundary conditions as if installed on the missile. The test articles shall not have been subjected to yield loads at any time prior to these tests.

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

30.8 Dynamic fatigue tests.

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

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

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

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

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

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

30.8.1.3 Measurement and instrumentation requirements. Microphones shall be used to control and continuously monitor the acoustic environment during the test. Strain gages, vibration transducers, or other instrumentation shall be placed on the specimen in such a manner that the dynamic response of the structure can be measured and the strain distributions can be determined.

Continuous recording and monitoring of the dynamic response is necessary to detect changes which may be indicative of fatigue failures in the structure.

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

30.8.2 Dynamic environmental tests. Vibration environmental ground test and aeroacoustic environmental ground test or a combination of both shall be performed to demonstrate that the structural integrity and operation of the missile is not impaired when excited by the simulated service life vibration and aeroacoustic environmental levels and associated durations.

30.8.2.1 Test article. The test article shall be a full scale functional missile representative of production missiles in all structural aspects.

30.8.2.2 Suspension of test article. The test article shall be suspended by suitable means to assure that the rigid body frequencies of the test article on its suspension are as low as possible but shall be not greater than one-half the frequency of the lowest elastic mode of the test article.

30.8.2.3 Test conditions. The test conditions shall simulate the various predicted service life vibration and aeroacoustic environmental levels and associated durations. When the test duration(s) are less than the missile service life environmental duration(s), the test amplitude(s) shall contain test time compression factors.

30.8.2.4 Instrumentation requirements. Accelerometers shall be used to control and monitor the vibration spectrum at appropriate intervals during the vibration test. Microphones shall be used to control and monitor the sound pressure levels at appropriate intervals during the aeroacoustic test. Strain gages and accelerometers shall be used to measure the dynamic responses of critical structure.

APPENDIX B

STRUCTURAL DEMONSTRATION TESTS

10. SCOPE

10.1 Scope. This appendix contains the demonstration requirements for the evaluation of structural integrity for guided missiles and compliance with the design requirements of this specification. The types of testing include, but are not limited to:

a. Structural loads survey tests
b. Vibration and aeroacoustic environment survey tests.
c. Aeroelastic stability flight tests.

This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

10.2 Purpose. The purpose of this appendix is to define the requirements for ground transportation, launch platform captive and free-flight structural tests for development and proof-of-design of structural integrity of guided missiles.

20. APPLICABLE DOCUMENTS

20.1 Government documents.

20.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document 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.

STANDARDS

MILITARY

MIL-STD-1763 - Aircraft/Stores Certification Procedures.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

20.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this specification to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

PUBLICATIONS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

NACA Report 1178 - Calibration of Strain-Gage Installations in Aircraft Structures for the Measurement of Flight Loads

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

20.2 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

30. REQUIREMENTS

30.1 General requirements. Ground transport, launch platform captive carriage, launch platform captive flight, and free-flight demonstration tests of the missile shall be performed to obtain data to substantiate the missile's structural integrity and to demonstrate compliance with the design requirements of this specification.

30.1.1 Structural demonstration test program. A structural demonstration test program shall be performed by the contractor and approved by the contracting activity. This test program shall be consistent with the missile's mission requirements and may include, but is not limited to the following:

a. Structural loads survey tests during:

1. Captive carriage (for ground and ship launched missiles).
2. Captive flight (for air launched missiles).
3. Carrier suitability (for air launched missiles mounted on carrier based aircraft).
4. Free-flight.

b. Vibration and aeroacoustic environment survey tests during:

1. Captive carriage (for ground and ship launched missiles).
2. Captive flight (for air launched missiles).
3. Free-flight.
4. Transportation.

c. Aeroelastic stability flight tests during:

1. Captive flight (for air launched missiles).
2. Free-flight.

30.1.1.1 Demonstration test planning conferences. At least two months prior to commencement of testing, a conference between the contractor and contracting activity shall be held to review and finalize the details of the structural demonstration program. Upon completion of each structural test phase, additional conferences shall be held to review the test results and establish a Plan of Action and Milestones (POA&M) to correct any deficiencies uncovered during the test demonstrations.

30.1.2 Vehicles for demonstration test program.

30.1.2.1 Launch platform. The ground, ship, and aircraft launch platform(s) shall be as designated by the contracting activity.

30.1.2.2 Transportation container. The transportation container shall be designated by the contracting activity.

30.1.2.3 Test missiles. The contractor shall provide all the structural test vehicles (STVs) and environmental measurement vehicles (EMVs) with installed instrumentation. These test missiles shall be structurally, inertially, and aerodynamically similar to the production missile and to the design presented in the structural analysis, structural dynamic analysis, structural test reports, and drawings. Configuration, material, and quality of workmanship shall be the same as for production missiles. Significant modifications made during the development program of the missile shall be incorporated on the test missiles. Explosive or hazardous materials may be simulated by non-explosive or nor-hazardous materials having similar physical and thermal properties.

30.1.3 Data acquisition system. The test data acquisition system shall be provided by the contractor. The instrumentation, installation, calibration, data-handling equipment, and methods of data reduction and analyses shall be specified by the contractor and approved by the contracting activity and shall provide for the following.

a. For captive flight and free-flight tests (of air launched missiles), a telemetry system shall be employed which shall be capable of transmitting all critical parameters required to ensure safety of flight. In addition to the telemetry system for captive flight tests, a launch platform on-board hard wired system may be used to record continuous test data signals.

b. For captive carriage tests (of ground and ship launched missiles), a launch platform hard wired system shall be used to record continuous test data signals.

c. Measurements shall be made with calibrated transducers, recorders, and associated electronic equipment. The output of the transducers shall be permanently recorded for post flight analysis.

d. The dynamic range, frequency response, linearity, etc., of the data acquisition system shall be compatible with the intended application of the data. The data sample length at each steady test condition shall be of sufficient duration to permit an adequate statistical analysis.

30.1.3.1 Instrumentation requirements. The contractor shall install and calibrate the instrumentation on the STV's and EMV's required for the test program. The contractor shall also be responsible for recording, telemetry, data reduction, and data analysis of the required measurements.

30.1.3.1.1 Types of instrumentation. Test instrumentation shall consist of a sufficient number of transducers to define the acoustic environment, vibration response characteristics, aeroelastic stability, structural loading, airload distribution, temperature distribution, as well as other instrumentation such that the data obtained will allow valid comparisons of the test data with the appropriate structural analyses, laboratory test results, and design conditions. Test instrumentation may consist of, but not limited to, microphones, accelerometers, temperature measuring devices, strain gages, pressure transducers, motion sensors, and calibrated load bridges (shear, bending, and torsion).

