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SUPERSEDING
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(See section 6.4)

MILITARY SPECIFICATION

AIRPLANE STRENGTH AND RIGIDITY FLIGHT LOADS

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

1. SCOPE

1.1 Scope. This specification covers the requirements for strength and rigidity for flight loading conditions applicable to airplanes.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

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

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 ard Standardization Department, (Code 93), Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 1510

SPECIFICATIONS

MILITARY

MIL-D-8706	Data and Tests, Engineering, Contract Requirements for Aircraft Weapon Systems.
MIL-D-8708	Demonstration Requirements for Airplanes.
MIL-A-8860	Airplane Strength and Rigidity General Specification for
MIL-A-8866	Airplane Strength and Rigidity, Reliability Requirements, Repeated Loads, and Fatigue.
MIL-A-8867	Airplane Strength and Rigidity, Ground Tests.
MIL-A-8868	Airplane Strength and Rigidity, Data and Reports.

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

PUBLICATIONS

AIR FORCE

SEG TR 65-04	Environmental Conditions to be Considered in the Structural Design of Aircraft required to Operate at Low Levels.
SEG TDR 67-28	Development of Improved Gust Load Criteria for USAF Aircraft.

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

2.2 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Applicability. Except as otherwise specified, the requirements specified herein apply to the complete airplane structure. Within the specified ranges of center of gravity position, strength is required for the specified values of the parameters and any lesser or intermediate values which may be critical and which are practicable of attainment.

3.1.1 Gross weight. The design gross weights for the flight loads and loading conditions specified herein shall be all gross weights from the minimum flying gross weight to the maximum design gross weight. For weights up to the basic flight design gross weight, strength shall be provided for all conditions for the values of parameters specifed for the basic flight design gross weights. At higher weight, strength shall be provided for by maintaining a constant mass times load factor ($n_z W$) product, except that the load factor shall be not less than that specified in Table I for the maximum design gross weight.

TABLE I. Symmetrical flight parameters.

Class of Air-plane	Symmetrical flight limit load factor: Basic flight design gross weight		Symmetrical flight limit load factor: All gross weights	Symmetrical flight limit load factor: Maximum design gross weight		Limit speed V_L	Time for abrupt control dis-placement t_1, second
	Max.	Min. at V_H	Min. at V_L	Max.	Min. at V_H		
1	2	3	4	5	6	7	8
VF, VA	7.50	-3.00	-1.00	5.50	-2.00	as specified	0.2
VT	7.50	-3.00	-1.00	4.00	-2.00		0.2
VO	6.00	-3.00	0	3.00	-1.00		0.3
VU	4.00	-2.00	0	2.50	-1.00		0.3
VS	3.50	-1.00	0	2.50	0		0.4
VW, VR, VP	3.00	-1.00	0	2.50	0		0.4

MISSION SYMBOLS FOR CLASS OF AIRPLANE

A - Attack
F - Fighter
O - Observation
P - Patrol
R - Reconnaissance
S - Antisubmarine
T - Trainer
U - Utility
W - Weather

3.1.1.1 Weight distributions. The weight distributions for the basic, high drag, dive recovery, landing approach, and takeoff configuration shall be all those that are critical as a result of all practicable symmetrical and asymmetrical distributions and shall be determined by consideration of all possible arrangements of variable, disposable, and removable items, including external stores, for which provision is required (including ballast required for structural demonstration tests) within the airplane strength and aerodynamic controllability limits.

3.1.2 Center of gravity positions. The design center of gravity positions at each weight and each aerodynamic configuration (position of variable geometry surfaces, size and location of external stores) shall include a tolerance beyond the actual maximum-forward and actual maximum-aft positions. Included shall be all weights and aerodynamic configurations which are attainable as a result of all practical symmetrical and asymmetrical distributions of useful load up to the maximum design weight, airplane attitudes and accelerations, fuel sequencing, and airplane flexibility. This tolerance shall be ± 1.5 percent of mean aerodynamic chord (MAC) or 15 percent of the distance between the most forward and most aft actual values from the complete center of gravity (CG) envelope, whichever is greater. This tolerance shall be applied so as to move the design center of gravities forward of the actual most forward position and aft of the actual most aft position. For airplanes with variable sweep wings, the reference MAC shall be that for the wings landing or take-off position.

3.1.2.1 Ballast support-structure. When sufficient ballast support structure strength cannot be identified and located for ballast weight distribution necessary to meet the specified CG requirements with the specified tolerances, the contractor may use a finite element distribution of the ballast weight throughout the forward or aft portions of the fuselage, as appropriate. When a finite element distribution is used, strength provisions shall be made and appropriately defined for the support-structure(s) for the ballast weight(s) to allow for a 1.0 percent MAC tolerance on the maximum forward and aft design CG. This deviation shall apply for the design of ballast weight support-structure only.

3.1.3 Aerodynamic configurations. For the flight load conditions of this specification, unless otherwise specified, all devices such as, but not limited to, flaps, slats, slots, cockpit enclosures, landing gear, speed limiting devices, and bomb-bay doors shall be in their closed or retracted positions. Alternately:

a. Speed limiting devices (including landing gear, if it is used as a speed limiting device) and bomb-bay doors shall be in the full open or extended positions as limited by available actuating (operating or holding) force or power, and, alternately, in all critical intermediate positions.

b. Aerodynamic devices used for maneuvering in flight other than take-off and landing, such as variable-position aerodynamic surfaces which provide for changes in altitude, attitude, translational motion, roll, or camber, shall be in the maximum open or extended position for its scheduled program plus a tolerance of 50 percent on surface(s) deflections and maximum surface(s) rate of deflection, and, alternately, in all critical intermediate positions or stalled positions if insufficient power is available to achieve its scheduled position. Scheduled position shall include all commanded error signals and flight control time lags and possible air data computer sensor errors.

c. For airplanes having variable geometry surfaces, such as wing sweeping, variable camber or variable position thrust devices, such as thrust-directed controls or engine nozzles, these surfaces or devices shall be in all positions within the limits of their scheduled program of travel.

3.1.3.1 Stores configurations.

3.1.3.1.1 Carriage. The load factors at store stations shall be those required at the appropriate design gross weight at the particular store location which includes the loads resulting from the structural dynamic responses between the airframe and the rack-store installation. For external store installation, the angular rates and acceleration with basic mission load and with heavier store items shall be those resulting from the requirements of 3.3 and 3.4.

3.1.3.1.2 Programmed release of stores. The programmed release of all combinations of stores by devices such as computers, or other electronic, or electro-mechanical devices, under any flight conditions including the effects of firing of ejection racks (if required) and "G-jump", shall not result in the limit strength of the airplane being exceeded. For attack (VA) airplanes, limit strength shall be provided to include the "G-jump" and ensuing load magnification effect after an initial release load factor of 6.0 or its appropriate n_zW product; this condition shall be considered for the programmed release of all combinations of stores. The gross weight shall be that for the maximum stores loading less 40 percent fuel.

