SUBPART B - FLIGHT

Section 1. Performance

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Section 1. Performance

Section 25.101 General.

a. **Rule text:**

(a) Unless otherwise prescribed, airplanes must meet the applicable performance requirements of this subpart for ambient atmospheric conditions and still air.

(b) The performance, as affected by engine power or thrust, must be based on the following relative humidities;

(1) For turbine engine powered airplanes, a relative humidity of --

(i) 80 percent, at and below standard temperatures; and

(ii) 34 percent, at and above standard temperatures plus 50° F.

Between these two temperatures, the relative humidity must vary linearly.

(2) For reciprocating engine powered airplanes, a relative humidity of 80 percent in a standard atmosphere. Engine power corrections for vapor pressure must be made in accordance with the following:

Altitude H (ft.)	Vapor pressure e (in. Hg)	Specific humidity w (Lb. moisture per lb. dry air)	Density ratio / = 0.0023769
0.0	.403	.00849	.99508
1,000.	.354	.00773	.96672
2,000.	.311	.00703	.93895
3,000.	.272	.00638	.91178
4,000.	.238	.00578	.88514
5,000.	.207	.00523	.85910
6,000.	.1805	.00472	.83361
7,000.	.1566	.00425	.80870
8,000.	.1356	.00382	.78434
9,000.	.1172	.00343	.76053
10,000.	.1010	.00307	.73722
15,000.	.0463	.001710	.62868
20,000.	.01978	.000896	.53263
25,000.	.00778	.000436	.44806

(c) The performance must correspond to the propulsive thrust available under the particular ambient atmospheric conditions, the particular flight condition, and the relative humidity specified in paragraph (b) of this section. The available propulsive thrust must correspond to engine power or thrust, not exceeding the approved power or thrust less --

(1) Installation losses; and

(2) The power or equivalent thrust absorbed by the accessories and services appropriate to the particular ambient atmospheric conditions and the particular flight condition.

(d) Unless otherwise prescribed, the applicant must select the takeoff, en route, approach, and landing configurations for the airplane.

(e) The airplane configurations may vary with weight, altitude, and temperature, to the extent they are compatible with the operating procedures required by paragraph (f) of this section.

(f) Unless otherwise prescribed, in determining the accelerate-stop distances, takeoff flight paths, takeoff distances, and landing distances, changes in the airplane's configuration, speed, power, and thrust, must be made in accordance with procedures established by the applicant for operation in service.

(g) Procedures for the execution of balked landings and missed approaches associated with the conditions prescribed in § 25.119 and § 25.121(d) must be established.

(h) The procedures established under paragraphs (f) and (g) of this section must --

(1) Be able to be consistently executed in service by crews of average skill;

(2) Use methods or devices that are safe and reliable; and

(3) Include allowance for any time delays, in the execution of the procedures, that may reasonably be expected in service.

(Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-38, 41 FR 55466, Dec. 20, 1976)

b. **Intent of Rule.** The intent of this rule is to provide generalized performance requirements, including the corresponding engine evaluation requirements, and applicable procedures for establishing airplane performance as detailed in this Subpart B.

c. **Background.**

(1) The regulatory history shows that this requirement originated from Section 110 of the Civil Air Regulations (CAR) 4b, September 1962. Amendment 25-AD was published in the Federal Register on December 24, 1964 (29 FR 18289). This amendment added Part 25 [New] to the Federal Aviation Regulations and replaced Part 4b of the CAR. It was part of the Agency recodification program announced in Draft Release 61-25, published in the Federal Register on November 15, 1961 (26 FR 10698). This rule was recodified from CAR 4b.110 without any substantive changes.
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(2) Notice of Proposed Rulemaking 75-10 (40 FR 10802, March 7, 1975), proposed:

- the deletion of §§ 25.45 through 25.75 (reciprocating engine-powered airplane performance requirements); and

- the transfer of the humidity correction factors for reciprocating engine-powered airplanes prescribed in that section to § 25.101(b).

Amendment 25-38 (41 FR 55454, December 20, 1976) followed Notice 75-10 and adopted the proposal. The following excerpt from the preamble to that Amendment describes the adoption of these changes.

> No unfavorable comment was received on the proposed change to strike the words “turbine powered" from § 25.101(a). Accordingly, proposed § 25.101(a) is adopted without substantive change.
>
> No unfavorable comment was received on proposed § 25.101(b) and it is adopted as proposed, except that it is clarified to indicate that the 80% relative humidity for reciprocating engines is based on standard atmospheric temperature [the vapor pressure values in the table in proposed § 25.101(b)(2) correspond to 80% relative humidity with a standard atmosphere].

c. **Policy/Compliance Methods.** Current FAA guidance is incorporated into the following material. The excerpts from FAA letters and memorandums were selected because they provide insight into FAA policy and guidance on this regulation as it pertains to powerplant issues (engine thrust ratings, thrust at altitude, etc.). Other examples of policy and guidance may be available for other "non-propulsion" areas.