30.1.3.1.2 Test condition parameters. Instrumentation to measure the general flight parameters listed below shall be installed. The data obtained from measurement instrumentation shall be used to show compliance with test requirements.

a. Airspeed and Mach number.
b. Pressure altitude.
c. Angles of attack, sideslip, and bank.

d. Normal, lateral, and longitudinal linear accelerations referenced at the center of gravity of the missile.

e. Roll, pitch, and yaw angular rates and accelerations referenced at the center of gravity of the missile.

30.2 Detail requirements.

30.2.1 Structural loads survey tests. Structural loads survey tests shall be performed for the test conditions of 30.2.1.2 to measure loads of the missile structure. These tests data shall be used to substantiate the structural integrity of the missile for critical loading conditions and compliance with the design requirements of this specification.

30.2.1.1 Instrumentation requirements. Missile structural loads shall be measured with strain gages and calibrated load bridges. Airload distributions shall be measured with pressure transducers. Accelerometers, thermal instrumentation and missile/aircraft interface instrumentation (for air launched missiles) shall also be provided. The loads instrumentation shall be capable of measuring shear, bending moment and torsion for the missile body and primary aerodynamic surfaces of the missile.

a. Strain gages: The missile shall be instrumented with sufficient calibrated load bridges to measure wing, fin and body shear, bending moments, and torsion. A set of backup calibrated strain gages shall also be installed, but not wired to the recording device. All calibrations shall be performed to 100 percent of captive flight design limit load and 75 percent of free-flight design limit load. The number of calibration load conditions shall be as required to derive load coefficients in a method similar to NACA Report 1178 and demonstrate good agreement between measured and applied loads for all significant combinations of applied shear, bending moment, and torsion. In cooperation with the appropriate Government Test Activity (GTA), the contractor shall develop a check calibration condition which will be performed at the contractor facility and repeated at the test site prior to data acquisition. This condition will be applied at a load level consistent with the capabilities of the GTA. If missile configuration makes calibrated load measurement impractical, direct strain measurement may be utilized with contracting activity approval. Areas of critical margins are to be instrumented for strain. These strain gage locations should correspond with static test instrumentation. Strain gages shall also be located to obtain representative stress/-strain distributions for comparison with analysis.

b. Accelerometers: The load instrumentation shall include sufficient accelerometer coverage (in addition to the requirements specified in 30.1.3.2) over the STV to determine the inertia load distribution required to correlate with and substantiate the static and dynamic analysis. Accelerometers shall be placed at the following locations, as applicable:

1. Vertical on both the right and left wing tips and midspan region.

2. Vertical on both right and left horizontal tips.

3. Lateral on the vertical tail tip(s).

4. Vertical and lateral within 12 inches of the nose and tail of the missile body.

5. Control surfaces.

c. Missile/aircraft interface: Instrumentation shall be installed to determine the loads at the launch platform interface (missile to launcher, launcher to pylon, missile to pylon, pylon to aircraft) to substantiate the structural integrity of the missile and missile/aircraft combination. Load measurements shall include, but not be limited to those required to determine vertical, side, and drag loads; pitch, yaw, and roll moments; and missile interface hook and sway brace loads and moments. The following instrumentation may be used, as applicable, to measure these loads:

1. Strain gages.

2. Calibrated strain gages to measure shear, bending moment, and torsion.

3. Accelerometers to measure load factors.

4. Pressure transducers.

d. Temperature transducers: The STV thermal instrumentation shall consist of thermocouples, thermistors, or other devices to measure the missiles external skin heat transfer rate distribution and internal component(s) temperatures. These devices shall be located such that representative temperature and heating distributions are obtained. The instrumentation shall be of sufficient density to detect hot and cold spots. An adequate distribution of internal temperature measuring devices (such as thermocouples or thermistors) shall be located in and around the critical components or structure subject to temperature restrictions.

e. Other instrumentation: Instrumentation shall be installed to measure the forces, position, and hinge moment of control surfaces.

30.2.1.2 Test conditions.

30.2.1.2.1 Captive carriage. For ground and ship launched missiles, structural load measurements shall be made on the STV while retained on the launch platform(s). The actual selected test parameters shall be consistent with the missile/launch platform combination mission requirements.

30.2.1.2.2 Captive flight. For air launched missiles, the STV shall be carried on each designated aircraft's weapon station (if carried on more than one). Structural measurements shall be made for captive flight operating conditions. The operating conditions shall include take-off, climb, cruise flight, maneuvering flight, adjacent store release and jettison, and descent. A load survey shall be performed to determine load trends for critical maneuvers including pull-ups, pushovers, rolling maneuvers, and lateral directional maneuvers. Both abrupt and steady maneuvers shall be performed. The loads survey shall be performed for all critical store combinations and loadings. The survey shall be performed at a minimum of three altitudes and eight Mach numbers at each altitude. The flight altitudes and speeds shall be selected to include the minimum altitude at which the maximum design Mach number can be obtained, the minimum altitude at which transonic effects begin to occur, and the minimum altitude at which the maximum dynamic pressure can be obtained, consistent with the design limit speed envelope of each aircraft/missile combination and safety of flight. The minimum altitude need not be lower than 2,000 feet above the surface or terrain.

30.2.1.2.3 Carrier suitability. Carrier suitability tests shall be performed in accordance with MIL-STD-1763 for air launched missiles carried on carrier-based aircraft. Carrier suitability testing is required to test the STV under dynamic conditions of actual catapult launches and arrested landings to substantiate the missile's compatibility with the aircraft. The STV shall be mounted on the most critical armament station of the test aircraft designated by the contracting activity. Carrier suitability shall be demonstrated on each designated aircraft type. Since the carrier suitability tests require use of government facilities, the GTA shall exercise technical control over the test facility during the demonstration tests.

30.2.1.2.4 Free-flight. Free flight tests shall be performed with test data taken at predetermined test points defined by Mach number, altitude, and maneuver. The flight profile (altitude and speed) shall be programmed to include the minimum altitude at which the maximum design Mach number can be obtained, the minimum altitude at which transonic effects begin to occur and the minimum altitude at which the maximum dynamic pressure can be obtained consistent with the design limit speed envelope of the missile. Missile maneuvers shall be programmed to apply critical loads to the airframe. These selected test parameters shall be consistent with the missiles mission requirements. For these tests, missile launch/ejection shall be considered part of free-flight and loads shall be measured.