3.1.3.1.3 Emergency stores release. Emergency release of the most critical combinations of stores shall not result in unacceptable aircraft motions or exceedance of limit strength of the airplane for the following conditions:

a. At speeds up to the maximum permissible speed for such release with all values of vertical load factor between 0.5 and 2.0.

b. At speeds up to landing, approach, and take-off limit speed (V_{LF}), with devices extended or open in their maximum open or extended position for take-off, with all values of vertical load factor between 1.0 and 1.5.

3.1.4 Air speeds. The airspeeds shall be those specified and any attainable lesser or intermediate air speeds that result in critical loads.

3.1.5 Altitudes. The altitudes used for the determination of flight loading conditions, other than take-off and landing approach, shall be all the altitudes that result in critical loads from sea level to those altitudes at which the limit equivalent air speed (EAS) and Mach number are maximums or maximum performance (Cruise Altitude) requirement. Sea level shall be used for landing approach and take-off.

3.1.6 Power settings. The power or thrust for the conditions of this specification, including gusts combined with manuevers, shall be all values between zero and the maximum attainable using thrust augmentation or auxiliary power devices, except that for consideration of air speeds applicable to gusts, the power need not exceed normal rated for reciprocating engines and military thrust (non-afterburning) for all gas turbine engines.

3.1.7 Pressurization. The limit pressure differential between pressurized portions of the structure and the ambient atmosphere shall be:

a. 1.33 times the maximum attainable pressure combined with 1-G flight loads. The maximum attainable pressure shall be defined as limited by the pressurization safety valve(s), plus the tolerance limit on the safety valve(s).

b. Zero and the maximum attainable pressure combined with flight loads.

c. 1.33 times the maximum attainable pressure combined with the loads due to ground test support equipment for pressurization tests.

3.1.8 Airload distributions. The distributions of airloads used in the structural design shall be those determined by the use of acceptable analytical methods and by the use of aerodynamic data which are demonstrated to be applicable as approved by the acquisition 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.

3.1.9 Positions of adjustable fixed surfaces. For each airplane configuration associated with the loading conditions of this specification, the position of fixed surfaces, which are adjustable in flight or on the ground shall be the extreme positions of the available range of settings of the configuration as limited by positive stops and also for all critical positions within that range.

3.1.10 Positions of cockpit enclosures, bomb-bay doors, landing gear and doors, dive recovery devices, and cowl flaps. Loads on cockpit enclosures, bomb-bay doors, landing gear and doors, dive-recovery devices, and cowl flaps shall be those resulting from the loading conditions of this specification for the fully opened, intermediate positions, and fully closed positions up to the limit speed for which operation of these components is required. If the airplane's aerodynamic characteristics are significantly affected by the positions of these items, the loads on the airplane shall be those resulting with these items fully opened as well as fully closed, considering each item individually.

3.1.11 Torque on primary control surfaces. The torque on primary control surfaces resulting from the loads and loading conditions of this specification shall be modified as follows:

a. Neglect the torque resulting from airloads forward of the hinge line of the control surface when this results in more critical torque by assuming that these airloads act at the hinge line, and

b. Assume tabs, other than those which can move relative to their associated surfaces only by virtue of the movement of the associated surfaces, are in those positions within their limits of travel which result in the most critical torque on the control surface, except that,

c. In those cases where the requirements of 3.1.11a and b, result in hinge moments greater than those which can be supplied by the control systems, the requirements of 3.1.11a and b, shall be modified, as necessary, in order that the resultant hinge movements are equal to those that can be supplied by the control systems, except 3.1.13. For the purpose of this requirement, the hinge moments that can be supplied by the control systems shall be those that result from application of the limit pilot-applied cockpit control forces in the case of manual or boosted controls or those that result from maximum control power or surface authority in the case of powered systems. The manner in which the requirements of 3.1.11a and b, are modified shall be such that the critical distributions of torque, consistent with the maximum specified value of resultant torque, are obtained.

3.1.12 Tab loads. Tabs shall be in all positions within their limit of travel at all speeds up to the limit speed. The associated control surfaces shall be in their neutral positions. The local angle of attack of the tab's associated fixed surface shall be zero. Airloads on portions of the airplane other than tabs may be neglected.

3.1.13 Unsymmetrical horizontal tail loads. The airloads on the horizontal tail for symmetrical flight conditions and symmetrical gusts shall be distributed unsymmetrically as well as symmetrically. The unsymmetrical distributions shall be obtained by multiplying the airloads on the horizontal tail on one side of the plane of symmetry by (1 + x) and the airloads on the other side by (1 - x). The value of x for all classes shall be 0.5 for point A of Figure 2 and for all points representing aerodynamic stall or buffet. For all other points, the value of x shall be 0.15. The airloads on the horizontal tail resulting from unsymmetrical flight conditions and side gusts shall be determined from specifically applicable aerodynamic data, or alternatively shall be distributed in a manner such that they produce a rolling moment defined by:

$$L = \frac{(q)\ (s_H)\ (b_H)\ \beta}{2400}\left[\frac{12\ A}{b_H} \pm \frac{3\ B}{C} - 0.4\gamma \quad -9\right]$$

where

L = rolling moment, ft. lbs
q = d7namic pressure, lbs. per sq. ft.
s_H = area of horizontal tail, sq. ft.
b_H = span of horizontal tail, ft.
β = angle of sideslip, degrees
γ = dihedral of horizontal tail, degrees
A = See figure 1, ft.
B = See figure 1, ft.
C = See figure 1, ft.

For aircraft with differential horizontal stabilizers, the unsymmetrical airload distribution shall be determined by wind tunnel test or specifically-applicable flight test data, combined with a buffeting dynamics computer model in which all airload and control system dynamic effects are included. Additionally, the maximum programmed deflections of the differential stabilizers shall be not limited by actuator power.

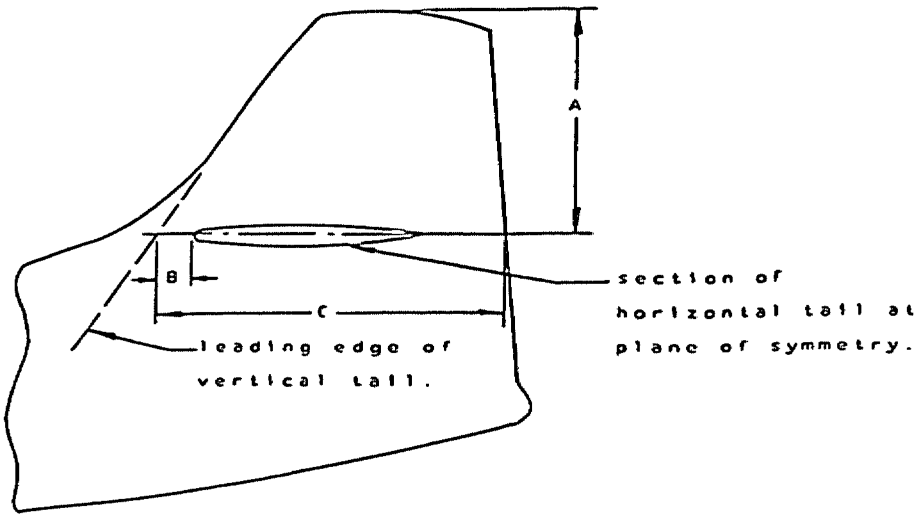


FIGURE 1. Pertinent dimensions for calculations of horizontal tail loads.