(1) The following guidance material was part of a joint FAA/industry/foreign airworthiness authority effort to develop guidance for the verification of acceptable turbojet (and turbofan) engine power and operating characteristics during takeoff from high altitude airports. A proposed Advisory Circular (AC) 25-XX has been incorporated into this Propulsion Mega AC, which also reflects consideration of comments received.

Advisory Circular 25-XX
TURBOJET OPERATIONS AT HIGH ALTITUDE AIRPORTS

1. **PURPOSE**. This advisory circular (AC) provides guidance for the verification of acceptable turbojet (and turbofan) engine power and operating characteristics during takeoff from high altitude airports. It consolidates FAA guidance concerning this subject and serves as a ready reference for those involved with transport category airplane type certification and operation. The intent of takeoff certification testing is:

    - to provide a database suitable to establish minimum engine performance for preparation of the AFM,
    - to provide appropriate exposure and experience that will ensure that engine operational problems are not likely to exist during service, and
    - to document compliance with the applicable requirements of Part 25.

    These guidance procedures should be considered during airplane type certification and supplemental type certification activities when the applicant requests approval of high altitude takeoff operations (airports above 2,000 feet.). Terms used in this AC, such as "shall" or "must," are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described herein is used. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the pertinent parts of Title 14, Code of Federal Regulations (CFR), commonly referred to as the Federal Aviation Regulations (FAR). This advisory circular does not change, create any additional, authorize changes in, or permit deviation from, regulatory requirements.

2. **APPLICABLE FEDERAL AVIATION REGULATIONS.** The applicable regulations are: §§ 25.101, 25.105, 25.111, 25.939, and 25.1521 of part 25.

3. **APPLICABLE ADVISORY/GUIDANCE MATERIAL.** The applicable advisory/guidance material includes:

    a. Advisory Circular 25-7-A, "Flight Test Guide for Certification of Transport Category Airplanes," March 31, 1998.

    b. Advisory Circular 25.939-1, "Evaluating Turbine Engine Operating Characteristics," March 19, 1986.

4. **BACKGROUND.**

a. Section 25.111(a) requires that the takeoff path extend from a standing start to a point at which the airplane is 1,500 feet above ground level (AGL), or at a point where the transition to the enroute configuration is completed and the final takeoff climb speed is reached, whichever is higher. Advisory Circular 25-7 recommends that the flight path data, or associated AFM (Airplane Flight Manual) methodology, be presented so that the flight path can be determined to 3000 feet above the takeoff surface to permit obstacle clearance analysis. For transport category airplanes powered by turbojet engines, the takeoff power verification tests are conducted using a constant power lever position once the power is set, and final adjustments are made prior to a predetermined airplane airspeed (usually 60-80 knots). During takeoff power verification, which should simulate in-service takeoff operations (recommended takeoff procedure per the Performance Section of the Airplane Flight Manual (AFM)), the following installed engine operational characteristics are demonstrated simultaneously:

(1) Power management demonstration

(2) Thrust lapse rate determination

(3) Verification of operation within engine limits

(4) Engine stability characteristics determination

b. Combined, the above tests are used to demonstrate engine/airframe installation compatibility and to define the finite level of installed takeoff thrust used to show compliance with the provisions of Subpart B of Part 25. This operational compatibility and installed thrust determination is used to establish acceptable airplane flight manual (AFM) performance and needs to be demonstrated throughout the approved altitude, velocity, and temperature operating envelope requested by the applicant, in compliance with the appropriate regulation. An applicant requesting FAA takeoff approval for high airport altitudes should recognize that additional compliance testing will be required to assure safe operation at those high altitudes.

c. Applicants have attempted to separate the above four items to ease the flight test compliance demonstration. In fact, there have been efforts to segment the takeoff thrust lapse rate calculation procedure to separately allow different compliance demonstrations on the runway and in flight. While a segmented analysis may be acceptable, to date these attempts have failed to verify the effects that variables (e.g., "cold" engine, low velocity) could have on the transient nature of the certification demonstration. The above four test items, therefore, should not be demonstrated separately, but should be evaluated during each flight test takeoff event.

d. Confirmation that problems do not exist has been demonstrated only by flight testing under actual ambient conditions within the altitude and temperature limits of the established takeoff envelope. Each engine and airframe installation is unique, and no changes, even within an engine model type or for a "throttle push," have been substantiated to a satisfactory degree without compliance demonstrations. Operational problems during takeoff conditions have been experienced on transport category airplanes. These operational problems have not been predictable by analytical means, but have appeared as a result of flight test demonstration or in-service operation.

e. The term "turbojet," as used throughout Part 25 of the regulations, includes turbofan engines. The guidance in this AC should therefore be considered equally applicable to turbojet and turbofan engine installations. The methods identified in this AC may also apply to future "propfan" or ultra high-bypass ratio engines, but further evaluation will be needed to confirm the applicability of this AC to novel engine installations. Modern turboprop engines that provide takeoff power adjustment by direct gearbox torque control, while operating at constant limiting turbine rotor speed, have been shown to demonstrate compliance with the applicable regulations without the use of the guidance provided in this AC.