30.2.2 Vibration and aeroacoustic environments survey tests. Vibration and aeroacoustic environments survey tests shall be performed for the test conditions of 30.2.2.2 to measure the dynamic response characteristics of the missile structure due to dynamic load inputs, and to measure the aeroacoustic environment, both internal and external. Measurement data shall be used to demonstrate that the airframe structure, structural components, and equipment do not experience excessive vibration which would contribute to structural fatigue or equipment malfunction. Flight test data shall also be used to:

a. Verify and update the predicted design vibration, aeroacoustic, and shock environments.

b. Validate analytical design data, and together with analytical, laboratory and ground test data substantiate that fatigue failures of the airframe structure and structural components will not occur for the service life of the missile.

c. Demonstrate each equipment is not subjected to vibration, aeroacoustic, or shock environments greater than the corresponding levels prescribed in the equipment specifications.

30.2.2.1 Instrumentation requirements.

a. Accelerometers shall be installed on the EMV to define the vibration and shock response characteristics of the missile. Accelerometers and mounting brackets or blocks shall not alter the response characteristics. The EMV shall be divided into zones (such as forward, center and aft body, wings, and control surfaces) and measurements shall be made at several locations in each zone. Emphasis shall be placed on locations where high amplitudes of vibration are expected to occur or where failures could be critical with respect to mission completion.

b. Dynamic pressure transducers shall be mounted on and within the EMV to define the aeroacoustic environment. Selection of these transducers and mounts shall preclude transducer response to mechanical vibrations.

30.2.2.2 Test conditions.

30.2.2.2.1 Captive carriage. For ground and ship launched missiles, vibration measurements shall be made on the EMV while on the launch platform(s). The actual selected test parameters shall be consistent with the missile/launch platform combination mission requirements.

30.2.2.2.2 Captive flight. For air launched missiles, the EMV shall be carried on each designated aircraft's weapon stations where the dynamic environment will be most severe. Vibration and aeroacoustic measurements shall be made for ground and captive flight operating conditions. The operating conditions shall include ground engine run-up to maximum thrust, taxi, takeoff, climb, cruise flight, and maneuvering flight with at least five speed increments at three altitudes, approach glide, and landing.

a. Flight altitudes: The flight altitudes and speeds shall be selected to include the minimum altitude at which design Mach number can be obtained, the minimum altitude at which transonic effects begin to occur, and the minimum altitude at which the maximum design dynamic pressure can be obtained consistent with the design limit speed envelope of each aircraft/-missile combination and safety of flight. The minimum altitude need not be lower than 2,000 feet above the surface or terrain.

b. Flight maneuvers: The flight maneuvers shall include symmetrical pull-up and pushover, wind-up and wind-down turns with at least five load factor increments, sideslip and split "S" at cornering speeds (maximum load factor to maximum angle of attack).

c. Vibration and aeroacoustic measurements shall also be made under the conditions listed below when they apply to the particular aircraft/missile combination being tested. The actual selected test parameters shall be consistent with the aircraft/missile mission requirements.

1. Operating afterburners and assist takeoff units.

2. While opening and with open weapon bays and deploying missile trapeze or pallets.

3. Flight near stalling speeds and at transonic speeds near Mach one.

4. During rapid ground accelerations or decelerations, such as catapult launch and arrested landings.

30.2.2.2.3 Free-flight. Free-flight test data shall be taken at predetermined test points, defined by Mach number and altitude. The flight altitude and speed test points shall be selected to include the minimum altitude at which the maximum design Mach number can be obtained, the minimum altitude at which transonic effects begin to occur, and the minimum altitude at which the maximum design dynamic pressure can be obtained consistent with the design limit speed envelope and safety of flight. Actual selected test parameters shall be consistent with the missile mission requirements.

30.2.2.2.4 Transportation. Transportation environmental survey tests shall be performed with the EMV inside its container. Vibration measurements shall be made on the EMV to substantiate that the missile will not be subjected to vibration and shock environments greater than the corresponding predicted environments used in the design of the missile. The mode(s) of transportation to be used during these tests shall be designated by the contracting activity, and may include railroad, truck, and air transportation, shore to ship transfer, and ship to ship transfer.

30.2.3 Aeroelastic stability flight tests. Aeroelastic stability flight tests for both the captive flight (for air launched missiles) and free-flight conditions shall be performed to measure the dynamic response (frequencies and damping) trends for substantiating that the missile is free from aeroelastic instabilities, including sustained limit amplitude instabilities throughout the free and captive design limit speed flight envelopes. In addition, flight test data shall be used to validate analytical design data and, together with analytical, laboratory, and ground test results, shall demonstrate that the design requirements of this specification have been satisfied for all configurations of the missile.

30.2.3.1 Modal excitation. A method of inflight vibration exitation shall be employed which is capable of exciting the structural modes that contribute to the critical flutter conditions.

30.2.3.2 Instrumentation requirements. Transducers shall be installed on the STV's to define and detect the expected modes of vibration, including frequencies and damping characteristics. As a minimum, accelerometers and motion sensors shall be installed and vibration response measurements made at the following locations:

a. Vertical (forward and aft) on both the right and left wingtips, longitudinal on one side only).

b. Vertical (forward and aft) on both right and left horizontal tail tips, longitudinal on one side only.

c. Lateral (forward and aft) on vertical tail tip(s).

d. Relative rotational pickups shall be used to determine the motion of each control surface.

e. Vertical and lateral within 12 inches of the nose and tail on the missile body.

30.2.3.3 Test Conditions.

30.2.3.3.1 Captive flight. Captive flight (for air launched missiles) tests shall be performed with test data taken at predetermined test points, defined by Mach number and altitude, in a prescribed order of ascending critically. The test points shall be selected at increasing Mach numbers up to design limit speed in suitable increments at constant altitude. Three or more altitudes, tested in descending order, shall be selected to include the minimum altitude at which the maximum design Mach number can be obtained, the minimum altitude at which transonic effects begin to occur, and the minimum altitude at which the maximum design dynamic pressure can be obtained consistent with the design limit speed envelope(s) and safety of flight. The minimum altitude need not be less than 2,000 feet above the surface or terrain. The tests shall be performed in suitable increments for safety and shall proceed after the dynamic test engineers at the ground station have determined from near-real-time data analysis that it is safe to do so.