3.1.14 Fail-safe and damage tolerance. So far as is practicable, the structure of utility (VU), reconnaissance (VR), trainer (VT), observation (VO), antisubmarine (VS), weather (VW), and patrol (VP) airplanes shall be designed to fail-safe. Following a fatigue failure or obvious partial failure of a single principal structural element, at least limit strength required for flight loads shall remain. The damage requirements shall be specified by the acquiring activity. These requirements supplement the repeated load, fatigue and damage tolerance requirements of MIL-A-8866 and the ground test requirements of MIL-A-8867.

3.1.15 Automated flight control systems. For flight control systems which use electronic, computer-assisted, or other augmenting means to effect pilot control inputs and authority to aerodynamic control surfaces (control surface(s) authority), strength shall be provided for the operative, inoperative and transit modes, except in the case where the design of the system includes fail operative features. In the fail operative case, strength shall also be provided within the aerodynamic stability and control limitations to:

a. Permit safe flight and landing when at least one-half of the automated capability of the flight control system is inoperative.

b. Permit, when the flight control system has a manual back-up capability, limited flight and field landing get-home capability when none of the automated capability of the flight control system is operative.

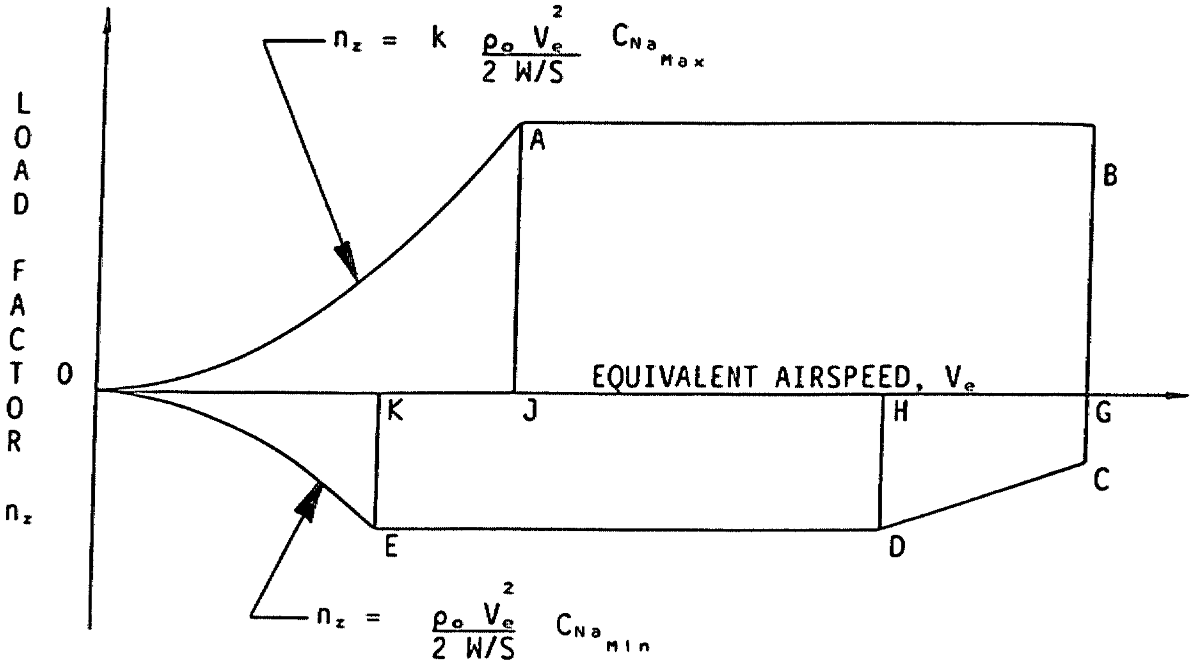
3.1.16 Deformation of internal and external access closures. Load carrying and nonload carrying internal and external access covers (including doors, panels, hatches, cowlings and other coverings), locking mechanisms, such as landing gear up locks and down locks, access closure latches and access closure fasteners shall not deflect adversely from their intended positions at loads up to the design limit load for each loading condition for which limit loads are specified. Unlocking, unlatching, or release of access closures, and unlocking or unfastening of mechanisms shall not occur at loads up to and including design ultimate for loading conditions for which limit or ultimate loads are specified, and at loads up to and including maximum design loads for landing. Access closures shall remain in place under ultimate flight loads if 10 percent of the fasteners are unfastened or if one latch or quick release fasteners selected at random on each edge of an access closure secured by these fasteners or latches is unfastened, such that no deflection will occur by which Ram air effects would cause increased loads.

3.2 Symmetrical flight conditions.

3.2.1 Balanced maneuver. The airplane shall be in the basic, high-drag, and dive-recovery configurations at all points on and within the maneuvering envelope bounded by O, A, B, C, D, E, and O of Figure 2 and further defined in Table I. The pitching velocity shall be the finite pitching velocity associated with the load factor developed. It shall be assumed that the elevator is deflected at a very slow rate so that the pitching acceleration is zero.

3.2.2 Accelerated pitch maneuver and recovery. The airplane shall be in the basic high-drag, and dive-recovery configurations. The airplane initially shall be in steady unaccelerated flight at the airspeed specified for the manuever and trimmed for zero control forces at that airspeed. The airspeed shall be constant until the specified load factor has been attained. The load factors to be attained shall be all values on and within the envelope bounded by O, A, B, C, D, and E of Figure 2. Except as noted in 3.2.2d the load factor at each airspeed shall be attained as specified in 3.2.2a and b, or 3.2.2e, below, for all center of gravity positions, and also shall be attained as specified in 3.2.2c, below, for the maximum-aft center of gravity position:

a. By a cockpit longitudinal control movement resulting in a triangular displacement-time curve as illustrated by the solid straight lines of Figure 3a provided that the specified load factor can be attained by such a control movement; otherwise by the ramp-style control movement illustrated by the dashed straight lines of Figure 3a. The time t_1 is specified in Table I. For the ramp-style control movement, the time t_2 shall be the minimum time that the control is held at the stops to attain the specified load factor.