5. **DEFINITIONS**.

a. ***Derated Takeoff Thrust***. For a turbojet powered airplane, the derated takeoff thrust is a thrust level, less than the maximum takeoff thrust, presented in the approved AFM with a set of separate and independent, or clearly distinguishable, takeoff limitations and performance data that complies with all the takeoff requirements of Part 25. When operating with a derated takeoff thrust, the value of the thrust setting parameter, which establishes thrust for takeoff, is presented in the AFM and is considered a normal takeoff operating limit.

b. ***Engine Limits***. Those engine component limitations established by the engine type certificate under the provisions of Part 33, or a lesser-approved value established by the airframe manufacturer. Normal limitations for turbojet engines apply to exhaust gas temperature (EGT), low speed compressor rotor speed (N1), intermediate speed compressor rotor speed, if applicable (N2), and high-speed compressor rotor speed (N2 for two spool engines, N3 for three spool engines). The approved limitation for the takeoff power setting parameter, whose performance data is also presented in the approved AFM and complies with all the takeoff requirements of Part 25 (e.g., takeoff power engine pressure ratio (EPR) or fan speed (N1)), is considered a limit.

c. ***Minimum Engine.*** For the purpose of this AC, a minimum engine is a production (or in-service) turbojet engine that produces the lowest allowable, minimum guaranteed level of installed thrust for a predetermined (or approved) value of the power setting parameter. The minimum engine thrust level is then used to determine the airplane performance presented in the AFM, except for determination of minimum control speeds.

d. ***Takeoff Thrust.*** For the purpose of this AC, the term "takeoff thrust" is the maximum approved level of installed engine thrust within the operating limits, including associated time limits, established by the engine type certificate under the provisions of Part 33, or a lesser approved value established by the airframe manufacturer.

e. ***Thrust Lapse Rate.*** As used in this AC, the takeoff thrust lapse rate is the reduction of available engine (and airplane) thrust that occurs during increasing airplane velocity for a constant power lever position and constant altitude takeoff maneuver used during the flight testing. These relationships are then used to determine engine thrust at constant power lever position up to 400 feet AGL and above.

f. ***Automatic Takeoff Thrust Control System (ATTCS)*** An engine power control system that automatically increases thrust or power on the operating engine(s) in the event of any one engine failure during takeoff. This system allows takeoffs to be conducted at less than the engine's maximum approved takeoff thrust during normal airplane operation (thereby extending engine life), while assuring AFM minimum airplane takeoff performance in the event of an engine failure.

6. **CERTIFICATION COMPLIANCE TESTING.**

a. ***General.*** The applicant must demonstrate that the turbojet powered airplane can satisfactorily replicate the airplane performance data presented in the AFM, and that the data presented in the AFM complies with all of the takeoff requirements of Part 25. Consideration must be given to all anticipated environmental conditions (i.e. rain, hail, icing) requested by the applicant, presented in the AFM and approved by the FAA, including ambient temperature and airport pressure altitude. Typical operating envelopes, established by the applicant, include ambient temperature ranges from -65°F (-54°C) to +120°F (+49°C) and pressure altitudes from -2000 feet (-610 meters) to +8000 feet (+2440 meters). Some applicants have submitted requests for high altitude operation to +14000 feet (+4267 meters) to enable operation into and out of La Paz, Bolivia. Major high altitude airports are listed in Table 1. Domestic high altitude airports frequently used for takeoff certification are listed in Table 2.

TABLE 1

MAJOR INTERNATIONAL AIRPORTS OF THE WORLD ABOVE 5000 FEET*

City (Airport)	Elevation (Ft.)	Runway Length (ft.)
Bogota, Columbia (El Dorado)	8,355	11,455
Denver, Colorado (Denver Intl.)	5,431	12,000
La Paz, Bolivia (Kennedy)	13,392	13,124
Mexico City, Mexico (Mexico City Intl.)	7,341	12,796
Quito, Ecuador (Mariscal Sucre)	9,226	10,240

** Ref: United Technologies/Pratt & Whitney Aircraft Group, "Aeronautical Vest-Pocket Handbook," August, 1986.*

TABLE 2

DOMESTIC HIGH ALTITUDE AIRPORTS**

City (Airport)	Elevation (ft.)	Runway Length (ft.)
Cheyenne, WY (Cheyenne)	6,156	9,200
Colorado Springs, CO (Colorado Springs Municipal.)	6,172	11,021
Durango, CO (Durango/La Plata Co.)	6,685	9,200
Casper, WY (Natrona Co. Intl.)	5,348	10,600
Laramie, WY (General Brees Field)	7,278	7,700

Leadville, CO (Lake County)	9,927	6,400
Telluride, CO (Telluride Regional)	9,086	6,900