30.2.3.3.2 Free-flight. Free-flight tests shall be performed with test data taken at predetermined test points defined by Mach number and altitude. The flight profile (altitude and speed) shall be programmed to include the minimum altitude at which the maximum design Mach number can be obtained, the minimum altitude at which transonic effects begin to occur, and the minimum altitude at which the maximum design dynamic pressure can be obtained consistent with the design limit speed envelope. Flight test data shall also be taken at high altitude where certain types of control surfaces are found to be more critical. These selected test parameters shall be consistent with the missiles mission requirements.

APPENDIX C

ANALYSES, DATA, AND REPORTS

10. SCOPE

10.1 Scope. This appendix contains the requirements for data necessary to show compliance with the design and test requirements of this specification and to show the dependent relationship between the schedules for structural engineering analyses and testing and schedules for manufacturing.

This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS

20.1 Government documents.

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

SPECIFICATIONS

MILITARY

MIL-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.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

20.1.2 Other Government documents and 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

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 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 officer.)

20.2 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

30. REQUIREMENTS

30.1 Submittal, format, and revision.

30.1.1 Submittal. The required data items for acquisition of guided missiles 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 of this appendix (see 6.3).

TABLE I. Latest initial submittal date.

Report	Applicable paragraph	Date (see footnotes 1/ and 2/)	Applicable DID no. (see 6.3)
Sched of structural work	30.2	90 days after ATP/DOC	DI-P-21461A
Structural description	30.3	90 days after ATP/DOC	DI-S-3595/ S-123-1
Structural design loads criteria	30.4.1	90 days after ATP/DOC	UDI-S-23272C
Fracture control plan	30.4.2	90 days after ATP/DOC	UDI-S-23272C
Aeroelastic stability program	30.4.3	90 days after ATP/DOC	UDI-S-23272C
Structural design loads analyses	30.5	60 days prior to structures CDR. Revision 60 day after completion of applicable flight tests	UDI-S-21462A
Aeroelastic stability analysis	30.6	Initial report: 30 days prior to structure CDR Intermediate revision: 30 days after first flight Final revision: 60 days after completion of applicable flight tests	UDI-S-23272C
Internal loads methodology	30.7.1	90 days after ATP/DOC	UDI-S-23272C
Structural analysis	30.7.2	30 days prior to structures CDR Final rpt. revision: 60 days after completion of applicable flight tests	UDI-S-21462A

TABLE I. Latest initial submittal date - Continued.

Report	Applicable paragraph	Date (see footnotes 1/ and 2/)	Applicable DID no. (see 6.3)
Air loads model wind tunnel test	30.8.1	60 days after completion of each tunnel entry.	DI-T-2072
Flutter model wind tunnel test	30.8.2	60 days after completion of each tunnel entry	DI-T-2072
Airframe rigidity tests	30.8.3	see footnote 3/	DI-T-2072
Dynamic environmental test	30.8.4	60 days after completion of applicable captive tests	DI-T-2072
Descr. of test articles	30.9.1.1	90 days after ATP/DOC	DI-NDTI-80566
Static test plan	30.9.1.2	90 days prior to start of testing	DI-T-21463A
Fatigue test plan	30.9.1.3	90 days prior to start of testing	DI-NDTI-80566
Sonic fatigue component test plan	30.9.1.4	90 days prior to start of testing	DI-NDTI-80566
Structural design, development and preproduction verif. test plan	30.9.1.5	90 days after ATP/DOC	DI-NDTI-80566
Static test progress	30.9.2.1	90 days after ATP/DOC	DI-T-2072
Fatigue test progress	30.9.2.2	90 days after ATP/DOC	DI-T-2072
Static test	30.9.3.1	90 days after completion of each test	DI-T-2072

TABLE I. Latest initial submittal date - Continued.

Report	Applicable paragraph	Date (see footnotes 1/ and 2/)	Applicable DID no. (see 6.3)
Static design development and preproduction component design verification test	30.9.3.1.1	30 days after tests	DI-T-2072
Fatigue test	30.9.3.2	90 days after completion of each test	DI-T-2072
Fatigue development test	30.9.3.2.1	60 days after completion of each test	DI-T-2072
Fatigue test teardown inspection	30.9.3.2.2	90 days after completion of full scale cyclic test teardown inspection	DI-T-2072
Sonic fatigue component test	30.9.3.3	60 days after completion of each test	DI-T-2072
Material substantiating data and analysis	30.10	30 days prior to structure CDR	DI-T-2072
Aeroelastic stability, vibration and aero-acoustic flight test planning	30.11.1	90 days prior to start of instrumentation on missile	DI-NDTI-80566
Structural flight test planning	30.11.2	90 days after ATP/DOC	DI-NDTI-80566
Flight load survey instrumentation calibration planning	30.11.3	45 days prior to start or instrumentation	DI-NDTI-80566
Structural captive and flight test program	30.11.4	90 days prior to flight of test missile	DI-S-30729

TABLE I. Latest initial submittal date - Continued.

Report	Applicable paragraph	Date (see footnotes 1/ and 2/)	Applicable DID no. (see 6.3)
Aeroelastic stability flight test letter	30.11.5.1	Two weeks after each missile flight test	DI-T-2072
Vibration and aero-acoustic flight test letter	30.11.5.2	Two weeks after each missile captive or flight test	DI-T-2072
Aeroelastic instability, vibration or sonic fatigue occurrence	30.11.5.3	Immediately	DI-RELI-80253
Vibroacoustic environment measurement	30.11.5.4	60 days after completion of tests	DI-MISC-80653
Flight load survey instrumentation and calibration progress	30.11.6	30 days after calibration is completed	DI-T-30728
Flight load survey instrumentation and calibration	30.11.7	60 days after completion of calibration	DI-T-30728
Flight load operations survey data	30.11.8	60 days after completion of tests	DI-T-30729
Dynamic response test	30.11.9	120 days after completion of tests	DI-T-30730
Structural flight test anomaly and failure	30.11.10	30 days after occurrence	DI-RELI-80253
Strength summary and operating restriction	30.12	30 days prior to request for authorization for first flight (footnote 2/)	DI-S-3589/S-111-1
Structural redesign	30.13	60 days prior to a proposed redesign production change	DI-S-30590

TABLE I. Latest initial submittal date - Continued.

Report	Applicable paragraph	Date (see footnotes (see Note 1 and Note 2)	Applicable DID no. (see 6.3)
Air-Vehicle structural integrity program (ASIP) master plan	30.14	90 days after ATP/DOC	DI-S-3570A
Structural manual	30.15	90 days after ATP/DOC	UDI-S-23272C
Structural dynamic manual	30.16	90 days after ATP/DOC	UDI-S-23272C
Maintenance instructions for control surfaces	30.17	Concurrent with delivery of first production missile	UDI-S-23272C

1/ Date of authorization-to-proceed (ATP) shall apply if such authorization is granted prior to date of contract (DOC).

