DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WESTERN REGION
P.O. BOX 92007, WORLDWAY POSTAL CENTER
LOS ANGELES, CALIFORNIA 90009

20 FEB 1970

In Reply
Refer to: WE-120

The Boeing Company
Commercial Airplane Group
747 Division
Seattle, Washington 98124

Attention: R.J. Schroers, Airworthiness Manager, FS OL-04

Subject : Type Certification Basis for the Boeing 747-100 Series Aircraft

Gentlemen:

The purpose of this letter is to provide a single documented summary of the subject model aircraft in order to simplify future references and avoid possible omissions in the use of such information. As you will recall we had agreed to this procedure during our final Type Certification Board Meeting.

The certification basis consists of:

(a) FAR Part 1, "Definitions and Abbreviations"

(b) FAR Part 21, "Certification Procedures for Products and Parts"

(c) FAR Part 25, "Airworthiness Standards: Transport Category Airplanes," effective 30 June 1966, with Amendments 25-1 through 25-8 plus Amendments 25-15, 25-17, 25-18, and 25-20.

(d) Special Conditions transmitted herewith dated 30 December 1969.

(e) FAR Part 36, "Noise Standards: Aircraft Type Certification"

(f) FAA approved Boeing Document D6-30801 entitled "Cabin Interior Material, Flammability Discrepancy List of Certain Airplane in Service Model 747"

Sincerely,

Rocco Lupis

for ROBERT H. STANTON
Chief, Aircraft Engineering Division

SPECIAL CONDITIONS

AIRFRAME SPECIAL CONDITIONS

1. FAR 21.21(b)(2), FAR 25.677(c) and FAR 25.695(a), (b), and (c) - Flight Controls

(Ref 2)

Eliminate FAR 25.677(c), first sentence; FAR 25.695(a), (b), and (c) and replace with:

"The aircraft must be shown by analysis, tests or both, to be capable of continued safe flight and landing after any of the following failures or jamming in the flight control system and surfaces (including trim, lift, drag and feel systems), within the normal flight envelope, without requiring exceptional piloting skill or strength:

(a) Any single failure, excluding jamming (e.g., disconnection or failure of mechanical elements, structural failure of hydraulic components, such as actuators, control spool housing and valves).

(b) Any probable combination of failures, excluding jamming (e.g. dual hydraulic system failures, any single failure in combination with any probable hydraulic or electrical failure, etc.).

(c) Any jam in a control position normally encountered during takeoff, climb, cruise, normal turns, descent and landing, unless the jam is shown to be extremely improbable or can be alleviated.

(d) Runaway to an adverse position and jam if it is probable that such runaway and subsequent jamming can occur."

2. FAR 21.21(b)(2) and FAR 25.571 - Sonic Fatigue Strength

(Ref 1)

Boeing will show by tests, analysis and supporting tests, or by the service history of airplanes of similar structural design and sonic excitation environment, that

(a) Sonic fatigue cracks are not probable in any part of the flight structure subject to sonic excitation; or

(b) Catastrophic failure caused by sonic fatigue cracks is not probable, assuming that the loads prescribed in FAR 25.571(c) are applied to all areas affected by those cracks.

3. FAR 21.21(b)(2) and FAR 25.305(c) - Continuous Turbulence

(Ref 1)

The dynamic response of the airplane to vertical and lateral continuous turbulence must be accounted for.

4. FAR 21.21(b)(2), FAR 25.471 through 25.511, FAR 25.573, FAR 25.721 through 25.727 - Landing Gear Criteria

(Ref 4)

FAR 25.471 through 25.511, FAR 25.573, FAR 25.721 through 25.727 have been retained, modified or replaced by the following paragraphs:

(a) GENERAL

The general design criteria of FAR 25.471 is directly applicable. The basic landing gear dimension data shall be expanded to include the additional main gear units.

(b) GROUND LOAD CONDITIONS AND ASSUMPTIONS

The criteria specified in FAR 25.473 is applicable for the design landing conditions except as noted in Paragraph (f).

(c) LANDING GEAR ARRANGEMENT

The multiple oleo main gear configuration does not meet the "conventional arrangement" requirement of FAR 25.477, with respect to the application of Paragraph (d) through (g). The landing impact design conditions shall meet the structural intent of FAR 25.479 through 25.485.