NOTES:

1. JA = GB = value specified in columns 2 and 5, table I.
2. GC = value specified in column 4, table I.
3. HD = KE value specified in columns 3 and 6, table I.
4. OH = v_H as specified in MIL-A-8860 .
5. OG = v_L as specified in MIL-A-8860
6. K = 1.25 for $M \leq 0.6$
   = 1.0 for $M \geq 1.0$
   = [1.625 - (0.625 M)] for $0.6 < M < 1.0$

where M is the Mach number corresponding to the speed being considered. K may be determined from applicable wind tunnel and flight test data acceptable to the procuring activity. This determination shall include consideration of abruptness of the maneuver, control surface limitations, Mach number, thrust, center of gravity position, external stores configuration, maximum safe angle of attack as limited by controllability, limiting buffet loads, and other effects which can be shown to have a significant bearing on the maximum attainable airplane normal force coefficient ($C_{Na_{Max}}$).

FIGURE 2. V-n diagram for symmetrical flight.

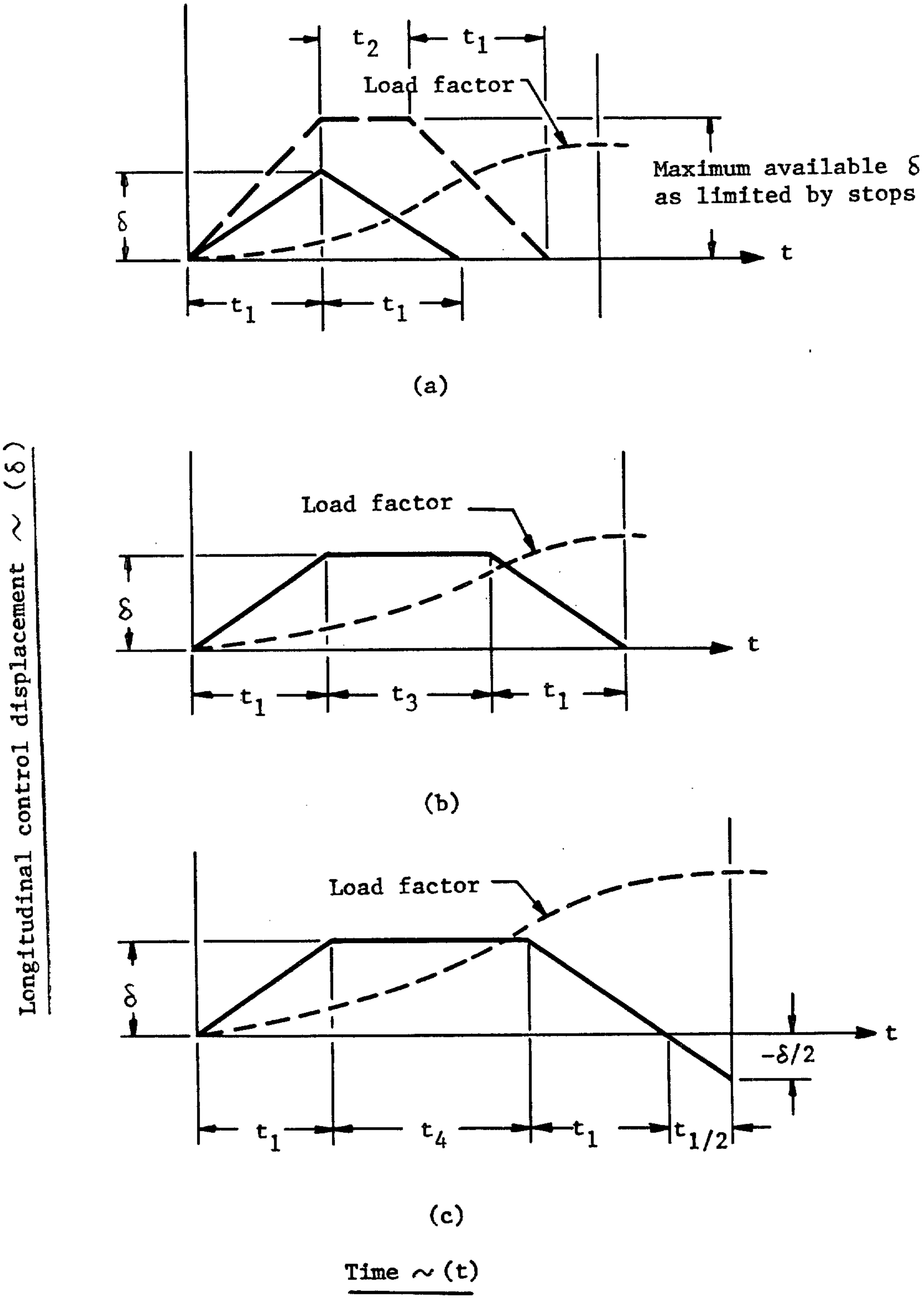


FIGURE 3. Cockpit longitudinal control displacement vs time diagram.

b. By a cockpit longitudinal control movement resulting in a ramp-style displacement time curve as illustrated by the solid straight lines of Figure 3b. The time t_1 is specified in Table I. The time t_3 and the control displacement δ shall be just sufficient to attain the specified load factor in time $2t_1$ plus t_3.

c. By a cockpit longitudinal control movement resulting in a ramp-style displacement-time curve as illustrated by the solid straight lines of Figure 3c. The time t_1 is specified in Table I. The time t_4 and the control displacement δ and minus δ /2 shall be just sufficient to attain the specified load factor coincidentally with the attainment of minus δ /2.

d. For all maneuvers of accelerated pitch, strength shall be provided so that a recovery can be made by the application of an abrupt maximum longitudinal-control force or maximum control surface authority (when applicable) in the opposite direction until maximum up-stabilizer or wing load has been attained consistant with safe recovery procedures.

e. For aircraft equipped with computer-controlled, fly-by-wire, active control, stability augmentation, direct lift control, or other types of control system where pilot control inputs do not directly establish control surface position, strength shall be provided in the airplane and control surfaces for all changes to the shapes and rates of the displacement-time requirements of 3.2.2a, b, or c imposed by the control surface authority as specified in 3.1.15.

3.2.2.1 <u>Low speed symmetrical maneuver with pitch</u>. The airplane shall be in the basic, high-drag, and dive-recovery configurations at all points on the maneuvering envelope bounded by O and A of Figure 2 and further defined in Table I. Design limit load factor shall be attained by point A, at a speed V_e equal to either of the following speeds:

a.

$$V_e = \sqrt{\frac{2N_z W}{\rho_o K C_{Na_{max}} S}}$$

where N_z = Design limit load factor

W = Design weight of the airplane, pounds
S = Surface area, sq. ft.
ρ_o = Air density, slugs/cu. ft.

$C_{Na\ max}$ = Maximum normal force coefficient

K for $M \leqslant 0.6$ = 1.25 or the maximum value greater than 1.25 at which critical buffet loads occur
K for $M \geqslant 1.0$ = 1.0
K for $0.6 < M < 1.0$ = 1.625 - .625

Alternatively, K may be determined from applicable wind tunnel and flight test data acceptable to the acquiring activity, provided such data reflects buffeting loads when K is greater than 1.25 and the design limitation is due to unsafe buffet or to an angle of attack beyond which the aircraft becomes uncontrollable.

b. V_e = the minimum speed at which the design limit load factor can be attained in a symmetrical pull-out by applying maximum longitudinal control force or control surface authority (as applicable) (see 6.3) in not more than 0.5 second and maintaining that force or surface authority until the maximum attainable load factor has been achieved.

