Exemption No. 7476

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 § 25.335(e)(3) of Title 14, Code of Federal Regulations	**Regulatory Docket No. 29893**

GRANT OF EXEMPTION

By letter dated November 19, 1999, H. Gail Sandford, Project Manager MD-17 Certification, The Boeing Company, 2401 E. Wardlow Road, Long Beach, CA 90807-5309, petitioned for an exemption from the design flap speed requirements of § 25.335(e)(3) of Title 14, Code of Federal Regulations (14 CFR) for the model MD-17 freighter airplanes. The proposed exemption, if granted, would allow the design flap speeds for the MD-17 to be calculated based on a power-on stall speed with the critical engine inoperative and the operative engines at the power setting appropriate for the flight condition.

The petitioner requests relief from the following regulation:

> **Section 25.335(e)(3)** - Specifies minimum design flap speeds, V_F, based on power-off stall speeds multiplied by an appropriate factor (1.6 for takeoff, and 1.8 for approach and landing). The intent of this requirement is to ensure the design flap speeds have adequate speed margin above the operational speeds of the airplane.

Related sections of 14 CFR:

> **Section 25.335(e)(1)** provides the general requirement that design flap speeds "must be sufficiently greater than the operating speed recommended for the corresponding stage of flight (including balked landings) to allow for probable variations in control of airspeed and for transition from one flap position to another."

> **Section 25.1511** requires that flap extended speeds, V_{FE}, be established for each flap position so that they do not exceed the design flap speeds, V_F.

Section 25.345 specifies certain structural load conditions at the design flap speeds, V_F. These include maneuvers, vertical and head-on gust conditions, and thrust impingement loads.

Section 25.321(d) includes a general requirement for consideration of critical thrust values when evaluating flight loads on the airplane.

Section 25.697(d) requires that the flap device control be designed to retract the surfaces from the fully extended position, at maximum continuous engine power, at any speed below V_F plus 9 knots.

The petitioner supports its request with the following:

"Pursuant to the Federal Aviation Administration procedures for processing petitions for rulemaking (Title 14 CFR Part 11 Subpart B), and specifically section 11.25 thereof, The Boeing Company, manufacturer of McDonnell Douglas MD-17 model aircraft, hereby files subject petition for an exemption from the requirements of FAR 25.335(e)(3) for the model MD-17 freighter airplanes.

"1.0 Substance of rule from which relief is sought:

"Section 25.335(e)(3) at Amendment 25-87 requires that the design flap speeds, V_F, may not be less than:

"(i) 1.6 V_{S1} with the flaps in takeoff position at maximum takeoff weight;
(ii) 1.8 V_{S1} with the flaps in approach position at maximum landing weight;
(iii) 1.8 V_{S0} with the flaps in landing position at maximum landing weight.

"2.0 Nature and extent of relief sought:

"2.1 Stall Speed Basis

"Section 25.335(e)(3): Relief is sought to allow design flap speeds, V_F, to be calculated based on a power-on stall speed with the critical engine inoperative and the operative engines at the power setting appropriate for the flight condition. The power-on reference stall speed, V_{SRPWR}, is defined as a speed not less than a 1-g power-on stall speed, which is a calibrated airspeed determined in the stalling maneuver and expressed as:

"$V_{SRPWR} = V_{CLMAX} / \sqrt{n_{ZW}}$

"Where:

"V_{CLMAX} = Speed occurring when lift coefficient is first a maximum;

"n_{zw} = Flight path normal load factor (not greater than 1.0) at V_{CLMAX};

"V_{SRPWR} is determined with:

"(i) The critical engine inoperative and the power or thrust setting on the remaining engines at the minimum power or thrust level appropriate for the flight condition used to show compliance with a required performance standard;

"(ii) The airplane in other respects (such as flaps and landing gear) in the condition existing in the test in which V_{SRPWR} is being used;

"(iii) The weight used when V_{SRPWR} is being used as a factor to determine compliance with a required performance standard;

"(iv) The center of gravity position that results in the highest value of the power-on reference stall speed; and

"(v) The airplane trimmed for straight flight at a speed selected by the applicant, but not less than 1.18 V_{SRPWR} and not greater than 1.36 V_{SRPWR}.

"This definition of V_{SRPWR} is consistent with the FAA-proposed Special Condition 1., "Stall Speeds and Minimum Operating Speeds," for the McDonnell Douglas MD-17.

"2.2 Flap Design Factor

"For the full flap configuration of the airplane only, relief is sought from FAR 25.335(e)(3)(iii) to allow the design flap speed, V_F, to be calculated based on a design speed factor of 1.6, rather than 1.8. The full flap configuration is used during steep approach and landing operations.