(d) LEVEL LANDING CONDITIONS

The level landing criteria of FAR 25.479 shall be directly applicable. The four main gear units shall be assumed to contact the ground with the airplane longitudinal axis in a horizontal attitude.

(e) TAIL-DOWN LANDING CONDITIONS

The airplane shall be assumed to contact the ground in any tail down attitude between level and maximum tail down attitude allowing clearance with the ground of each part of the airplane other than the main gear wheels. The airplane forward velocity component shall be the most critical value from V_{L_1} to 1.25 V_{L_2}, where V_{L_1} and V_{L_2} are

designed in FAR 25.481. Each main gear unit shall be designed for its most critical combination of vertical load and drag load. All other criteria in FAR 25.481 not superseded by the above criteria shall be directly applicable. The distribution of loads between the gear units for the effects of critical combinations of spin-up and spring-back loadings on the main gear units must be considered for the gear units and their supporting structure.

(f) ONE-WHEEL LANDING CONDITION

Unless the airplane and landing gears are designed for equivalent or more critical conditions, the airplane will be assumed to land in a level pitch attitude at design landing weight with a descent velocity of 7 fps at the maximum roll angle attainable within the geometric limitations of the airplane with the contact velocities and gear loading conditions of FAR 25.479(a), (b), and (c).

NOTE: This condition need not be coupled with either a 6 ft./sec. landing at maximum takeoff weight or a 12 ft./sec. reserve energy drop test.

(g) SIDE LOAD CONDITIONS

On the main gear units, side loads of 0.8 of the vertical reaction (one one side) acting inward and 0.6 of the vertical reaction (on the other side) acting outward must be combined with one-half of the maximum vertical ground reactions obtained in the level landing, tail-down landing, or rolled attitude landing conditions. These loads shall be assumed applied at the ground contact point and to be resisted by the inertia of the airplane. Drag loads may be assumed to be zero.

(h) REBOUND LANDING CONDITION

The criteria of FAR 25.487 shall be directly applicable.

(i) GROUND HANDLING CONDITIONS

The criteria of FAR 25.489 shall be directly applicable. The main gear load equalizer system shall be assumed fully effective for design limit ground handling conditions.

The assumed effectiveness of the main gear load equalizer system must be verified by appropriate full-scale ground load tests and measurements.

(j) TAKEOFF RUN

The criteria of FAR 25.491 shall be directly applicable.

The landing gear units and the landing gear support structure will be designed for a limit vertical load factor of 2.0 acting at the airplane center of gravity. The drag and side loads will be assumed zero.

(k) BRAKED ROLL CONDITIONS

The criteria of FAR 25.493 shall be directly applicable. The main gear vertical and drag loads shall be equally distributed among the main gear units.

(l) TURNING

The criteria of FAR 25.495 shall be directly applicable. The main gear vertical loads shall be assumed fully equalized on the two main gear units on one side of the airplane centerline.

(m) TAIL-WHEEL YAWING

Not applicable to this airplane.

(n) NOSE-WHEEL YAW

The criteria of FAR 25.499 shall be directly applicable. The terminology shall be interpreted to apply braking to all main gear wheels on one side of the airplane centerline.

(o) PIVOTING

The criteria of FAR 25.503 shall be applied individually to each wing main gear unit. In addition, all main gear units shall be designed for the scrubbing and/or torsion loads induced by pivoting about the most critical point consistent with the available main gear braking on one side of the airplane and the available thrust and torque on the airplane. Maximum static engine thrust must be considered only on the engines on the opposite side of the airplane centerline from the pivot point.

(p) REVERSED BRAKING

The criteria of FAR 25.507 shall be directly applicable.

(q) TOWING LOADS

The criteria of FAR 25.509 shall be directly applicable.

(r) GROUND LOAD: ASYMMETRICAL LOADS ON MULTIPLE-WHEEL UNITS

The criteria of FAR 25.511 shall be directly applicable.

(s) FATIGUE EVALUATION OF LANDING GEAR

The criteria of FAR 25.573 shall be directly applicable.

(t) SHOCK ABSORPTION TESTS

The nose gear, body main gear, and wing main gear shall be separately drop tested to the requirements of FAR 25.721 through 25.727. Distribution of effective weight on the wing or body main gear unit shall be made in a rational or conservative manner consistent with the airplane attitude being simulated. The effect of the load equalizer system shall be simulated during the wing and body main gear drop tests.