*** Ref: AOPA Aviation USA, 1991 Edition.*

b. ***Certification compliance demonstration takeoff testing*** is generally accomplished at the highest airport altitude that, with the extrapolation permitted, will give the altitude for which the applicant has applied for FAA approval (see paragraph 6d for altitude extrapolation). The intent of this testing is to provide a data base suitable to establish minimum engine performance for preparation of the AFM takeoff performance data, to provide experience that will ensure that problems are not likely to exist during service, and to document compliance with the applicable requirements of Part 25. Takeoff certification compliance testing simultaneously demonstrates that the following individual takeoff elements can be satisfactorily accomplished during anticipated in-service operation:

(1) Power Management Demonstration**.**

(i) The takeoff power setting curve is installation dependent and is the takeoff setting parameter used by the flightcrew to set, and adjust if necessary, the power during the initial takeoff segment, usually below 80 knots. The takeoff power setting curve is constructed to always provide the minimum engine takeoff thrust consistent with AFM performance. The ability of the flightcrew to obtain the takeoff limiting power setting with suitable accuracy and in a timely manner may be dependent upon the altitude and ambient temperature requested by the applicant, particularly for hydromechanical or supervisory fuel control systems. The higher the airport pressure altitude and ambient temperature, the higher the throttle lever angle (TLA) or engine cross-shaft/power lever angle required to obtain the AFM limited takeoff power setting (see Figure 1). Electronic Engine Control (EEC) systems, Full Authority Digital Electronic Control (FADEC) systems, etc., typically use either a full throttle advance or throttle quadrant detent power control system design and procedure. The ability to set takeoff power may also be a function of engine trim. The test engines should be set to the least conservative (higher throttle position to obtain the power setting parameter value) trim tolerance prior to the certification demonstration testing if appropriate and/or possible.

(ii) Sea level, standard ambient temperature flight test demonstrations may not provide an acceptable demonstration of high altitude or high ambient temperature operation or identify problems associated with the flightcrew's ability to set the required full takeoff power during other ambient conditions.

(2) Thrust Lapse Rate.

(i) The takeoff thrust rate decay with velocity is established by test to demonstrate compliance with § 25.101. A common analytical procedure used with turbojet powered transport category airplanes is to establish or verify a velocity or Mach number relationship for the ratio of the power setting parameter (e.g., EPR or N1) at velocity to that at power "set" (the EPR or N1 at ~0.1 Mach number) to derive EPR/EPR_{SET}, $N1_{TRANSIENT}/N1_{STEADY\ STATE}$ vs. velocity or $Mach_{number}$, as shown in Figure 2. For EEC-controlled engines, the lapse rate may be programmed logic or the power “set” (or target) value may basically be held constant throughout the takeoff condition based on available limit margins, and flight testing is conducted to demonstrate that the controlled lapse rate behavior does indeed follow the predetermined thrust lapse rate schedule logic. The relationships, defined or verified by flight test, are then used to establish the installed takeoff thrust for minimum engine performance at any other velocity throughout the takeoff segments as presented in the AFM. A typical EPR data trace during a takeoff demonstration for a hydromechanical fuel controlled engine is sketched in Figure 3. Other methods may be proposed by the applicant to establish the takeoff thrust lapse rate relative to the velocity that is used for AFM preparation.

(ii) The relationship of power setting parameter with velocity may change with any of the following variables:

(A) Engine service airbleed for cabin environmental control or thermal anti-icing protection systems.

(B) Engine accessory horsepower extraction (gearbox loads).

(C) Hot or cold engine operation. For this test, the accepted definition of a cold engine is one that has not been operated at a power setting higher than idle for a period of more than 6 hours. However, engine initial thermal conditions demonstrating an effect on thrust lapse rate behavior or operating characteristics have been identified requiring an extended “cold-soaked” condition. These pre-test conditions, previously used on specific engines, may require a minimum shutdown period of 12 hours (overnight) and/or the core engine internal temperature be at the prevailing ambient temperature prior to engine start. The degree of initial thermal cooling and its effect on the engine’s thermal expansion characteristics during takeoff should be examined and certification testing conducted accordingly.

(D) Airport pressure altitude.

(E) Ambient temperature.

(F) Flightcrew power setting techniques.

(iii) The degree of power setting parameter change with velocity will vary with each engine model type and with each airplane installation, and the change is impractical to analytically predict to the accuracy necessary to establish AFM performance. Experience has indicated that the power setting ratio (e.g., EPR @ vel/EPR @ "set") may be quite dissimilar for different engine installations. Figure 4 is a sketch of a dissimilar relationship between the engine power setting ratio and airplane Mach Number. This thrust lapse rate behavior may only be accurately determined from actual flight testing from high altitude airports with accurate flight test instrumentation and flightcrews familiar with thrust lapse rate test objectives.

