Exemption No. 5758

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
RENTON, WASHINGTON 98055-4056

In the matter of the petition of **The Boeing Company** for an exemption from § 25.1435(b)(1) of the Federal Aviation Regulations	**Regulatory Docket No. 27384**

PARTIAL GRANT OF EXEMPTION

By letter of July 9, 1993, Mr. John A. Miller, Chief Engineer, Airworthiness, 777 Division, The Boeing Company, P.O. Box 3707, Seattle, WA, 98124-2207, petitioned for exemption from the static pressure test requirement of § 25.1435(b)(1) of the Federal Aviation Regulations (FAR), for the hydraulic system on the Boeing Model 777-200 airplane. By letter of August 18, 1993, Mr. Timothy E. Hickcox, Manager, Certification, 777 Division, The Boeing Company, provided clarifying and additional information in support of the same petition for exemption.

Section of the FAR affected:

> Section 25.1435(b)(1) states that a complete hydraulic system must be static tested to show that it can withstand 1.5 times the design operating pressure without a deformation of any part of the system that would prevent it from performing its intended function. Clearance between structural members and hydraulic system elements must be adequate, and there must be no permanent detrimental deformation. For the purpose of this test, the pressure relief valve may be made inoperable to permit application of the required pressure.

ANM-93-037-E

Related Section of the FAR:

Section 25.1435(a)(2) states that each element of the hydraulic system must be able to withstand, without rupture, the design operating pressure loads multiplied by a factor of 1.5, in combination with ultimate structural loads that can reasonably occur simultaneously. Design operating pressure is maximum normal operating pressure, excluding transient pressure.

The petitioner's supportive information is as follows:

In lieu of a ground static test (4500 psi), Boeing proposes to demonstrate compliance with § 25.1435(b)(1) by a combination of a test of the complete hydraulic system at its operating pressure (3000 psi), and component testing at 1.5 times operating pressure (4500 psi) per § 25.1435(a)(2), and airplane ground and flight testing.

Boeing asserts that the granting of this exemption with respect to testing a complete hydraulic system at 1.5 times operating pressure is in the public interest because the proposed method of demonstrating compliance will provide greater assurance of airplane safety than that required by § 25.1435(b)(1).

Boeing provides the following factors to substantiate their position that this petition for exemption not only provides for an equal or greater level of safety, but eliminates inefficiencies and added cost as well.

Purpose of § 25.1435(b)(1), Pressure Test/Measured Deflections.

The purpose of § 25.1435(b)(1) is to show adequate separation between hydraulic system elements and structure and that there will be no permanent detrimental deformation that would prevent the system from performing its intended function. To ensure hydraulic system integrity and no contact between hydraulic lines, structure, or surrounding systems, Boeing's design & installation requirement is to maintain a minimum 0.25 inch clearance envelope around all tubing in excess of expected motion.

Additionally, Boeing has concluded from pressure testing in the Flight Controls Test Rig (FCTR), that tubing deflections due to pressurization are so minimal that testing at 4500 psig provides no perceivable benefits. In fact, the pressure testing reveals that without instrumentation, it is difficult, if not impossible, to tell that the tubing has deflected. Measured deflections were 0 to 0.0065 inches, which Boeing considers to be well within the design envelope (Note: FCTR figures/photographs and a plot of measured deflections from three separate test setups were submitted as substantiating data).

Improved Design Processes.

On the 777 program, Boeing has used improved processes and contemporary plumbing technology to assure an accurate initial installation with proven hydraulic components. As part of a Digital PreAssembly (DPA) buy-off process, Boeing's design, analysis, safety, and certification groups study computer aided, three-dimensional interactive applications (CATIA) models in detail to ensure that the design meets all requirements before, during, and after design release.

Present Test Method.

Boeing states that the present 4500 psig static test would require disabling of all relief valves, disconnection of all fly-by-wire flight control packages with their own relief valves, and disabling of all hydraulic motors. In addition, the structure that the landing gear is connected to may yield under the 1.5 times normal pressure load, so the landing gear actuators must be disconnected from the hydraulic system. Disabling so many of the hydraulic components results in deactivation of most of the hydraulic system. Thus, normal operation of the hydraulic system is impossible, and transient effects, relative motion, and system interaction cannot be seen.