3.2.2.2 Vertical translation maneuver. For airplanes equipped with direct-lift-control (DLC) and/or vertical thrust vectoring control (TVC), strength shall be provided in the airframe for an abrupt application of the applicable control, at load factor up to design, within 0.5 seconds at all speeds up to V_H.

3.2.3 Landing and take-off approach configuration pull-outs. The airplane shall be at the limit speed V_{LF}. The landing gear and other devices which are extended during take-off or landing approach shall be in their maximum open or maximum extended positions. The load factors shall be all values from 0 to 2.0. Maneuver conditions of 3.2.1 and 3.2.2 shall apply. The design weight for each condition shall be:

a. Take-off. The design weight for take-off shall be the maximum design weight and alternately the basic flight design weight.

b. Landing approach. The design weight for landing approach shall be the maximum landing design weight.

3.2.4 Wing sweeping. For variable-sweep wing airplanes, strength shall be provided for sweeping the wings at all speeds, altitudes, weights up to the maximum design gross weight, wing positions, and load factor between -2.0 and 5.5.

3.3 Unsymmetrical flight conditions.

3.3.1 Rolling maneuvers. The airplane shall be in the basic, high-drag and specified store configurations. The airspeeds shall be all airspeeds up to limit speed (V_L). During the maneuver, the directional control shall be:

a. Held fixed in its position for trim with zero rudder-control force in wings-level flight at the speed required, and

b. Displaced as necessary to maintain zero sideslip up to limits of the rudder authority.

The cockpit lateral control shall be displaced to all the displacements to the maximum available displacement attainable by a pilot lateral control force of 60 pounds (two equal and opposite 48-pound forces applied at the circumference of the control wheel) by application of the control force in not more tha 0.1 second for airplanes with stick controls and not more than 0.3 second for airplanes with wheel controls; for automated flight control type systems (see 3.1.15), application of the maximum control surface(s) authority is required. The control force(s) or authority shall be maintained until the required change in angle of bank is attained, except that, if a roll rate greater than 270 degrees per second would result, the control position may be lessened or authority modified, subsequent to attainment of the maximum rolling acceleration, to that position resulting in a roll rate of 270 degrees per second. The maneuver shall be checked by application of the maximum available displacement attainable with a 60-pound lateral control force (two equal and opposite 48-pound forces applied at the circumference of the control wheel) applied in not more than 0.1 second for stick controls and in not more than 0.3 second for wheel controls. For automated flight control type systems, maximum lateral control surface(s) authority shall be used.

3.3.1.1 Rolling pull-out. For all airplanes, the initial load factor shall be all values between 1.0 and 0.8 design load factor. The airplane shall be initially in a steady constant-altitude turn at an angle of bank to attain the load factor at the specified airspeed. The airplane shall roll out of the turn through an angle of bank equal to twice the initial angle and maintain this opposite bank. Constant air speed and constant cockpit longitudinal control surface authority shall be maintained. For VF, VA and VT classes, the load factor shall also include all values from -1.0 to 1.0 with the maneuver starting from laterally level flight and the airplane rolling through 180 degrees.

3.3.1.2 Level flight roll (VA, VF, and VT airplanes only). The initial load factor shall be 1.0. The airplane shall execute a 360-degree roll starting from wings-laterally-level flight. The longitudinal control-surface authority shall be held constant at the trim position required for level flight prior to commencing the roll.

3.3.1.3 Unsymmetrical maneuvers for automated flight control - augmented aircraft. For aircraft equipped with flight control systems where pilot inputs do not directly establish control surface position (such as computer-controlled, fly-by-wire, active control, or stability augmentation systems), the airplane shall additionally be designed for maximum abrupt pilot input of all longitudinal, lateral and directional controls (stick, wheel, side-arm controller and rudder pedal).

These pilot input rates shall be such that the specified control displacement rates, roll rates, and load factors of 3.3.1 and 3.3.2 shall not be exceeded, and shall be used to establish critical control surface authority for conditions of steady roll with abrupt pitch, steady pitch with abrupt roll, and those combinations of abrupt pitch and abrupt roll representing control column positions intermediate between only pitch or only roll.

3.3.1.4 Demonstration maneuvers. Structural design shall include maneuvers required to satisfy the structural demonstration requirements of MIL-D-8708.

3.3.2 Roll in take-off or landing approach configuration. The air speed shall be V_{LF} in the landing approach configuration. The load factor shall be 1.0. The lateral control shall be displaced in accordance with 3.3.1. The roll need not be carried beyond 90 degrees angle of bank.

3.3.3 Sideslips and yawing maneuver. The conditions of this paragraph are essentially flat maneuvers without substantial degree of coupled roll. Lateral-control displacement or authority shall be included to maintain the wings in a level attitude, except that for the high-speed rudder-kick and reversed-rudder conditions of 3.3.3.5 and 3.3.3.6, an angle of bank not more than 5 degrees shall be maintained. The minimum speeds for this paragraph shall be in the minimum speeds at which the angles of bank can be maintained. For all conditions, the normal load factor shall be 1.0.

3.3.3.1 Steady sideslip. The airplane shall be in the basic and high-drag configurations. The airspeed shall be all speeds up to V_L. A 300-pound rudder-control force shall be slowly applied. For aircraft having direct side force control, pilot input sufficient to provide the specified sidewise acceleration and displacement shall be applied to the surface(s) capable of applying the direct side force, and compensating forces applied to other directional, roll, or pitch control surfaces such that no change in roll or pitch attitude occurs during sidewise translation.

3.3.3.2 Low speed rudder kick. The airplane shall be in the takeoff and landing configurations at speeds up to V_{LF} and additionally shall be in the basic and high-drag configurations at speeds up to $0.6V_H$. The cockpit directional control shall be displaced in not more than 0.2 second to the maximum displacement attainable as limited by stops, or maximum output of the power-control system, or a 300-pound directional-control force. The control displacement or force shall be maintained until the maximum over-swing angle of sideslip is attained and the airplane attains a steady sideslip. Recovery shall be made by reducing the directional control displacement to zero in not more than 0.2 second.

3.3.3.3 High speed rudder kick. The airplane shall be in the basic and high-drag configuration at speeds up to V_L for VA, VF, and VT airplanes, and up to V_H for other type aircraft. The cockpit directional control shall be displaced to the maximum displacement attainable with a 180-pound directional-control force applied in not more than 0.2 second. The control force shall be maintained until the maximum over-swing angle of slideslip is attained and the airplane attains a steady sideslip. Recovery shall be made by reducing the directional-control displacement to zero in not more than 0.2 second.