(iv) The regulations require that the engine operation and takeoff power setting techniques must not require exceptional piloting skill or alertness. The lapse rate for a given installation may, however, be quite different if the flightcrew "sets" the takeoff power late (say 80 knots) to that "set" early (say 40 knots). The demonstrated lapse rate may also be considerably different if no final power setting adjustments are made following power "set," compared to a power setting procedure where a final power setting adjustment is made prior to the constant power lever position portion of the takeoff. Figure 5 sketches this trend. To ensure that the power setting techniques are representative of expected in-service operation, at least 6 duplicate takeoffs should be conducted by two different pilots to obtain an average. Some of these certification takeoffs should have final adjustments made after the initial power "set" and some should be close enough to the desired takeoff power setting so that no adjustments are required. Depending upon the applicant's data reduction techniques, the final power setting ratio may correct for minor "off target" power setting values, without invalidating the acquired thrust lapse rate data.

(v) Use of reduced takeoff thrust setting procedures during compliance testing may be used to simulate hot day operation thrust lapse rate for AFM preparation. Several levels of reduced thrust should be evaluated with each variable listed above to provide an acceptable average database.

(3) <u>Engine Limits Compliance.</u>

(i) All engine parameters (i.e., N1, N2, N3, EGT, etc.) must be shown to be within their established and approved operating limits, when installed and operated as identified in the AFM. These engine limits are established in compliance with Part 33 of the regulation, and the limits are listed in the AFM in compliance with § 25.1521.

(ii) Due to the thermal expansion within a turbine engine, the margins to these operating limits are engine installation dependent, are most likely to be transient in nature, and, like the thrust lapse rate, may be affected by service airbleed, horsepower extraction, hot or cold engine operation, airport pressure altitude, ambient temperature, and power setting techniques. Experience has shown that the peak or maximum engine parameter may occur at a velocity near the end of the constant throttle takeoff (see Figure 6). The maximum rotor speed (minimum limit tolerance) generally occurs at the highest operating airport pressure altitude, as indicated in Figure 7. The maximum EGT on the installed engine will most likely be at the highest flat rated ambient temperature at any given altitude.

(iii) It is impractical for an applicant to be required to demonstrate maximum ambient temperature while at the highest airport pressure altitude. Some adjustments to the data will be required to correct for ambient temperature differences, as well as power setting adjustments. The applicant's engine limits data reduction technique should be reviewed to determine that adequate analytical adjustments are made, as necessary, for minimum engine, off target power setting, and for ambient temperature conditions other than the maximum. An adequate number of tests should be conducted to obtain a representative average for each of the installation variables that may affect evaluation of the engine limits. Sometimes a variable, such as service airbleed, may not have the same effect on all engine parameters. For example, a 1.0 LB/sec 6th stage airbleed may not affect the N1 rotor speed, but may cause a significant percentage change in the N2 rotor speed compared to the no airbleed values.

(iv) It is practical, however, to require that the airplane be tested at a sea level ambient temperature near the "knee of the curve" (highest flat-rated temperature for a given altitude) for takeoff power, as indicated in Figure 1. There are several locations near or at sea level where ambient temperatures near 85°F (29°C), typical of the knee of the takeoff power setting curve, are available throughout the year to permit demonstrations representative of hot day operation. Data obtained during this testing may also be used to establish a suitable correction for high altitude ambient temperature test data.

(4) Engine Stability Characteristics.

(i) The operational characteristics of the engine/inlet during takeoff must be demonstrated to be stable in compliance with § 25.939. AC 25.939-1 provides suitable operating characteristics description and testing techniques. This compliance testing must be demonstrated during takeoff, since it has been established that an engine surge of any kind (audible or incipient) could cause the flightcrew to take corrective action that could result in a hazardous situation.

(ii) Unacceptable operating characteristics have occurred at high altitude airports as a result of insufficient surge margin (due to high inlet distortion/loss of pressure recovery) at high engine airflow and high angles of attack when the airplane is within the ground effect (typically following rotation). The highest corrected takeoff engine airflow generally occurs during a high altitude takeoff. The inlet design and configuration can also affect the engine's surge margin. For example, a long inlet design may exhibit an airflow choking characteristic, while a more open, short inlet design has less of a tendency to inhibit airflow into the engine. Actual high altitude takeoff flight test demonstrations at maximum engine airflow conditions and airplane rotation angles are necessary to confirm that the installation will perform satisfactorily.

(iii) These operating characteristics tests should be conducted concurrent with the engine limits and lapse rate testing. Some attempts have been made to simulate the high altitude operating characteristics testing so that they can be conducted in clean air apart from the rest of the high altitude takeoff tests. The problems that exist are the inability to conduct inflight "cold" engine testing and to obtain an adequately low airspeed. It is suggested that a moderate degree of over-rotation be evaluated as part of this testing to cover normal in-service flightcrew operational techniques.

c. ***Airplanes with an Automatic Takeoff Thrust Control System (ATTCS).***

(1) Certifying maximum engine operating limits on airplanes with an ATTCS is slightly more complicated. Day-to-day normal airplane operation at less than maximum takeoff thrust levels (thus reduced N1, N2, N3, EGT, etc.) must ensure that adequate engine operating limit margins are available should maximum takeoff thrust be applied automatically (via ATTCS actuation) during an engine-out takeoff. This requirement is stated in Appendix I of Part 25, paragraph I25.5(b)(1).