Boeing further states that the 777 4500 psig test would require the following changes: The brake accumulator, ram air turbine ground checkout module, brakes, brake circuit relief valve, stabilizer trim motors, flap motor, slat motor, all primary flight control packages (a total of twenty nine power control units (PCUs) for the ailerons, spoilers, flaperons, elevators, and rudder), main gear actuators, main gear door open/close actuators, nose gear actuators, and hydraulic pump pressure hoses would be disconnected. The system pressure relief valves would be plugged. Hydraulic pressure, provided by a ground power source, would be connected directly to the associated pump's pressure hose.

Complicated changes are required for deactivation and major reconfiguration of the hydraulic system via Flight Configuration Changes (FCs), followed by removal of all FCs to restore all components and systems to the basic configuration. Boeing asserts that the associated paperwork and added cost (work and rework), without any added benefit, make the present test inefficient and non-value added.

Proposed Test Method, Including Airplane Testing.

The 3000 psig test proposed by Boeing would test the complete system under normal operating conditions (nothing disabled), and the resulting effects of hose and tubing sweeps in conjunction with control surface movement(s) can be observed. Boeing asserts that this test method will provide a more complete view (greater level of safety) of system operation when compared to the semi-static or completely static 4500 psig test.

The proposed test would be more efficient in that no FCs would be installed, normal 3000 psig test pressure would be used without any restrictions, and other airplane factory work and testing could be conducted concurrently.

Boeing still intends to perform the static proof pressure testing on all components at 4500 psig, subject to 3000 psig operation, during component qualification testing.

Additionally, during the 777-200 airplane test program, Boeing will conduct ground and flight testing to help verify that the hydraulic system performs its intended function and, hence, airplane safety is ensured. Normal flight conditions, as well as non-normal conditions (e.g. refused takeoff (RTO), stall recovery, simulated dual engine out (ram air turbine (RAT) operation)), will be conducted. Airplane ground and flight testing will demonstrate hydraulic system performance for compliance with §§ 25.671(c), 25.672(a), 25.1309(a), (c), and (d), and 25.1435(b)(2), and RAT operation for compliance with § 25.671(d). The early extended range twin engine operations (ETOPS) flight test program will impose a minimum of one thousand cycles on the airplane, thus providing greater test coverage than any previous commercial airplane test program.

Historical Perspective and Precedent.

Boeing notes that in an examination of the historical records of eight previous certification programs (Boeing 707-120, 727 E002, 737-300, 747 RA002, 747 SP, 747-400, 757-NA001 & NA002, and 767 VA002), proof pressure tests have disclosed problems that would also have been found at 3000 psig, which makes the 4500 psig test a non value-added test. The types of problems found were minor leaks, loose B nuts, missing clamps, crossed hydraulic lines, and tubing interferences due to installation errors (not due to pressurization/deflection).

Boeing states that none of these past tests revealed deformation in the hydraulic systems that would have prevented performance of their intended functions and further notes that tubing interferences are not a significant airplane in-service problem. Past tests have not caught problems that primarily contribute to hydraulic system losses. The primary causes of hydraulic system loss due to leakage include vibration induced by pump ripple, or installation of tubing in high vibration environments.

Boeing notes that in the past the FAA has accepted pressure testing at 3000 psig in lieu of 4500 psig (e.g., the 747-400 tail section test waiver). The tail section of the 747-400 was replumbed and required a pressure test. The pump that was available for the test was unable to pressurize the system to 4500 psig due to normal system hydraulic internal leakage. The FAA then granted a waiver for a 3000 psig test, which was completed satisfactorily. The 767 power transfer unit installation had a waiver with no pressure test requirement. Also, pressure testing for all of the engine modifications (new installations) after initial certification have been waived by the FAA.

In view of the substantiating factors detailed above, Boeing asserts that its proposed method of pressure testing of the complete hydraulic system of the 777 airplane is in the public interest, as it provides greater assurance of safe operation and does not impose inefficiencies and added cost (work and rework) associated with the static pressure test defined in § 25.1435(b)(1) and hereby petitions the FAA to grant the subject exemption.