NOTE: The wing landing gear need not be drop tested in the one-wheel landing condition coupled with the 6 ft./sec. maximum takeoff weight landing or the 12 ft./sec. reserve energy landing.

(u) Documented substantiation of the design criteria shall include a dynamic taxi analysis, dynamic landing analysis, and pertinent gear load data obtained from gear instrumentation during flight testing.

5. FAR 21.21(b)(2) and FAR 25.609 - Main Landing Gear Structural Considerations

(Ref 1)

The main landing gear system must be designed so that if it fails due to overloads during takeoff and landing (assuming the overloads are symmetrical about the longitudinal axis of the airplane) the failure mode is not likely to puncture any part of the fuel system including that contained in the fuselage.

6. FAR 21.21(b)(2) and FAR 25.561 - Wheels-Up Landing Emergency Condition

(Ref 1)

The airplane must give each occupant every reasonable chance of escaping serious injury when the airplane is assumed to make a wheels-up landing on a prepared runway.

SYSTEMS AND EQUIPMENT SPECIAL CONDITIONS

1. FAR 21.21(b)(2) - Operation Without Electrical Power

(Ref 1)

Boeing will demonstrate in flight at the maximum certificated altitude satisfactory operation of the airplane for a period of not less than five minutes with the electrical power systems inoperative, including AC power and battery. The five minute period is based on the time considered necessary for a flight crew to diagnose the difficulty and return the operative portion of the sytem to service.

2. FAR 21.21(b)(2), FAR 25.803 - FAR 25.815, and FAR 25.853 - Passenger Evacuation and Crashworthiness

(Ref 1)

Additional and revised passenger evacuation and crashworthiness requirements are listed in Boeing Document "Special Passenger and Crashworthiness Requirements for Type Certification-Model 747," D6-30800, which must be approved by the Chief, Aircraft Engineering Division, FAA Westen Region.

3. FAR 21.21(b)(2) - Pressurization System

(Ref 1)

Since the maximum certificated altitude is to be more than 40,000 feet, the cabin altitude shall not exceed 40,000 feet after the loss of a typical skin panel bound by the crack stopper pattern, door seal, window, or windshield, unless the design is such that a loss of windshield is extremely remote. Compliance may be demonstrated by analysis, considering approved emergency descent procedures with a 17 second delay after the 10,000 feet warning horn has sounded.

4. FAR 21.21(b)(2) - Inertial Navigation System

(Ref 5)

"When attitude information and either heading information or heading stabilization is supplied by a single stabilized source to the bank and pitch indicator required by FAR 25.1303(a)(7) and the direction indicator required by FAR 25.1303(a)(8), and by a second single stabilized source to duplicates of these instruments required by FAR 25.1321 or any operating rule, an additional source of attitude reference must be provided for use of the flight crew."

PROPULSION SPECIAL CONDITONS

1. FAR 21.21 (b)(2) and FAR 25.903(d) - Engine Installation

(Ref 1)

(a) The airplane shall incorporate design features with respect to the engine installation to minimize the possibility of hazard to the airplane in the event of engine rotor or blade failures or in the event of internal engine fires which may burn through the engine case.

(b) Consideration shall be given to the effect of whirl mode resulting from engine unbalance or from the effect of an engine mount failure.

2. FAR 21.21(b)(2) and FAR 25.955 - Fuel System Continuous Feed

(Ref 1)

The fuel system shall provide for continuous feed of all fuel to the engines without interruption of fuel flow due to depletion of fuel in tanks other than the main tanks.

3. FAR 21.21(b)(2) and FAR 25.959 - Unusable Fuel

(Ref 1)

The amount of fuel in each tank which becomes unusable with a critical tank pump inoperative shall be determined and included as information in the Airplane Flight Manual.

4. FAR 21.21(b)(2), FAR 25.969 and FAR 25.979 - Pressure Fueling System

(Ref 1)

(a) The pressure fueling system shall have an automatic shutoff device to prevent filling the expansion space in the fuel tanks. This device shall be checkable for proper operation before fueling and shall provide indication of failure of the device to operate.

(b) The effect on the expansion space of different ground attitudes which may be expected in service shall be determined.

(c) The fuel system shall be designed such that overfilling the tanks will not cause structural damage to the tanks from fluid pressure in the event of failure of the automatic shutoff device. Compliance with this condition shall be demonstated by test under the most critical fueling condition. This condition shall consider failure or malfunction

of fuel pressure regulation in the fuel delivery system. If the fuel tanks are not designed to withstand unregulated fuel delivery pressure, a means either to regulate manifold pressure or to prevent overpressure or to warn of overpressure in the fuel tanks shall be provided.