(2) During certification testing, ATTCS-simulated operation should be evaluated, one engine at a time, at several airspeeds within the "critical time interval," as defined in paragraph I25.2(b) of Appendix I. These tests will help determine the transient engine effect (power setting overshoot, unique engine thermal transients, engine operating characteristics, etc.) due to the automatic thrust/power increase, and determine the critical airspeed where minimum engine limit margins occur. The applicant should repeat these tests at a high altitude airport to verify that the automatic power reset, engine limits, and engine operating characteristics

developed for low altitude ATTCS operation do not change and possibly become critical at higher altitudes.

d. ***Extrapolation.*** There have been questions concerning the ability to extrapolate flight test data from one altitude to permit operation at a higher altitude. Advisory Circular 25-7-A, paragraph 3(a)(8)(iii), states that when the basic takeoff tests are accomplished between sea level and approximately 3,000 feet, the maximum allowable extrapolation limits are 6,000 feet above and 3,000 feet below the test field elevation. In addition, with conservative adjustments, additional extrapolation is permitted. This extrapolation applies only to the airplane performance data. It does not apply to the takeoff thrust lapse rate, power management, engine limits evaluation, or operational characteristics. The FAA limits the extrapolation of engine data, obtained in takeoff testing to show compliance with § 25.111, to +3,000 feet (+914 meters) above the maximum altitude at which takeoff testing is performed. This data extrapolation should only be allowed if the appropriate engine power setting overboost (for the maximum altitude airport for which takeoff approval is sought) is used during the demonstration at the lower altitude airport. If the applicant chooses to demonstrate engine power overboost, the overboost condition(s) should be coordinated with and approved by the engine manufacturer. Operation of the engine during the overboost condition(s) should remain within the approved engine limitations.

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END OF AC 25-XX

(2) Additional guidance on "High Altitude Airport Certification for an Airplane" is contained in the following excerpt from an FAA letter, dated December 5, 1986, issued in response to a letter received from an applicant. The applicant requested approval of a model airplane powered by turbofan engines and operating at airports up to 14,000 feet. Other than certain changes necessary for the pressurization and passenger oxygen system, no other certification activity was included in this proposal that would specifically address this high altitude airport request. The model's current Airplane Flight Manual contained approved performance data for airport altitudes as high as 8,400 feet. That current approval was based, in part, on engine certification testing that was conducted at test airport altitudes up to approximately 6,000 feet ,and takeoff and landing performance certification at approximately 2,300 ft.

Your proposal to extend the airport approval to as high as 14,000 feet without actual demonstration of satisfactory airplane and engine operation at or near the desired altitude appears to be deficient. Uncertainties associated with aircraft and engine performance and operation at these very high airport altitudes, some of which are difficult if not impossible to predict, have necessitated that only moderate altitude extrapolations be employed. Airplane performance extrapolation in excess of 10,000 feet and engine operation extrapolation of 8,000 ft., as proposed by the referenced letter fails to account for the many complex factors influencing satisfactory high altitude airport airplane and engine functioning. This is especially applicable for an airplane such as your model airplane, which has not, as of yet, been evaluated to a 14,000 feet airport altitude with any engine type.

In general, it is considered necessary for each new airplane basic model and each unique engine type, or significant change in engine variant, be exposed to actual high altitude airport engineering compliance evaluation at the desired engine thrust levels with only a moderate amount of airport altitude extrapolation. Existing FAA policy material related to airplane performance suggests as much as a 6,000-foot performance extrapolation may be permitted without imposition of performance penalties. For engines, depending upon previous installation approvals and the experience of like engine types, or substantially altered engine design, high altitude airport evaluation may justify as much as a 2,000 to 3,000 foot extrapolation of satisfactory operation. If, however, an engine characteristic were encountered at a test altitude which would establish that altitude extrapolation would be inappropriate, actual airplane altitude testing for engine operation purposes would be required without any extrapolation permitted. In any case, each engine and each installation would have to be evaluated as to the type and degree of extrapolation permitted.

Specifically, for the airplane model in question, the following high altitude airport evaluations should be included for support of your request for 14,000-foot airport approval:

a. Engine Ground Starts.

b. Reverser Abuse (5 knot) Landing.

c. Normal pressurization operation, and normal/non-nuisance oxygen system operation on start taxi, takeoff, landing and shutdown.

d. AFDS Approach.

e. AIM autoland if such certification is sought

f. Landings, with manual and autobrakes, at maximum GV for structure or performance limitation (also confirm tire speed margin for tailwind and hot brakes)

g. All-engine thrust lapse rate takeoff.

h. Takeoffs demonstrating manual thrust set and, if desired for approval, ATS thrust set/operation.

i. Procedural takeoff with VR-10 idle hop, limit T/WP and climb/access to flap cleanup.

j. Any other test necessary to qualify airplane systems whose operation may be sensitive to, or dependent upon, field altitude.