A summary of the petition was published in the Federal Register on August 11, 1993 (58 FR 42752). One commenter responded to the request for comments. The commenter supports the petitioner's reasons, from a practical and economic standpoint, for not testing at 4500 psig, but recommends testing at the maximum system relief pressure, which the commenter believes is 3,750 psig (or 1.25 times the design operating pressure of 3,000 psig).

The Federal Administration's analysis/summary is as follows:

The FAA has carefully considered the information provided by the petitioner, and has determined that there is sufficient merit to warrant a partial grant of exemption.

Purpose of § 25.1435(b)(1).

The FAA concurs that the purpose of § 25.1435(b)(1) is as stated by the applicant. While the tubing deflection tests conducted by the applicant on its FCTR test setup are not exhaustive, they are a quantitative indicator of the expected deflections and thereby required separation between components. In this regard, the applicant's design and installation requirements to ensure adequate clearance are satisfactory.

Improved Design Processes.

Even with improved design processes, errors are possible. The pressure test is intended to identify problems related to possible errors in the design process. Therefore, the FAA does not concur that improved processes provide a level of safety equivalent to testing at the required pressure. However, the FAA concurs that the DPA buy-off checks process instituted by the applicant is a contributing factor to ensure compliance to an acceptable level of safety.

Present Test Method.

Section 25.1435(b)(1) acknowledges the existence of and the need to deactivate relief valves in the hydraulic systems during proof pressure tests. The FAA concurs that due to deactivation of various components, the hydraulic systems are out of configuration during the test, additional paperwork is required, and added cost is incurred.

The FAA does not concur that it is a non-value added test simply because it is inconvenient to conduct at pressures higher than 3000 psig. There is merit in testing the total system at pressures greater than 3000 psig since even under normal operation, the hydraulic systems generate pressures exceeding 3000 psig and most components are subjected to it. The various relief valve settings in the 777 hydraulic systems and components range between 3600 and 3900 psid (d=differential). It is therefore feasible, with nothing disabled, to run the test at pressures in excess of 3000 psig, but less than most relief valve settings (e.g., 3600 psid).

Proposed Test Method.

The FAA concedes that the proposed dynamic test (with nothing disabled) may be a better test than the required static test, and that it may meet the intent of the rule at an acceptable level of safety, provided it is run at or near the relief valve setting as discussed above, and in combination with other tests proposed by the applicant. (The FAA is considering a rule change to reflect this as part of the activities of the Hydraulic Test Harmonization Working Group of the Aviation Rulemaking Advisory Committee.)

Historical Perspective and Precedent.

The successful completion of pressure tests on past programs is not relevant justification for a reduced pressure test. The examples of past instances where the FAA did not require pressure testing to 1.5 times the design operating pressure were only for limited changes to the airplane. The amount and locations of changes were evaluated by the FAA prior to granting a waiver. It was possible in these cases for the FAA to determine, by inspection, that clearances around the modified hydraulics were sufficient to preclude problems that would be found during a pressure test. In summary, the past waivers are not applicable to the petition.

Disposition of Public Comment.

The commenter's assertion that the system should be tested at 3,750 psig is based on the assumption that 3,750 psig is the maximum system relief pressure. Because the actual maximum system relief pressure is 3,600 psig, the action being taken is consistent with the commenter's apparent intent.

In consideration of the foregoing, I find that a partial grant of exemption is in the public interest. Therefore, pursuant to the authority contained in §§ 313(a) and 601(c) of the Federal Aviation Act of 1958, delegated to me by the Administrator (14 CFR 11.53), the Boeing Company is hereby granted an exemption from § 25.1435(b)(1) of the FAR to the extent necessary to permit type certification of the Model 777-200 by testing of the complete hydraulic system at 1.25 times the design operating pressure, or the system relief pressure, if lower, but not less than 3600 psig,

in lieu of 1.5 times the design operating pressure. All test results pertinent to this exemption must be documented in a report and a copy provided to this office.

Issued in Renton, Washington, on October 1, 1993.

/s/ Ronald T. Wojnar
Manager, Transport Airplane Directorate
Aircraft Certification Service