5. FAR 21.21(b)(2) and FAR 25.977 - Fuel Tank Outlet Screens

(Ref 1)

The fuel system outlet screens in the fuel tanks shall be of a type which is not subject to clogging by ice formation on the screen. The design shall be such as to minimize the ingestion of foreign matter through the screen.

6. FAR 21.21(b)(2) and FAR 25.997 - Fuel System Filters Ice Protection

(Ref 1)

The fuel system filters shall be protected against clogging by ice formation from water entrained in the fuel at low temperatures.

7. FAR 21.21(b)(2) and FAR 25.1015 - Oil Tank Tests

(Ref 1)

If a presurized oil tank is used, the test pressure for structural substantiation shall not be less than 5 psi above the maximum system pressure.

8. FAR 21.21(b)(2) and FAR 25.1091 - Engine Air Inlet

(Ref 1)

The engine air inlets shall be protected against the ingestion of hazardous quantities of water or slush during operation on wet runways.

9. FAR 21.21(b)(2) and FAR 25.1103 - Engine Bleed Air System

(Ref 1)

(a) The engine bleed air system shall be designed such that no hazard to the airplane will result in the event of a bleed duct failure between the bleed air source and the airplane bleed service.

(b) Engine operation shall not be adversely affected when the maximum amount of compressor bleed air is being extracted.

10. FAR 21.21(b)(2), FAR 25.1155 and (new) FAR 25.933 - Thrust Reversing System

(Ref 1)

(a) The thrust reversing system shall have means to automatically retard the power control to a low thrust position in the event of inadvertent

actuation of a thrust reverser caused by a malfunction in the reversing system. In addition, a throttle interlock in the thrust reversing system shall be provided to prevent application of thrust greater than forward idle thrust when the thrust reverser is not in the position for reverse thrust, except that a higher forward thrust level will be acceptable at the reverse interlock position if it is shown that directional control of the airplane can be maintained under the most critical reversing condition with a malfunction of a reverser.

(b) If the thrust reversers are not type certificated with the engine, they shall be substantiated by compliance with FAR 33.97 or by tests that will provide equivalent reliability.

(c) Reverse thrust operation shall have no detrimental effect on the aircraft from contamination of cabin air, exhaust gas impingement on structure or ingestion of debris into the engine air intake.

11. FAR 21.21(b)(2) and FAR 25.1141 - Engine Control Systems

(Ref 1 and Ref 6)

The powerplant control system shall be investigated to show that no single failure or reasonable combination of failures in the aircraft installed components of the system will cause a hazardous condition which cannot be safely controlled in flight.

12. FAR 21.21(b)(2) and FAR 25.1163 - Engine Ignition System

(Ref 1)

The engine ignition system shall be capable of inflight restarting independently of the main generating system.

13. FAR 21.21(b)(2) and FAR 25.1189 - Fluid Shutoff Valves

(Ref 1)

(a) The fuel and hydraulic fluid shutoff valves shall be of fireproof construction or shall be located such that a powerplant fire will not affect their operation.

(b) The fuel shutoff valves to the engine shall be located such that shutting off fuel will not be prevented in the event of a structural failure of the engine mount causing separation of the engine from the airplane.

14. FAR 21.21(b)(2) and (new) FAR 25.1305(x) - Air Turbine Starters

(Ref 1)

The air turbine starting system shall incorporate a means of indication to the flight crew when the turbine starter is energized by the air starting system.

15. FAR 21.21(b)(2) and Proposed FAR 25.981 - Fuel Vapor Ignition Protection

(Ref 1)

The fuel system shall be protected against ignition of fuel vapors in the tanks and tank venting system from lightning strikes. Compliance with this requirement shall be based on the following:

(a) Protection against ignition of fuel vapor in or emanating from the vent outlets by direct or swept lightning strikes, as applicable, and from corona, plasma, streamering, or blast effects.

(b) Protection against vapor ignition from arcing caused by direct or swept strikes on insulated components such as filter caps and access plates.

(c) Protection against penetration of tank structure by direct or swept strikes.

(d) Protection of electrical system components which may be adversely affected by induced voltage surge.