3.3.3.4 Reversed rudder (for VF, VA and VT only). At speeds up to V_H, recovery from the steady sideslip of 3.3.3 shall be made by application of a 180-pound rudder-control force in the opposite direction in not more than 0.2 second. Maintain opposite rudder force until maximum over-swing angle occurs.

3.3.3.5 One-engine-out operation. For multi-engine aircraft, sudden stopping of an engine at all speeds above the approved one-engine-out minimum takeoff speed up to V_L for VF, VA and VT airplanes, and up to V_H for all other classes shall not result in unacceptable aircraft motions or vibrations within these specified speed ranges. The airplane at V_{LF} shall be in the takeoff and landing approach configurations and at all other speeds, the configuration shall be the basic and high-drag. The limit strength of the airplane shall not be exceeded in a symmetrical pull-out to a load factor of 2.25 or $0.5n_z$, whichever is greater, with each engine, one at a time, inoperative and all other engines delivering normal-rated power or thrust. These requirements shall not be construed to supersede or obviate applicable flying-qualities or power-plant-installation requirements for one-engine-out operation.

3.3.3.6 Engine failure. The airplane shall be in the basic configuration. The airspeeds shall be all speeds from the approved one-engine-out minimum takeoff speed to V_H. The critical engine shall suddenly fail. If reverse thrust is possible because of automatic features, the failed engine shall deliver reverse thrust. All other engines shall deliver normal-rated power or thrust, except that takeoff power or thrust is applicable at speeds up to V_{S_L}. Automatic feathering, decoupling, or thrust-controlling devices shall be operating and alternately not operating. With these devices operating, limit strength is required. With automatic devices not operating, ultimate strength is required. The directional control shall be:

a. Held in the neutral position until maximum sideslip is attained.

b. Moved by a 300-pound force applied in 0.2 second so as to restore the original heading, the initiation of the restorative motion to occur at all critical times from the instant of failure to the instant of maximum sideslip.

3.3.3.7 Unsymmetrical thrust. With aircraft utilizing thrust vectoring devices, strength shall be provided in the airplane to recover safely from any maneuver requiring unsymmetrical thrust that is specified within the aerodynamic flying qualities and stability requirements.

3.3.3.8 Direct side force control. When applicable, strength shall be provided for abrupt application of the maximum direct side force control authority in such a manner so that a maximum side force load factor (N_Y) of 3.0 is not exceeded. Strength shall be provided for this maneuver at all speeds from minimum speed to maximum level flight speed (V_H).

3.3.3.9 Evasive maneuvers. Consideration shall be given to analyze aircraft strength for evasive maneuvers such as; jinking, missile break, etc.

3.4 Spins. These conditions are applicable to Classes VA, VF, VO, VT, VU airplanes. Releasable external stores may be jettisoned after the first turn. The entry speed shall be that of point A of Figure 2. All critical combinations of the spin parameters of Table II shall be used in the determination of limit loads or, alternatively, the limit loads may be determined from applicable spin-parameter data that have been approved for this purpose by the acquiring activity. Net loads shall include both airloads and inertia values.

3.5 Gust loads. The airplane shall encounter loads caused by vertical and lateral gusts. These loads shall be determined by the discrete gust and continuous turbulence approach. The approach to be used shall be established by the acquring activity for individual airplanes.

TABLE II. Spin parameters.

No.	Type		Spin	Yawing velocity, rad/sec.	Rolling velocity rad/sec.	Pitching velocity rad/sec.	Load factor
1	Steep	To right	Erect	(1) 5.0 for fuselage-mounted engines on VA, VF and VT airplanes	+3.5	±1.5	$n_z/2$
2			Inverted		-3.5	±1.0	-2.5
3		To left	Erect		-3.5	±1.5	$n_z/2$
4			Inverted		+3.5	±1.0	-2.5
5	Flat	To right	Erect	(2) 3.5 for wing-mounted engines on VA, VF and VT airplanes	+1.5	0	+1.0
6			Inverted		-1.5	0	-1.0
7		To left	Erect		-1.5	0	+1.0
8			Inverted	(3) 2.0 for VU and VO airplanes	+1.5	0	-1.0

3.5.1 Discrete gust analysis. The airplane shall be considered in straight and level, unyawed flight with the appropriate balancing horizontal tail load and trim vertical tail load. It shall encounter discrete vertical and lateral gust of design velocity at the specified speeds and critical weights. Design gust velocities shall be:

a. 66-FPS-EAS at V_G

b. 50-FPS-EAS at V_H

c. 25-FPS-EAS at V_L

d. 50-FPS-EAS at speeds up to V_{LF} for the landing approach with the landing gear and other devices which are open or extended in their maximum open or maximum extended positions.

e. For altitudes above 20,000 feet the specified equivalent gust velocity shall be multiplied by the factor:

$$\sqrt{\frac{\sigma \text{ at altitude}}{\sigma \text{ at } 20{,}000}}$$

where: $\sigma = \rho/\rho_0$

3.5.1.1 Discrete gust formulas. Airplane loads derived from the discrete gust approach shall not include possible benefits that may be derived from a stability augmentation system. Loads on airplane components shall be derived using the gust loads formulas specified in 3.5.1.1a, 3.5.1.1b and 3.5.1.1c below. These loads shall be balanced throughout the airplane by linear and rotational inertia forces.

a. Vertical gusts on the wing and fuselage. Loads on the wing and fuselage shall be derived from the load factor established from the following formula:

$$n = n_o \pm \frac{K_w V_e U_{de} a}{498 (W/S)}$$

where: n_o = 1.0

V_e = Equivalent airspeeds in knots

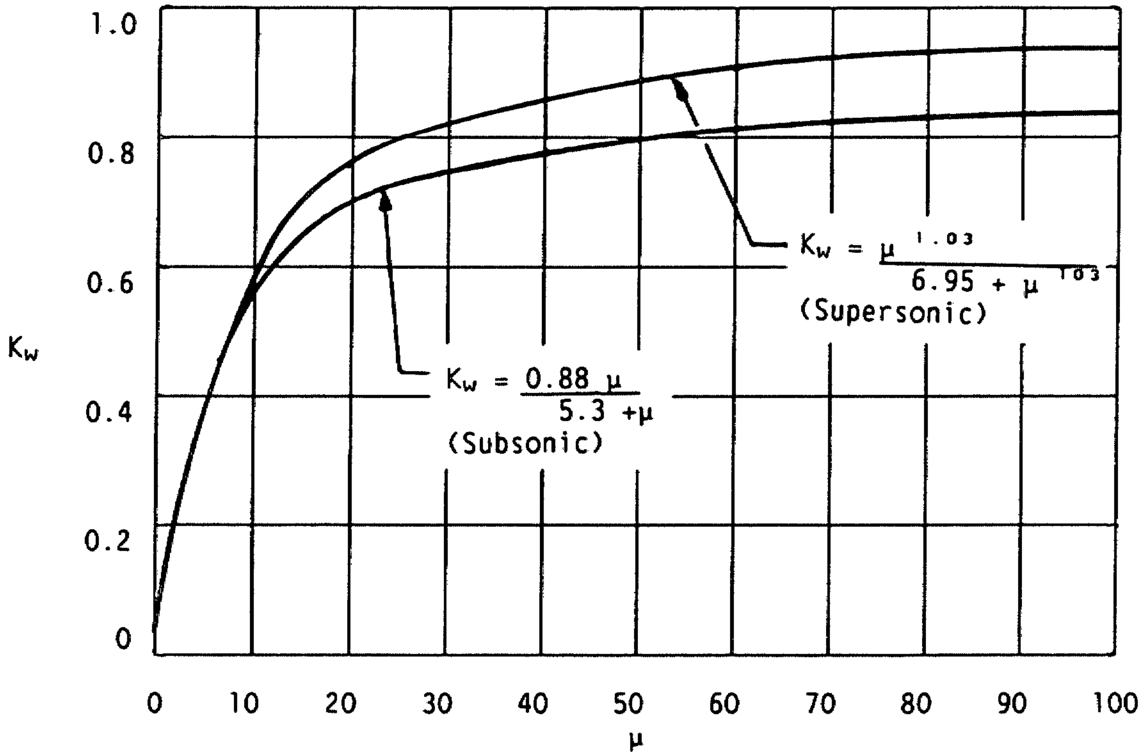
U_{de} = Maximum equivalent gust velocity in feet per second of a single (1-cosine) gust of 25 wing mean aerodynamic chord lengths.

W/S = Wing loading in pounds per square foot

a = Rate of change C_{N_A} with angle of attack (per radian) corrected for Mach number and aeroelastic effects.

K_w = Dimensionless gust factor which is shown in Figure 4.

b. Vertical gust on the fuselage and horizontal tail. The horizontal tail shall be attacked by gust of design velocity. The load on the tail shall be calculated as follows:



mass ratio (μ) $= \dfrac{2W}{\rho\ g\ ca\ S}$

Gust factor (K_w) = A dimensionless term which accounts for the alleviated motion of the airplane and the time lag of the build-up of aerodynamic lift. This parameter is based on mass ratio as shown in Figure 4 and is expressed in terms of μ. The curve marked subsonic shall be used only for speeds below the critical Mach number. The curve marked supersonic shall be used for speeds above the critical Mach number.

Where:

- w = weight, lbs
- ρ = density
- g = gravity, assume 32.2 ft/sec.^{2}
- c = average chord, ft, (span area)
- a = rate of change with angle of attack
- S = wing area, ft^2
- W/S = wing loading, lbs/ft^2

FIGURE 4. Gust factor (K_w) mass ratio (μ).

$$F_{h.T.} = \frac{K_{w_t}}{498} \cdot U_{d_e} \cdot V_e \cdot S_{h_t} \cdot a_{h_t} \cdot \left(1 - \frac{d\varepsilon}{d\alpha}\right)$$

where a_{ht} is the rate of change of the horizontal tail normal force coefficient. The gust factor K_{w_t} shall be equal to 1.1 K_w for the super-critical regime. No transient lift development shall be considered. No reduction in dynamic pressure at the tail is to be considered. The term $(1 - d\varepsilon/d\alpha)$ represent the steady downwash effect at the tail.

c. Lateral gusts on the fuselage and vertical tail. Fuselage and vertical tail gust loads shall be calculated using the pertinent gust velocities of 3.5.1 assumed acting horizontally. The tail plane is considered to have an initial side slip of zero degrees. The load shall be calculated without consideration of unsteady lift phenomena in accordance with the formula:

$$F_{vt} = \frac{K_{w_{vt}}}{498} \cdot U_{d_e} \cdot V_e \cdot S_{vt} \cdot a_{vt}$$

where $K_{w_{vt}}$ shall be taken equal to 1.0 and a_{vt} is the rate of change of the vertical tail normal force coefficient.

3.5.1.2 Low altitude attack mission. For all airplanes for which low altitude capability is required, the airplane shall encounter a vertical 25-FPS-EAS gust while performing a pilot-applied or programmed symmetrical pull-out. The airspeeds shall be all speeds up to V_H. The pilot-applied or programmed-pull-out load factor shall be the greatest of:

a. The load factor for low-altitude bombing systems (LABS), toss, or other programmed bombing systems.

b. 0.6 times the design maximum symmetrical flight limit load factor.

c. 2.25.

3.5.1.3 Gust criteria for aerial delivery. The air speed shall be aerial delivery speed (V_{AD}) with the weight from the minimum flying weight to the maximum design weight at altitudes from sea level to 20,000 feet. The cargo doors and cargo ramp shall be open and the flaps extended. The airplane shall encounter a gust of 50-FPS-EAS before and after cargo extraction and 25-FPS-EAS during cargo extraction.

3.5.2 Gust response parameters. The gust response parameters, A and N_o, shall be based on a dynamic analysis that includes all rigid and significant flexible degrees of freedom. The quantity, A, is the ratio of the root mean value of the response to the root mean square value of the turbulence input and is expressed:

$$A = \left[\int_0^\infty [T(\Omega)]^2 \; \phi_n(\Omega) \, d\Omega \right]^{1/2} \frac{\text{units}}{\text{ft/sec}}$$

The quantity N_o is the characteristic frequency of the response and is expressed:

$$N_o = \frac{V}{2\pi A} \left[\int_0^\infty \Omega^2 \; T(\Omega)^2 \; \phi_n(\Omega) d\Omega \right]^{1/2} \frac{\text{cyc}}{\text{sec}}$$

where: $T(\Omega)^2$ = the squared modulus of the frequency response function.
$\phi_n(\Omega)$ = the normalized power spectrum of atmospheric tubulence.
(Ω) = reduced frequency expressed in radians/ft.

The effects of stability augmentation systems shall be included, and possible saturation or non-linearities in such a system at high levels of gust velocity shall be taken into account. The dynamic analysis shall be conducted for all major components of the airplane at suspected critical points for these components. The power spectrum of atmospheric turbulence to be used and appropriate values of scale of turbulence are shown in 3.5.2.3 and Table III. Design loads shall be the greater loads of the analyses in 3.5.2.1 and 3.5.2.2.

TABLE III. Turbulence field parameters.