"3.0 Description of aircraft covered:

"The MD-17 airplane is an all cargo airplane designed to carry outsized and special cargo into short and/or austere fields and to provide special cargo delivery capabilities not available with any other airplane type certified by the FAA. The Boeing MD-17 is a pressurized, transport category airplane powered by four turbofan engines that are positioned to provide power-augmented-lift. The unique design features of the MD-17 allow it to operate at airports with very short runways.

"The MD-17 has an externally-blown flap (EBF), which is a fixed-vane, double-slotted flap that is deflected directly into the engine exhaust stream. The resulting flap/exhaust stream interaction provides augmented powered lift relative to conventional transport category airplane designs, allowing slow takeoff and landing speeds, steep approach capabilities, and precise flight path and touchdown control for short runway operations.

"The MD-17 will normally operate with full flaps only during steep approach and landing operations. Normal approach and landing operations are accomplished using 3/4 flap, and at this flap setting, the MD-17 will comply with the current 1.8 flap design speed factor.

“4.0 Information provided in support of petition:

"FAR Part 25 flap design speeds (V_F) are derived from power-off stall speeds in a specific configuration (§25.335(e)(3)). Appropriate multiplying factors (1.6 for takeoff, and 1.8 for approach and landing) are applied to these power-off stall speeds to obtain design flap speeds for each flap position (§25.335(e)(3)). The resulting flap design speeds are defined to be sufficiently greater than the operating speed recommended for the corresponding stage of flight (§25.335(e)(1)). The factors allow for probable variations in pilot control of airspeed, speed additives for gusts, crosswind components, wind gradients, engine out and for transition from one flap position to another (§25.335(e)(1)).

"Once flap design speeds have been determined in each phase of flight, flap loads are developed taking into account separate criteria for maneuver load factor, vertical gust, and head-on gust (§25.345).

"The MD-17 blown flap design results in significant dependencies between thrust level, stall speeds, and thrust impingement loads not envisioned by the current regulations. Consequently, the current FAR rule for determining flap design speeds, V_F, is not appropriate for the novel MD-17 power-augmented-lift design. The rationale supporting our petition for exemption follows:

“4.1 The MD-17 power-augmented-lift design realizes a significant beneficial effect on stall speed from power effects:

"At the conditions applicable to the determination of the takeoff speed, V_2, the MD-17 achieves a 15 percent reduction in critical-engine-inoperative power-on stall speed (V_{SRPWR}).

"At approach thrust, the MD-17 achieves over a 50 percent increase in lift due to power-augmented-lift effects. This results in a stall speed reduction of approximately 20 percent with approach thrust at maximum landing flap relative to the zero thrust stall speed.

"Because there are no provisions in Part 25, for reducing the operational approach speeds to take into account the beneficial effects of power-augmented-lift on stall speeds, Boeing and the FAA have proposed, as part of a special condition, a "power-on stall speed" appropriate for operational speed determination. The same power-on stall speed definition is being proposed as the appropriate basis for the MD-17 design flap speeds.

“4.2 Backside design features result in stable operational thrust level during approach and landing:

"The MD-17 is designed to fly steep landing approaches using "backside techniques" which rely on thrust to control flight path angle and pitch to control airspeed. The MD-17 integrated design provides some unique differences in throttle usage during the approach and landing compared to conventional transports. Only minor thrust modulation is necessary during the approach and landing to maintain or recover the desired flight path. The design features and operational procedures of the MD-17 discourage the use of large throttle adjustments. The Direct Lift Control (DLC) feature, actuated via push button switches on the throttles, is used to provide rapid control of the flight path in the down direction without throttle movement.

"Separate from the DLC function, the spoilers are biased upward in the flaps-extended configuration. In this configuration, the spoilers are electronically linked to the throttles to provide an airplane response equivalent to instantaneous engine response to thrust lever movement. This feature provides a high level of control feedback and further minimizes the need for thrust adjustments. As a result of these design features and backside approach procedures, only small adjustments of thrust are required during the approach and landing flight phases.

“4.3 Use of full flap normally occurs only at or near the final steep approach airspeed:

"The MD-17 use of full flap will usually occur during final approach after the airspeed has stabilized at or near the final steep approach airspeed of 1.2 V_{SRPWR}. The MD-17 is designed to fly steep landing approaches using "backside techniques" which rely on thrust to control flight path angle and pitch to control airspeed. The MD-17 will normally be operated with less than full flap up until the aircraft is slowed to an airspeed near the final steep approach airspeed of 1.2 V_{SRPWR}.