NOTE: AFM takeoff performance penalty is not required if the predicted takeoff performance validity can be reasonably checked by time/distance to accelerate, engine lapse, takeoff flare and V climbout path parameters. (Refer to Advisory Circular 25-7, “Flight Test Guide for Certification of Transport Category Airplanes,” for reference to such verification tests.)

(3) The following excerpt is from an internal FAA memorandum, which was originally issued in June 28, 1994, and reissued subsequently on August 19, 1994. This memo provides additional guidance on the availability of takeoff thrust/power on both turbojet and turbopropeller installations for use by U.S. operators for time periods up to ten minutes. It originated from requests by U.S. operators to allow the use of takeoff thrust for up to ten minutes at certain airports.

The Joint Aviation Requirements (JAR) allow the use of takeoff thrust/power for up to ten minutes after the shutdown or failure of one or more engines. However, Part 1 of the Federal Aviation Regulations (FAR) defines ***rated takeoff thrust/power*** as limited to five minutes of operation. At some airports (mostly foreign) the maximum allowable airplane takeoff weight is limited by the climb gradient capability (at maximum continuous thrust/power) needed to clear distant obstacles after takeoff. The availability of takeoff thrust/power for use up to ten minutes enables some foreign operators to dispatch at an increased gross weight relative to U.S. operators under these conditions. U.S. operators have expressed a desire to be treated equally in similar circumstances in order to be competitive.

The Transport Standards Staff has reviewed Part 25 and determined that no revisions are needed to provide the flexibility for an engine inoperative "10-minute" takeoff thrust/power rating. The limiting phrase is found in Part 1 in the definition of ***rated takeoff thrust/power***. The Engine and Propeller Standards Staff is proposing a regulatory change to Part 1 to harmonize the FAR with the JAR. The proposed wording would extend the current definition of ***rated takeoff thrust/power*** for turbine engines in Part 1 as follows:

> ." . . and limited in use to periods of not over 5 minutes for takeoff operation, ***and, for turbojet (including turbofan) and turbopropeller engines, when specifically requested by the engine type certificate holder, to periods of not over 10 minutes for engine inoperative takeoff operations***."

The Engine and Propeller Directorate has verified that the engine inoperative "10-minute" rating is well within the boundaries of the engine certification standards of Part 33 for turbine engines.

Since the Part 1 definition is not limiting with respect to ratings selected by the engine manufacturer for abnormal operations, we have adopted the following procedure to allow the FAA approved transport category Airplane Flight Manual (AFM) to be revised to incorporate instructions regarding the engine inoperative "10-minute" takeoff thrust/power rating for airplanes with turbine engine installations. Upon receipt of a written request from an applicant seeking an engine inoperative "10-minute" takeoff thrust/power rating the following items will be addressed:

The engine type certificate holder shall request in writing to the cognizant aircraft or engine certification office for approval of an engine inoperative "10-minute" takeoff thrust/power rating for the relevant turbine engine models.

The aircraft or engine certification office shall ensure that the relevant engine type certification data sheet is revised to note the extended turbine engine rating.

The transport category airplane type certificate holder shall request in writing to the cognizant Aircraft Certification Office (ACO) the desire to establish the engine inoperative "10-minute" takeoff thrust/power rating for the relevant airplane/engine model(s). The request should include the engine type certificate holder's "endorsement" of the extended turbine engine rating.

The transport category airplane type certificate holder shall present the appropriate AFM revisions concerning the engine inoperative "10-minute" takeoff thrust/power operation to the ACO for review and approval.

The ACO shall ensure that the relevant airplane type certification data sheet (TCDS) is revised to note the extended turbine engine rating.

The engine inoperative "10-minute" rating operation should be processed as an engineering approval unless there are actual hardware changes. The AFM revision should specify that using takeoff thrust/power for more than five minutes (not to exceed ten minutes) is approved for use only in the event of an inoperative engine(s) due to shutdown or failure. The AFM obstacle clearance charts [see §§ 121.189(d) and 135.379(d)] should be revised to reflect the increased climb capability.

This interim procedure, which is available upon request, may be used to provide the additional obstacle clearance capability for U.S. operators. When the Part 1 amendment is effective, the normal certification procedures will apply.

(4) The following two excerpts are from internal FAA memoranda that address the issue of engine maximum continuous rating. These originated because of reports that a specific engine manufacturer's personnel had indicated that maximum continuous rating may be used only in situations of "dire need." This would be in conflict with FAA policy that the maximum continuous rating is just that -- approved for maximum continuous operation with no time or situation restriction.