Altitude (Ft)	Mission Segment	Direction	P_1	b_1	P_2	b_2	L (Ft)
0-1,000	Low Level Contour	Vertical	1.00	2.7	10^{-5}	10.65	500
0-1,000	Low Level Contour	Lateral	1.00	3.1	10^{-5}	14.06	500
0-1,000	Climb, Cruise, Descent	Vertical & Lateral	1.00	2.51	0.005	5.04	500
1,000-2,500	Climb, Cruise, Descent	Vertical & Lateral	0.42	3.02	0.0033	5.94	1750
2,500-5,000	Climb, Cruise, Descent	Vertical & Lateral	0.30	3.42	0.0020	8.17	2500
5,000-10,000	Climb, Cruise, Descent	Vertical & Lateral	0.15	3.59	0.00095	9.22	2500
10,000-20,000	Climb, Cruise, Descent	Vertical & Lateral	0.062	3.27	0.00028	10.52	2500
20,000-30,000	Climb, Cruise, Descent	Vertical & Lateral	0.025	3.15	0.00011	11.88	2500
30,000-40,000	Climb, Cruise, Descent	Vertical & Lateral	0.011	2.93	0.000095	9.84	2500
40,000-50,000	Climb, Cruise, Descent	Vertical & Lateral	0.0046	3.28	0.000115	8.81	2500
50,000-60,000	Climb, Cruise, Descent	Vertical & Lateral	0.0020	3.82	0.000078	7.04	2500
60,000-70,000	Climb, Cruise, Descent	Vertical & Lateral	0.00088	2.93	0.000057	4.33	2500
70,000-80,000	Climb, Cruise, Descent	Vertical & Lateral	0.00038	2.80	0.000044	1.80	2500
above 80,000	Climb, Cruise, Descent	Vertical & Lateral	0.00025	2.50	0.000000	0.00	2500

3.5.2.1 Rational-probability analysis. A rational-probability analysis (RPA) shall be conducted using the general procedure of Publication SEG TDR 67-28. Application of the RPA results in ultimate (not limit) loads. The analysis shall be conducted using an acceptable failure probability of 0.0005 for one airplane, typical mission profiles for the airplane under consideration, the design fatigue life, and spectral response parameters, A and N_o, computed as specified in 3.5.2. The spectral exceedance curves, power spectral shape and scales of turbulence to be used in this analysis shall be as specified in 3.5.2.3 and Table III.

3.5.2.2 Design envelope analysis. The design envelope analysis is based on a limit load concept, and no part of the airplane's structure shall have a limit strength level less than that determined from this analysis. Scales of turbulence used to compute the response parameter, A, shall be as specified in the turbulence model given in 3.5.2.3. Limit gust loads thus derived shall be added to the mean load and multiplied by 1.5 to establish ultimate loads for comparison with RPA loads. The design limit gust velocity, Y_d/A, shall be considered to strike the airplane at all critical weight-altitude combinations with airplane speed at V_H. Y_d/A is a true gust velocity where Y_d is the incremental value of the response parameter (load, acceleration, or stress) of interest and A is defined in 3.5.2. The values of Y_d/A for each altitude shall be:

a. 40 feet per second from 0 to 1000 feet, then

b. Varying linearly to 58 feet per second at 2500 feet, then

c. Varying linearly to 62 feet per second at 7000 feet, then

d. Varying linearly to 55 feet per second at 27,000 feet, then

e. Varying linearly to 14 feet per second at 80,000 feet.

3.5.2.3 Normalized power spectrum. The scale of turbulence L, to be used to compute gust response factors in both the RPA and design envelope analysis are also shown in Table III. The normalized power spectrum of atmospheric turbulence shall be:

$$\phi n(\Omega) = \frac{L}{\pi} \frac{1 + 8/3\,(1.339 L\Omega)^2}{[1 + (1.339\,L\,\Omega)^2]^{11/6}}$$

3.5.2.4 Combined gust and maneuver loads during low level contour operations. Combined gust and maneuver loads during low level contour operation shall be determined in a rational manner by the contractor, and, if more critical than gust alone, shall be used for design. A rational-probability analysis shall be conducted using the general procedure of SEG-TR-65-04.

3.6 Workmanship. The engineering design, and related analyses shall be of professional quality prepared by qualified personnel. Any document(s) submitted shall be easily readable, correctly identified, and properly validated.

4. QUALITY ASSURANCE PROVISIONS

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

4.1.1 Responsibility for compliance. All items must meet all requirements of Section 3. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Methods of inspection.

4.2.1 Design data. Structural design and analysis data shall be in accordance with specifications MIL-D-8706 and MIL-A-8868 and the applicable DD 1423.

4.2.2 Laboratory tests. Laboratory tests shall be in accordance with MIL-D-8706 and MIL-A-8867.

4.2.3 Flight tests. Navy demonstration flight tests shall be in accordance with MIL-D-8708.

4.3 Documentation. This specification establishes the basic inputs and requirements for some of the documentation and calculations for the aircraft. The criteria to establish the design and to size certain equipments shall meet the preformance objectives as mandated by the mission(s). Hence, the visual inspection of these documents shall be as follows:

TABLE IV. Visual inspection criteria.

Inspection for	Classification of Defect
Legibility	Critical
Accuracy	Critical
Correctness	Critical
Completeness	Major
Validation	Major
Traceability	Minor
Approvals	Minor

5. PACKAGING

This section is not applicable to this specification.

6. NOTES

6.1 Intended use. The requirements of this specification are intended to be used for the structural design of airplanes as affected by inflight loads.

6.2 Ordering data.

6.2.1 Acquisition requirements.

This paragraph is not applicable to this specification.

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

6.3 Definitions. For definitions of terms used in this specification see Section 6 of MIL-A-8860, except as follows:

> Maximum longitudinal control force. The maximum longitudinal control force is a longitudinal pull force applied to the grip of the control stick (wheel) which varies linearly with control position from a value not less than 60 pounds (120 for wheel control) for control in its most rearward position, to a value not less than 200 pounds for all positions of the stick (wheel) forward of mid-position.

Control surface(s) authority. Control surface(s) authority is that combination of active feedback controls which involves a pilot force or programmed displacement input and rate of pilot force or programmed displacement input to the control surface(s) which results in the appropriate airplane response to perform its intended maneuver.

Maximum control surface(s) authority. That combination of pilot force or programmed displacement input and rate of pilot force or programmed displacement input to the control surface(s) that results in maximum loads being generated on airframe components during the maneuver for which it is specified.

6.4 Superseding data. See superseding data in Section 6 of MIL-A-8860. This specification, MIL-A-8861B(AS) supersedes MIL-A-008861A(USAF) in part and MIL-A-8861. However MIL-A-008861A(USAF) will remain in force until cancelled by the Air Force and superseded by specification MIL-A-87221(USAF).

6.5 Subject term keyword listing.

Airplane Strength and Rigidity Flight Loads.
Flight Loads, Airplane Strength and Rigidity.
Loads, Flight, Airplane Strength and Rigidity.
Rigidity, Strength and; Airplane Flight Loads.
Strength and Rigidity; Airplane Flight Loads.

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

Custodian:
Navy - AS

Preparing activity:
Navy - AS

(Project 1510-N011)

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TABLES

FIGURES

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-A-8861B(AS)	AIRPLANE STRENGTH AND RIGIDITY FLIGHT LOADS

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)*: ______
b. ADDRESS *(Street, City, State, ZIP Code)*	

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

DD FORM 1426 82 MAR

PREVIOUS EDITION IS OBSOLETE.