“4.4 Flap loads will account for thrust impingement effects due to the flap being deflected directly into the engine exhaust stream:

"Thrust impingement effects will be calculated using maximum continuous thrust (MCT) at the design flap speed, V_F, with all engines operating, except during go-around or balked landing.

"During a go-around or balked landing, where the power is increased to maximum takeoff thrust, the MD-17 airspeed will be 1.2 V_{SRPWR}. The airspeed during go-around or balked landing does not differ appreciably from the final approach airspeed because of the MD-17 backside characteristics where increased thrust increases flight path angle rather than airspeed. The slipstream effects considered for propeller aircraft are analogous to the thrust impingement effects for the MD-17. Therefore MD-17 flap loads will be evaluated at a speed equal to 1.4 V_{SRPWR}, with thrust impingement effects based on maximum take-off thrust. This approach for calculating thrust impingement effects provides an equivalent level of safety to that of current propeller aircraft for the balked landing scenario (FAR 25.345(b)(1)).

“4.5 The Boeing design flap load requirements appropriately reflect the novel MD-17 power-augmented-lift design features:

"In the interest of providing the public with a safe aircraft, Boeing intends to comply with FAR 25 requirements for calculating flap loads in the following manner:

"(1) Flap design speeds will be based on the critical-engine-inoperative power- on stall speed (V_{SRPWR}). The thrust level used to determine stall speed for each flight condition is:

"(a) Takeoff: Maximum takeoff thrust on three engines with critical engine inoperative.
b) Approach and Landing: Thrust on three engines to maintain the approach flight path angle at 1.2 V_{SRPWR} with critical engine inoperative.

"(2) The flap design speed, V_F, for a steep approach at the full flap position for landing will be 1.6 V_{SRPWR}. Based on C-17 design and analysis, the MD-17 maximum flap extended speed, V_{FE} , for full flaps, with maximum flap index, is expected to be 175 knots with a design flap speed, V_F, of 181 knots. Thus there is a 6 knot margin at the maximum full flap deflection.

"(3) The flap design speed, V_F, for the normal approach at the 3/4-flap position for landing will be 1.8 V_{SRPWR}

"(4) Thrust impingement effects for approach and landing will be evaluated with maximum continuous thrust with all engines operating at V_F. MD-17 flap loads will also be evaluated at a speed equal to 1.4 V_{SRPWR}, with maximum take-off thrust.

“4.6 MD-17 steep approach speed margins are equivalent to those of conventional transports:

"Flap design factors in 25.335(e) are intended to create a safe margin between the actual operational speed and the flap structural design speed. The factor covers a wide range of contingencies including variability in pilot airspeed control, speed additives for gusts, crosswind components, wind gradients, engine out and for transition from one flap position to another (§25.335(e)(1)).

"Conventional transports have "airspeed additives" to the landing approach speed to allow for probable variations in control of airspeed, speed additives for gusts, crosswind components, wind gradients and for an engine out. The MD-17 has no airspeed additives because it is designed to fly steep approaches using backside techniques. MD-17 approach speeds are based on providing adequate margin from stall in the event of loss of thrust on the critical engine during approach, or for an all engine approach. This results in the same approach speed for either case thus providing the same speed margins relative to the flap design speed. The MD-17 is designed to be flown at backside airspeeds (thrust controls flight path and pitch controls airspeed). In the backside regime, the aircraft has greater inherent speed stability and is safer to operate without airspeed additives.

"The following is a comparison of the ratio between operating speed and flap design speed comparing conventional transports with 15 knot allowable approach speed additives to the MD-17 with the steep approach short field landing design speed factor of 1.6:

"Conventional Transport (DC-9-30 at maximum landing weight)

"Flap design/placard speed with full flaps = 180 knots
Operating speed with airspeed additives = 1.3 * 98.6 +15 = 143.2 knots
Ratio 180/143.2 = 1.26

"Conventional Transport (MD-80 at maximum landing weight)

"Flap design/placard speed with full flaps = 195 knots
Operating speed with airspeed additives = 1.3 * 102 + 15 = 147.6 knots
Ratio 195/147.6 = 1.32

"MD- 17 at maximum landing weight

"V_{SRPWR} = 113
Flap design speed with full flaps = 1.6 * 113 = 181 knots
Operating speed = 1.2 * 113 = 136 knots
Ratio 181/136 = 1.333

"This comparison shows that the margin between operating speed and flap design speed is larger for the MD-17 than for conventional transports operating with a 15 knot airspeed additive. In addition, as proven by C-17 operations, airspeed deviations for the MD-17 will be less than deviations experienced by conventional transports during approach because of the much more precise speed control inherent in the MD-17 blown flap design. This comparison with conventional transports supports the statement that the MD-17 with a flap design speed factor of 1.6 has an equivalent level of safety to conventional transports.