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

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

30.1.2 Form of reports. Each report shall be securely bound in a loose leaf style with stiff cardboard covers 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 8-1/2 inches and not more than 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, missile component, or member. Each page shall bear the page number, report number, model designation, and date. Reports shall consist of the following parts:

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

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

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

b. Guided missile 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.

30.1.2.3 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.

30.1.2.4 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.

30.1.2.5 Symbols. Symbols, abbreviations, and units, if they do not appear in standard lists of missile nomenclature, shall be defined in a table of symbols. The units of all quantities shown in the reports shall be noted.

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

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

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

30.1.2.9 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, information shall be included to explain the methods used and the results obtained. Diagrams or sketches showing points of application of loads shall be included.

30.1.2.10 Conclusions. Conclusions are required for all reports with the exception of the design loads report.

30.1.3 Missile modifications. Modifications of the missile 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.

30.1.4 Substantiation of related models. Contract documents shall define by reference to this specification, the data required for substantiation of prototype and production missiles. For related models, revised or added pages shall 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.

30.1.5 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 30.1.2.2.

30.1.6 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.

30.2 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-day 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 appendix.

b. By major structural components, dates for:

(NOTE: Availability in the following means available at the contractor's engineering facility for review by representatives 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 for release for demonstration.
h. Date of first delivery to contracting activity for flight tests.
i. Date of first delivery to service operating activities.

j. The code used to identify captive and flight loading conditions. This identification shall correlate conditions selected for analyses and tests with those of this specification.

30.3 Structural description report. This report shall contain reduced size drawings, perspectives, sketches, or other data, as necessary, to permit a 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, 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 missile. 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 missile, 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.

30.4 Structural design loads criteria and program reports. The reports of 30.4.1 through 30.4.3 shall consist of that information necessary to detail the design criteria for determining all structural design loads. All deviations from 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 this report. This report shall not repeat the explicit design requirements of this specification or the detail specification, but shall expand or amplify generalized requirements as contractually necessary and appropriate to make the requirements specifically applicable to the missile under acquisition. Where the requirements grant the contractor an option or alternative in the method of compliance therewith, the report shall state the option or alternative chosen.

30.4.1 Structural design loads criteria report. This report shall include, but not limited to, sections a through h.

a. Handling and transportation design loads criteria.
b. Launch platform interface design loads criteria.
c. Launching design loads criteria.
d. Transition from launch to free-flight design loads criteria.

e. Free-flight design loads criteria: This section shall present all design weights specified in this specification 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. This section shall set forth the specific design conditions selected for analysis, 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 shall be included. A range of KEAS curves and V_H and V_L curves shall be superimposed, and the design gust load factor shall be shown.

f. Control system design loads criteria: This section 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.

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

1. Missile weights and loading configurations in terms of fuel and payload.

2. Mission and maneuver analyses.
3. Maneuver loads spectra and the derivation thereof.
4. Gust loads.

5. Airspeeds and maneuver load factors to be used for design of component parts of the airframe, such as flight control systems.

6. Ground operations including, when applicable, catapult and arrestments.

h. Vibroacoustic criteria and program: This section shall include a list of actions and dates pertinent to the airframe structural dynamic loads and sonic 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 sonic fatigue component tests, as follows:

1. Aeroacoustic environment prediction: This section shall include, but not be limited to, the following:

(a) Three views of the missile with major dimensions and surface areas identified.

(b) A list of the significant aeroacoustic load sources. This list shall include, but not be limited to, the following:

(1) Boundary layer pressure fluctuation noise.
(2) Wake noise.
(3) Cavity noise.
(4) Base pressure fluctuation noise.
(5) Noise caused by oscillating shocks.
(6) All other noise of aerodynamic origin that may be associated with unsteady flow phenomena.

(c) The temperature-humidity environment to be assumed in aeroacoustic loads calculation, and definition of regions of structure experiencing high temperatures.

(d) A tabular enumeration and its derivation of time duration and associated temperatures of acoustic loads for the specified service life of the missile. The tabulation shall show 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 (such as wind tunnel models, and rocket models) shall be discussed in detail.

(g) Plans for environmental measurements of airframe structural aeroacoustic loads during all captive operations and missile flight.

2. 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.

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

(c) Techniques to be used for designing sonic-fatigue strength into structural components. The bases for their proposed use shall also be stated.

(d) The method in which combined environmental (such as temperature, creep, corrosion, pressure differentials, and load factor) effects will be accounted for shall be stated.

3. Sonic fatigue component tests: This section shall include, but not be limited to, the following:

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

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

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

4. Vibration environments prediction section. This section shall include, but not be limited to, the following:

(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 missile for each different vibration environment to be encountered during captive and flight operations.

(c) Description and analysis, where applicable, of anti-vibration provisions (including anti-vibration 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 captive and flight operations.

5. Dynamic environment tests: This section shall include, but not be limited to, a description of the test facilities and test equipment that are available and their characteristics, capabilities and limitations.

30.4.2 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 missile. The plan shall provide for the establishment of a fracture control board to provide an organizational focus to supervise the implementation 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.

30.4.3 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 missile and determining vibration modes.

b. Methods of representing aerodynamic forces, including compressibility, control surface 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.

e. The substantiation 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.

30.5 Structural design loads analyses report. This report shall present in detail the magnitudes and distributions of all applied structural design loads. The development of any new or unconventional methods of determining 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 this report. This report shall include, but is not limited to, the following:

a. Handling and transportation loads.
b. Launch platform interface loads.
c. Launching loads.
d. Transition from launch to free-flight loads.
e. Free-flight loads analysis: This section shall present at least the following information:

1. References to detailed aerodynamic and other data used to determine the magnitude and distribution of aerodynamic loads.

2. 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. List of missile weights, speeds, altitudes, load factors, load distributions, and other pertinent conditions that were investigated with sufficient amplifying information to show that such investigations covered all critical loads.

4. 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.

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

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

f. Control system loads: This section 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.

g. Repeated loads. This section shall present the net shear, bending moment, and torsion distributions for the various components of the missile 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:

1. Distribution of applied in-flight loads at the wing, fuselage, control surfaces, and other surfaces, including missile weight, altitudes, speed, symmetrical and unsymmetrical load factors.