16. FAR 21.21(b)(2) and FAR 25.939 - Negative Acceleration

(Ref 1)

It shall be demonstrated that under conditions of negative acceleration appropriate to the operation of the airplane that engine malfunction due to fuel supply interruption does not occur and that no hazardous condition will result from the effects of negative acceleration on other systems in the airplane.

17. FAR 21.21(b)(2) and (new) FAR 25.939(c) - Compressor Blade Vibration

(Ref 6)

The engine installation shall be investigated to show that compressor blades are not adversely affected by inlet airflow characteristics under various flight conditions (stall, yaw, rotation, etc.) such as to cause blade vibration stresses in excess of stress levels which have been substantiated as satisfactory for continuous operation.

18. FAR 21.21(b)(2) and FAR 25.1183 - Lines and Fittings

(Ref 6)

The powerplant installation should be designed to minimize the possiblity of flammable fluid leakage of aircraft installed components on hot sections of the engine which will result in a fire or exposion hazard.

FLIGHT TEST SPECIAL CONDITIONS

1. FAR 21.21(b)(2) - Operational V-N Envelope

(Ref 2)

With the airplane in the cruise configuration, the positive maneuvering load factors at which the onset of buffeting occurs must be determined for the ranges of airspeed or mach number, weight and altitude for which the airplane is to be certificated, except that load factors greater than the structural limitations need not be investigated. The envelopes of load factor versus speed and altitude so determined must provide a sufficient range of speeds and load factors for normal operations (0.5 g's minimum). Probable inadvertent excursions beyond the boundaries of the buffet onset envelopes must not result in unsafe conditions.

Information shall be included in the airplane Flight Manual which will permit the flight crew to determine the combinations of altitude, speed, weight, and maneuvers which may be flown without encountering such conditions.

2. FAR 2.21(b)(2) - Environmental Testing

(Ref 1)

This special condition requires that one or more test aircraft be instrumented at the pilot's seat and at aircraft C.G. to record vertical and horizontal accelerations, frequencies and amplitudes of the dynamic response of the aircraft to turbulence. These data shall be correlated with the pilot's qualitative assessment of his ability to see and use his flight instruments and safely control the aircraft during the turbulence encountered. Turbulence has been defined in a document on Atmospheric Turbulence, as incremental vertical accelerations measured at the C.G. of the aircraft. The degree of turbulence, as defined by this document, which is encountered during the flight tests will be noted in the AFM.

3. FAR 21.21(b)(2) and FAR 25.307 - Out-Of-Trim Condition

(Ref 2)

The aircraft must have satisfactory maneuvering stability and controllability with the degree of out-of-trim which might be reasonably expected in service. The degree of out-of-trim will be that which results from a three-second movement of the primary longitudinal trim system at its highest rate with no aerodynamic load in both the airplane nose up and nose down directions, or the maximum mistrim that can be sustained by the autopilot while maintaining level flight in the high speed cruising condition, whichever is greater.

Compliance with maneuvering stability portion of this Special Condition requires that the stick force per g curve have a positive slope between -1

g and +2.5 g's at speeds up to V_{FC}/M_{FC} and there shall be no reversal in either control sensing or elevator force slope up to V_{DF}/M_{DF}.

Compliance with the controllability portion of the Special Condition requires that it shall be possible to produce at least 1.5 g's for recovery from an overspeed condition at V_{DF}/M_{DF} using the elevator alone and with not more than 125 pounds of elevator stick force or it shall be possible by use of the longitudinal trim system to produce 1.5 g's for recovery while the 125 pound elevator stick force is being applied. In those instances where buffeting or other phenomena of such intensity as to be a strong deterrent to further application of elevator stick force occurs at a lesser force and prior to developing 1.5 g's, the trim requirement must be met while that force is being applied.

The loads imposed on the airplane by these conditions shall not exceed the strength requirements for the airplane.

1. FAR 21.21(b)(2) - Inflight Thrust Reversal

(Ref 1)

Boeing will establish that no condition that could jeopardize the capability of the airplane to terminate its flight safely will result from the inflight application of reverse thrust unless it can be shown that the means to prevent inadvertent application of reverse thrust provided in accordance with FAR 25.1155 is sufficiently effective to establish that the possibility of inflight reversal, inadvertent or deliberate, is extremely unlikely. The conditions and/or operation procedures under which the thrust reverser can be returned to the forward thrust position shall be defined and demonstrated.