"4.7 C-17A service experience has shown no problems related to flap loads: The MD-17 is a commercial derivative of the U.S. Air Force C-17A. The USAF fleet of 50 aircraft has accumulated in excess of 160,000 hours of flight with an excellent safety record. The C-17 has a full flap design speed of 175 knots. There have been no problems due to flap loads to date. It should also be noted that the current C-17 fleet is utilized for a significant amount of training, wherein more approaches are accomplished than would occur in normal C-17 service in the same number of flight hours. The commercial utilization of the MD-17 is expected to include fewer steep approach operations than the C-17 military utilization.

"4.8 Compliance with existing requirements would have significant adverse impacts on MD- 17:

"Due to the unique design and mission requirements of the MD- 17, compliance with the power-off stall speed basis of design flap speed requirements in §25.335(e)(3), and the design speed factor of 1.8 in §25.335(e)(3)(iii) would increase the cost of the MD-17 without a commensurate increase in safety. Enforcement of the existing FAR provisions would require a redesign of MD-17 flap structural systems, impacting not only the cost of the product, but also the mission capability of the aircraft.

"5.0 Reasons why granting an exemption is in the public interest:

"The introduction of the MD-17, with its heavy outsized cargo carrying capability and its unique short field performance, will greatly benefit the public's interest.

"The MD-17 will be used in the relatively new and growing outsize cargo air transport market. This market is currently the exclusive province of foreign air carriers. The An-124, a former Soviet Union military-developed heavy air cargo aircraft, routinely flies cargo into and across the United States. U.S. Department of Transportation data shows 228 such trips, accomplished under exemption, in 1998. The U.S. heavy manufacturing industry, infrastructure development companies, freight forwarders, humanitarian relief organizations, the space and telecommunications industry, and governments have all become users of this type of airlift. The types of cargo being hauled include the new family of large aircraft engines, spacecraft and satellites, humanitarian relief goods, construction vehicles and oil exploration equipment. The former Soviet Union designed the An-124 and the IL-76 for military transport. Since the end of the Cold War, these aircraft have been used, with little or no modification, by commercial industry, for global commercial cargo transport. The recent agreements between the U.S. and Russia, culminating in the Export-Import Bank's $1 billion loan approval, have opened the doors for U.S. companies like Pratt & Whitney, Rockwell Collins and Sundstrand to supply components for Russian passenger and cargo aircraft. The U.S. government should support MD-17 early market entry to compete in this market.

"The MD-17 represents a U.S. built product with new capabilities to further expand this emerging market. In addition to handling heavy and outsize cargo, the MD-17 is also environmentally-controlled and capable of utilizing smaller airfields. These capabilities open new opportunities for damage-sensitive cargo and for capacity expansion of increasingly congested primary airports. Furthermore, this capability offers new shipping alternatives for industry involved in infrastructure development in remote world regions that often lack efficient transportation networks.

"Production of the MD-17 benefits a highly skilled aerospace workforce throughout California and 38 other states with 65 percent of the supply base consisting of small businesses. Furthermore, aircraft sales represent a large positive contributor to U.S. balance of trade. MD-17 sales abroad can have a favorable impact to net exports, a key input in the Gross Domestic Product equation. The aircraft also represents an example of U.S. policy to develop dual use technologies and to promote U.S. industry while protecting export technologies.

"The benefits associated with the co-production of the MD-17 and the C-17A will benefit the United States Air Force. The MD-17 commercial cargo aircraft can be a valuable addition to the United States Civil Reserve Air Fleet (CRAF) program by introducing a capability not currently present in the program. This aircraft may also offer an alternative for NATO allies to contribute increased airlift in support of world humanitarian and peace-keeping efforts.

"Granting the exemption so that the MD-17 can be introduced will benefit the public by the introduction of a reliable alternative for air transport of heavy/outsized equipment serving two to three times as many airports as the existing freighter aircraft as well as reducing the C-17 acquisition cost (taxpayer burden). Additionally, domestic air carriers operating the MD-17 will increase revenue for the U.S. and potentially establish early entrant dominance in the emerging heavy, outsized air cargo industry. While the MD-17 remains unmatched in capability, this early entrant advantage will enable the U.S. industry to better preempt the current and future entrants, e.g., the Russian AN-124, the Airbus Beluga, the IL-76, the An-70, and the Airbus FLA.