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

h. Vibroacoustic environment analysis. This section shall consist of an initial analysis report and final analysis which shall be submitted as a revision to the report.

1. Initial vibroacoustic environment analysis. This initial submittal of the analyses for aeroacoustic and vibration environments of the airframe structure shall include the requirements of (a) and (b).

(a) Aeroacoustic loads environment.

(1) A complete list of the important noise sources associated with missile captive and flight operations.

(2) A concise description of all aeroacoustic load prediction methods employed, including testing of acoustic models.

(3) 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.

(4) The effects of variation in engine thrust, missile speeds, and other important operating variables on these aeroacoustic load characteristics.

(5) Isobel (overall and one-third octave bands) contour plots of the aeroacoustic loads superimposed on the external surface configuration of the missile for various important captive and flight modes.

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

(7) For structures that are aerodynamically or otherwise heated, the structural temperatures associated with the aeroacoustic loads shall be included.

(8) Exposure time at the various aeroacoustic load levels for the service life of the missile. Incorporate the results from mission profile analysis.

(b) Vibration and other oscillatory loads environments.

(1) A description of the vibration prediction methods employed. Any vibration measurements made during the development program of the weapon system, 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.

(2) 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 frequency), the one-third octave band load levels, and the frequencies of discrete components of the spectrum, to be encountered by the missile while captive and in free-flight, at various locations on the airframe structure.

(3) The effects of variation in engine thrust, missile speed, dynamic pressure, load factor, and other important operating variables on these vibration environment characteristics.

(4) A description and analysis of the effect, where applicable, of the anti-vibration 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.

(5) Exposure time at the various vibration levels for the service life of the missile. Incorporate the results from mission profile analysis.

2. Final vibroacoustic environment analysis: This report shall revise the initial data to reflect the results of all airframe structural aeroacoustic and vibration environment tests, both captive flight and free-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 missile components have not been exceeded, and that the minimum damping requirement is met for all significant airframe dynamic response modes.

30.6 Aeroelastic stability analysis reports. These reports shall consist of an initial analysis report, an intermediate analysis report, and a final analysis report.

a. Initial aeroelastic analysis report. As a minimum, this report shall include the requirements of 30.6a1 through 30.6a4.

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. These flutter analyses shall be presented for several Mach numbers at each altitude. In addition, the analyses results shall be presented for 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 this specification. 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 missile. The report shall include, at least, the results of the three-dimensional flutter analyses described in 30.6a1a through 30.6a1j. 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 missile 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.

(a) Wing flutter analyses: Both symmetric and antisymmetric modes shall be investigated for various CG positions. Significant fuselage, empennage, and control system modes shall also be included.

(b) Empennage flutter analyses: Both symmetric and antisymmetric 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.

(c) 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.

(d) Other surfaces which are exposed to the air stream: Flutter investigations shall be performed for missile components, other than control surfaces, which are exposed to the air stream. These include but are not limited to canard surfaces, scoops, booms, and strakes.

(e) Deployable-surface flutter analyses: Flutter analysis shall be performed for missiles of which wings and/or control surfaces are deployed during the transition from the launch platform to free-flight. Both symmetrical and anti-symmetrical modes shall be investigated. As a minimum deployable-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.

(f) Aeroservoelastic analyses: The dynamic characteristics of control surface actuating systems shall be included in the flutter analyses. The effect of high temperatures on the dynamic characteristics of the actuating systems, including the hydraulic fluid (if applicable), shall be included.

(g) 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 missiles which are deemed to be most susceptible to chordwise mode flutter.

(h) 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 missile deemed most susceptible to flutter. When panels may be subjected to in-plane compressive stresses due to missile 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 missile attitude or surface shape.

(i) Whirl mode flutter: When applicable, whirl mode instability analysis shall be performed for the total and complete propulsion system plus the missile system. The analysis shall include, but not be limited to, the following:

(1) Airframe modes.
(2) Engine modes and engine mount-isolator modes.
(3) Power transmission system modes including drive shaft modes.
(4) The modes of fans or any other blades.
(5) The fan or all other blade aerodynamic and dynamic loads, such as gyroscopic loads.
(6) All accessories for all systems that are considered important.

(j) Fail safe: Analyses shall be made that assume failures of various components of the missile that are significant from a flutter standpoint. As a minimum, the failure, malfunction, or disconnection of any single element of the flight control system, or in any flutter damper connected to a control surface shall be analyzed.

2. Divergence analyses section: Divergence analyses shall be performed for all wings, stabilizers, and fins. Divergence analyses shall also be performed for long slender bodies having significant lift or forward located lifting surfaces, and all-movable control surfaces and their actuating systems. The divergence analysis shall determine the divergence speed (or dynamic pressure), the load amplification, and corresponding elastic deformation and loads at the design limit speed to show that the structural design limit loads will not be exceeded. 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 30.6a1. 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 this specification. 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. 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 missile design limit speed in knots equivalent airspeed and Mach number versus altitude.

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

(c) Blown-up drawing of missile 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 missile.

(e) For flutter dampers, a description of the method of operation, installation in the missile, design values intended to meet damping versus frequency, and results of laboratory qualification tests of the flutter dampers.

(f) If the NASTRAN computer program is used for the finite element model and vibration modal analyses, a listing of the input data.

(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 stiffness.

(h) For control surfaces, 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 stiffness of all actuators.

(k) Schematic diagram of the missile flight control systems, (longitudinal control system, lateral control system, directional control system). Also a detailed explanation of how the hydraulic (including redundancy), electrical, and power supply, as applicable, is used to actuate these various control systems.

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

(m) For concentrated masses such as engines, weight, CG location, mass moments of inertia, and stiffness of the supporting structure.

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

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

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

(b) Plots of calculated normal modes (mode shapes and node lines), frequencies and generalized masses of the fully coupled missile.

b. 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 substantiation 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, stiffness, and free-play, and modification of aerodynamics based on wind tunnel tests (both flutter model and steady state 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 be limited to, the following:

1. A tabular summary of all flutter analyses performed indicating for each analysis the modes used, the aerodynamic theory representation, 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.

2. The flutter summary plot(s) shall be updated showing predicted flutter speed boundaries and missile 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 missile lifting surfaces.

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

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

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

6. 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 to include the lower stiffness levels at compatible flight conditions where flutter margins are minimum.

7. Addenda to this report shall be submitted for parametric variation flutter analyses performed to determine sensitivity of the flutter speed margins of the missile due to variation of mass properties of control surfaces. These parametric study results shall be presented for all control surfaces and other controls exposed to the airstream.