“6.0 Summary of Boeing Petition

"This petition addresses FAR Part 25, Section 25.335(e)(3) at Amendment 25-87, which is included in the MD-17 Certification Basis. It is requested that MD-17 calculations of flap design speeds be exempt from the requirement to use power-off stall speeds. In addition, it is requested that MD-17 calculations of flap design speed for full flaps be exempt from the requirement to use a design flap speed factor of 1.8. The Boeing design methodology, based on power-on speeds with critical engine inoperative and a 1.6 factor at full flaps for V_F, provides adequate safety.

"Accordingly, pursuant to the provisions of 14 CFR, Section 11.25, Boeing hereby petitions for an exemption as noted above for the MD-17. "

A summary of the petition was published in the Federal Register on February 28, 2000 (65 FR 10591). No comments were received.

The FAA's analysis/summary is as follows:

The design flap speeds required by § 25.335(e) of 14 CFR are used to develop structural loads as defined in § 25.345. Therefore, it is important to ensure that the design speeds are sufficiently greater than operational speeds, as stipulated by § 25.335(e)(1). In addition, § 25.335(e)(3) establishes design speed minimums based on stall speed. While the proposed design speeds for the MD-17 would not meet the minimum requirements of this sub-paragraph, the airplane would meet the general requirement that the design flap speeds be sufficiently greater than the corresponding operational speeds.

The MD-17 power-augmented-lift design results in reduced powered-on stall speeds, and therefore, allows reduced operational speeds. In addition, airspeed deviations during approach will be less than deviations experienced by conventional transports because of the more precise speed control inherent in the MD-17 blown flap design. Because of these reasons, a reduction in the flap design speeds will still allow for an adequate speed margin above operational speeds.

Special Conditions No. 25-151-SC, issued on the MD-17 airplane include provisions for reducing the operational approach speeds to take into account the beneficial effects of power-augmented-lift on stall speeds. These special conditions define a "power-on stall speed" for operational speed determination. The same power-on stall speed definition is being proposed as the appropriate basis for the MD-17 design flap speeds, and is provided below.

All of the related requirements that reference these speeds will be fully complied with once the design flap speeds have been established as outlined in the petition. Examples are the loads requirements outlined in § 25.345, and the requirement for flap extended speeds provided in § 25.1511.

The service experience on the C-17A indicates there have been no flap problems due to flap design loads. This is further evidence that the flap design criteria used on the MD-17, which is a derivative of the C-17A, will not adversely affect the safety of the aircraft.

In consideration of the foregoing, I find that a grant of exemption is in the public interest and will not significantly affect the level of safety provided by the regulations. Therefore, pursuant to the authority contained in 49 U.S.C. 40113 and 44701, delegated to me by the Administrator, The Boeing Company is hereby granted an exemption from 14 CFR § 25.335(e)(3) to the extent necessary to allow Boeing relief from the design flap speed requirements subject to the following conditions and limitations:

1. The petition is granted to the extent required to permit design flap speeds, V_F, to be calculated based on a power-on stall speed with the critical engine inoperative and the operative engines at the power setting appropriate for the flight condition. The power-on

reference stall speed, V_{SRPWR}, is defined as a speed not less than a 1-g power-on stall speed, which is a calibrated airspeed determined in the stalling maneuver and expressed as:

$$V_{SRPWR} = V_{CLMAX} / \sqrt{n_{ZW}}$$

Where:

V_{CLMAX} = Speed occurring when lift coefficient is first a maximum;

n_{ZW} = Flight path normal load factor (not greater than 1.0) at V_{CLMAX};

V_{SRPWR} is determined with:

(i) The critical engine inoperative and the power or thrust setting on the remaining engines at the minimum power or thrust level appropriate for the flight condition used to show compliance with a required performance standard;

(ii) The airplane in other respects (such as flaps and landing gear) in the condition existing in the test in which V_{SRPWR} is being used;

(iii) The weight used when V_{SRPWR} is being used as a factor to determine compliance with a required performance standard;

(iv) The center of gravity position that results in the highest value of the power-on reference stall speed; and

(v) The airplane trimmed for straight flight at a speed selected by the applicant, but not less than 1.18 V_{SRPWR} and not greater than 1.36 V_{SRPWR}.

2. In addition, the petition is granted to the extent required to permit the design flap speed, V_F, to be calculated using a multiplying factor of 1.6 (rather than 1.8) applied to the power-on stall speed, for the full flap configuration of the airplane only.

Issued in Renton, Washington, on March 27, 2001.

/s/ Ali Bahrami
Ali Bahrami
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