8. Recommended missile configurations to be evaluated during the aeroelastic stability flight test demonstration.

c. Final aeroelastic analysis report: This report shall contain data demonstrating flutter and divergence safety requirements up to 1.15 V_L for the missile. 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 3.8.1 required damping coefficient, "g", margin exists up to V_L and to substantiate that the 3.8.1 required flutter and divergence margins of safety beyond V_L exist. 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.

30.7 Internal loads analysis reports.

30.7.1 Internal loads methodology. The methodology to be used for determining the internal load distribution shall be prepared for contracting activity acceptance. This 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.

30.7.2 Structural analysis report. The structural analysis report shall contain the following sections:

a. Stress analysis: Stress analysis shall consist of those data that relate to the analytical determination of the ability of the missile structure to support critical loads and meet the specified strength requirements. This section shall include curves, tables, or both, giving the particular component detail resultant loads, shears, bending moments, and torsional moments. In general, the stress analysis section 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. Sketches shall be provided throughout the analysis to minimize the necessity of referring to drawings of the missile. 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. 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. 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 sub-sections for the following major structural groups:

1. Wing, including all attachments and actuating structure, and movable control surfaces.

2. Fuselage except wing and control surface attachments.

3. Fixed and movable control surfaces, their attachments, and actuating structure.

4. Control system including actuators.

5. Miscellaneous structure.

b. Fatigue analysis: Fatigue analysis shall provide verification of the ability of the airframe to withstand the fatigue design load spectra of section 3.6.1 for the required life. All data necessary for this determination shall be included 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.

c. Damage tolerance analysis: The damage tolerance section shall contain the analytical verification of the damage tolerance characteristics of the airframe. 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 and stress levels. 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.

d. Sonic fatigue analysis. This section shall include the following:

1. Initial sonic fatigue analysis.

(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.

2. Final sonic fatigue analysis. The data of 30.7.2d shall be revised to reflect the final aeroacoustic loads environment analyses of 30.5h2 based on the laboratory, captive, and flight tests data compiled during the vibroacoustic loads program including data measured on the flight article.

30.8 Reports of laboratory tests to define environments and characteristics.

30.8.1 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 missile 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 missile parameters.

30.8.2 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 missile, 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 missile. 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 in the theoretical flutter analysis 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 missile parameters.

30.8.3 Airframe rigidity test report.

a. Flutter compliance data. This section shall contain the results of tests performed to demonstrate compliance with the detailed requirements, as specified in section 3.8, for:

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

2. Location and tolerance of balance weights, provision for re-balancing, and the protection installed to prevent changes in mass balance of control surfaces due to atmospheric effects.

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

4. 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.

5. Freeplay of all control surfaces and comparison with specified values. Dimensional analyses of all actuating system parts for each control surface showing minimum and maximum freeplay values due to manufacturing tolerances shall be included.

6. Rotational stiffness of control surfaces and comparison with theoretical values.

7. 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.

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

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

10. Actuator test data including static stiffness, freeplay, and dynamic stiffness for all operating modes of the system.

b. Ground vibration modal test data: This section shall contain the results of the ground vibration modal test, as follows:

1. Description and photographs of the missile suspension system, the excitation system, instrumentation, procedures, data reduction procedures, and the missile configuration.

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

3. 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 missile experimental vibration modal data, calculated vibration modal data and flutter or vibration model data shall be included.

4. 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 or modified mass matrix of the dynamic system shall not have off-diagonal elements greater than 10 percent of the unit diagonal elements.

5. Results of all vibration tests (including tests with temperature effects simulated) performed to determine the dynamic characteristics of actuating systems of control surfaces 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.

6. 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.

c. Thermoelastic test data: This section 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.

d. Rigidity test data: This data 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.

30.8.4 Dynamic environmental test report. This report shall include the results of the vibration and aeroacoustic environmental ground tests as follows:

a. A discussion of the work performed, test objectives, results and conclusions.

b. Date and place of test.

c. A description of test setups, facilities, test methods and conditions, test article suspension equipment supplemented by drawings and photographs.

d. Test procedures, test levels and associated tolerances, durations, and a copy of the test log.

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

f. A list of rigid body suspension modes (frequencies and mode shapes).

g. Test measurements of the vibration input and responses of the test article at the beginning, end, and at appropriate intervals during each run. These test data shall be provided as acceleration spectral density on log-log format.

h. Test measurements of the acoustic field surrounding the test article at the beginning, end, and at appropriate intervals during each test run. These test data shall be provided as one-third octave band sound pressure levels in dB units.

i. A detail description and discussion of any test failure anomaly which may occur during the test. Reasons for the failure and recommendations for future action regarding design changes to correct the problem and associated analysis and retest requirements shall be included.

30.9 <u>Reports of laboratory tests to define static and fatigue strength</u>. The following reports are required describing the static and fatigue test programs.

30.9.1 <u>Test plans and program reports</u>.

30.9.1.1 <u>Description of test articles report</u>. 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.

30.9.1.2 <u>Static test plan report</u>. 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 basis 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 missile, all loads shall be referenced about a standard location on the structure and be balanced about this reference location.

(c) Complete missile 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. 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 missile weight, load factor, speed, and altitude. 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, and load) 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 (such as types of transducers and size and gage of wire) 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; such as calibration data, transducer type, resistance, gage factor, and bridge voltage.

c. Each test shall be identified by applicable Appendix A paragraph number.

30.9.1.3 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 basis 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 heat concentrations.
(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 application 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 (such as stress or strain, deflection, temperature, pressure, and load) 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 (such as calibration data, transducer type, resistance, gage factor, and bridge voltage).

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.

30.9.1.4 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 the basis 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.

30.9.1.5 <u>Structural design, development and preproduction verification test plan report</u>.

a. This report shall contain an outline and schedule of all static, fatigue, and sonic fatigue component 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, and wing pivots.

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 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.

30.9.2 Test status reports.

30.9.2.1 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 30.9.2.1a with as much information required by 30.9.2.1b through 30.9.2.1i as is available. Subsequent submittal with revised 30.9.2.1a 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 Appendix A shall be shown for all tests described. Planned submittal dates for the remaining information of items 30.9.2.1b. 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 missile.

g. Failure to meet specification: As soon as possible, the contractor shall report to the contracting activity, 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 contracting activity.

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.

30.9.2.2 <u>Fatigue test progress reports</u>. The initial submittal of fatigue test progress reports shall be made in accordance with Table I and shall include the information of 30.9.2.2a. Subsequent submittal with revised 30.9.2.2a. 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 Appendix A 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 and buttock line. 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 hours.

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 production missile.

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 contracting activity 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 non-destructive 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 missiles that are to be affected.

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

30.9.3 Final test reports.

30.9.3.1 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 missiles in which changes will be incorporated and number of backfitted missiles shall be indicated.

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

30.9.3.1.1 Static design development and preproduction component design verification test report. 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.
d. Stresses.
e. 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.

30.9.3.2 <u>Fatigue test report</u>. 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.

30.9.3.2.1 <u>Fatigue development test reports</u>. 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.

30.9.3.2.2 <u>Fatigue test teardown inspection report</u>. 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.

30.9.3.3 <u>Sonic fatigue component test report</u>. 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.

30.10 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, as specified in section 3.4, and to substantiate compliance with applicable design requirements. The data shall be presented in a manner similar to the presentation in MIL-HDBK-5.

30.10.1 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 missile 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.

30.11 Flight test reports.

30.11.1 Aeroelastic stability, vibration and aeroacoustic flight test planning report. 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 control surface motion sensors).

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 such as speed, Mach number, altitude, dynamic pressure, load factor, and angle of attack. Maneuvers expected to produce the most severe vibration and aeroacoustic environments and structural dynamic responses shall be identified.

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

30.11.3 Flight 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 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.

30.11.4 Structural flight and ground operations test program report. This report shall include a detailed description of the instrumentation, approximate locations of instrumentation in the missile, 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 missile, 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.

30.11.5 Structural dynamic flight test reports.

30.11.5.1 Aeroelastic stability flight test letter reports. These letter reports shall contain the results of aeroelastic stability flight tests and shall include the following:

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

b. 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 missile. 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 missile 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 missile configuration.

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

30.11.5.2 Vibration and aeroacoustic flight test letter reports. These letter reports shall contain the results of vibration and aeroacoustic flight tests and shall include the following:

a. Missile configuration, altitudes, Mach numbers, equivalent airspeed (knots), load factor, fuel content and dynamic pressure.

b. 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 missile. 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.

30.11.5.3 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.

30.11.5.4 Vibroacoustic environment measurement report. This report shall include:

a. Outline of testing performed.

b. Description of the methods of vibration and aeroacoustic measurement employed for the test determination of the vibration and aeroacoustic environment of the missile.

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. Captive 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. Captive 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.

h. Discrete frequencies and amplitude.
i. Identification of internal and external vibration and aeroacoustic sources.

j. Comparison of test results with predicted design environments.

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

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

30.11.6 Flight load survey instrumentation and calibration progress reports. Brief summary type progress reports reflecting the progress being made in instrumenting and calibration of the flight load missile 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 contracting activity action.

30.11.7 Flight 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.

30.11.8 Flight load 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 missile during the structural flight test. The contractor shall submit an intermediate report after each missile flight test and a final report at the completion of the flight test program containing the following:

a. The information on the operational missile shall include: three view drawings; V-n diagrams; dimensions; weights; and any other significant items of a structural loads nature. The test missile 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, or installation of external instrumentation equipment of significant size.

b. The comparison of attained maneuvers versus specified maneuvers in the structural flight test program shall be represented in tabular form. Information shall include: missile 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: 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.

30.11.8.1 Intermediate flight load survey report. The flight load and test condition data obtained during each missile flight test shall be reduced, analyzed, and evaluated on a continuing basis throughout the FSD 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.

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, missile 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 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 cross-coupling 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 missile, 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, angle of attack, and rate of pitch; (3) aileron position, hinge moment, angle of bank, and rate of roll; and (4) rudder position, hinge moment, 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 missile configuration, test condition, airspeed or Mach number, and altitude.

30.11.8.2 Final flight loads survey report. 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. Particular emphasis shall be directed toward establishing that the missile is satisfactory for all critical flight conditions existing within its design operational flight or, if necessary, provide suitable flight 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 missile. In instances where a flight demonstration is scheduled, the report need contain only the applicable portions (mostly condition data) of the requirements in Appendix B.

30.11.9 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 dynamic load inputs. Both discrete and power spectral density methods of analysis shall be 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, missile configurations, speeds, and altitudes being flown by service missiles. Flight or captive conditions which result in significant dynamic stresses 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.

30.11.10 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 or aeroservoelastic instability. The report shall include the following:

a. Date and place of incident.

b. Flight test conditions and missile 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 missiles. The effect on flight test program schedule and any recommended flight restrictions until FSD flight test missiles are modified.

e. Recommended a Plan of Action and Milestones (POA&M) for redesign of production missiles and missiles in which design changes will be incorporated and number of missiles to be back-fitted.

30.12 Strength summary and operating restriction report. A strength summary and operating restriction report shall summarize the strength of the missile 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 missile 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 missile. 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 missile. If the missile 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 missile 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 missile 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 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.

h. Recommendations for operational restrictions including restrictions on use of lateral and directional controls.

i. List of critical margins of safety for each major component of the missile. 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 Appendix A. Diagrams or reduced-size drawings of the missile or of major components, such as a wing and the fuselage, 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.

30.13 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.

30.14 Air-Vehicle 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 missile 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.

30.15 Structural manual. This document shall consist of all the data and procedures normally used by the contractor in the structural analysis of missiles 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.

30.16 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 missiles, 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.

30.17 Maintenance instructions for control surfaces. Maintenance instructions for each control surface 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 missile.

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 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 and painting.

g. The maximum allowable mass properties, such as 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.

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APPENDIX B
OPERATIONAL USE TESTS

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APPENDIX C
ANALYSES, DATA, AND REPORTS

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL M 8856B	2. DOCUMENT DATE *(YYMMDD)* OCTOBER 22,1990

3. DOCUMENT TITLE
MISSILES, GUIDED, STRUCTURAL INTERITY GENERAL SPECIFICATION FOR

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) AUTOVON *(If applicable)*	7. DATE SUBMITTED *(YYMMDD)*

8. PREPARING ACTIVITY

a. NAME COMMANDING OFFICER NAVAL AIR ENGINEERING CENTER	b. TELEPHONE *(Include Area Code)* (1) Commercial (908) 323-2476 (2) AUTOVON 624-2476
c. ADDRESS *(Include Zip Code)* SYSTEMS ENGINEERING & STANDARDIZATION DEPT LAKEHURST, NJ 08733-5100	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340