EXCERPT #1: This philosophy has come up in almost every certification and we have repeatedly pointed out, and held firm to the fact, that the "maximum continuous rating" is just that -- approved for maximum continuous operation, with no time or situation restriction.

We recognize that this matter has been related to warranties in which FAA should not be involved, and we have refused several . . . attempts to include statements in the Airplane Flight Manual that would imply FAA . . . approval that "maximum continuous" is to be used only in an emergency.

EXCERPT #2: It has come to our attention that some engine manufacturer's personnel have indicated to the aircraft manufacturer and to certain prospective operators of the aircraft that the engine's maximum continuous rating may be used only for situations of dire need and that, if this is not observed, the engine warranty is voided.

We do not have a written statement from the engine manufacturer on this matter, but it appears that the issue involved is one of time-before-overhaul warranties. This matter has been brought up previously on other engines manufactured by [*the engine company*] where the maximum continuous rating has been established at a level near or at takeoff output. [*The engine manufacturer*] seems to view the maximum continuous output as an emergency rating, but the fact remains that aircraft performance is established using maximum continuous output. Any economic pressure that tends to discourage the usage of maximum continuous thrust whenever needed may be detrimental to safety.

Sometime ago, [*the airplane manufacturer*] discussed the feasibility of emergency ratings for their long-range model airplane with this Division, but took no action toward petitioning for such a rating. As you are aware, our present regulations do not recognize emergency or contingency engine ratings for fixed-wing aircraft.

It is suggested that our concern be brought to the attention of [*the engine manufacturer*] and that it be suggested to them that their warranty policies be developed in a manner that will create no doubt as to the meaning and intent of the maximum continuous rating. They could, for example, establish a sliding scale of overhaul periods based upon the operators' thrust level usage.

(5) The following excerpts are from FAA Order 8000.58, “Reduced Power Takeoffs - Turbopropeller Powered Transport Airplanes,” dated June 28, 1983. This order provides guidance for takeoff certification and operations using reduced power on turbopropeller (turboprop)-powered transport airplanes.

BACKGROUND.

a. Airlines have been using reduced thrust for takeoffs since 1970 (with turbojet powered airplanes), using the guidance material that has been issued. Some turboprop airplane operators have also used reduced takeoff power. The FAA has looked at the current guidance for turbojet powered airplanes and has determined similar guidance is appropriate for allowing reduced power procedures for turboprop airplanes.

b. 'The guidance in this order is predicated upon the use of a procedure contained in paragraph 5d that provides equivalency to the assumed temperature method used with turbojets to determine the reduced power level to be used for any given takeoff condition. For turbojets, the assumed temperature method bases the performance on higher true airspeeds than actually exist, adding conservatism to the takeoff field length and obstacle clearance. These conservatisms will prevent derogation of safety from current levels. Individual operators may elect to include additional conservatisms to simplify their operating procedures.

c. This order covers the occasional use of reduced thrust for takeoff when operational considerations permit, as opposed to operations on an airplane with a full time derated engine installation. Part 25 takeoff performance rules were predicated on the assumption that only a small percentage of the takeoffs are performance limited and that exposure to marginal takeoff conditions was therefore very low. The indiscriminate use of reduced thrust for takeoff could on the other hand increase this exposure as much as l00 percent. The guidance in this order thus provides a level of safety equal to that provided by the takeoff performance requirements of Part 25.

ACCEPTABLE MEANS OF COMPLIANCE. Under §§ 25.10l(c), 25.101(f), and 25.101(h), it is acceptable to establish and use a takeoff power (reduced takeoff power) setting that is less than the rated or derated takeoff power if:

a. The establishment of the reduced power takeoff data is handled through the type certification process and contained in the AFM.

b. The reduced takeoff power setting:

(1) Does not result in loss of systems or functions (or that the function's capabilities are not significantly affected) that are normally operative for takeoff such as automatic spoilers, engine failure warning, configuration warning or any other safety related system dependent upon a minimum takeoff power setting or power lever angle.

(2) Is based on an approved engine takeoff power rating or derating for which airplane performance data is provided.

(3) Does not introduce difficulties in airplane controllability or engine response/operation in the event that rated takeoff power (or derated takeoff power, if such is the performance basis) is applied at any point in the takeoff path.

(4) Is at least 90 percent of the rated takeoff power (or derated takeoff power, if such is the performance basis) for the existing ambient conditions.

(5) Is predicated on a careful analysis of propeller efficiency variation at all applicable conditions.

c. Relevant speeds (VEF, Vl, V/R, and V2) used for reduced power takeoffs are not less than those which will show compliance with the required controllability margins with the rated takeoff power (or derated takeoff power, if such is the performance basis) for the ambient conditions.

d. For each 1.n percent reduction in power, the maximum takeoff gross weight is diminished by n.5 percent from the gross weight at which compliance with all applicable performance requirements is determined using the criteria in b. and c. of this order, with the operating engines at the reduced takeoff power selected for takeoff.

e. The AFM states, as a limitation, that reduced takeoff power settings may not be used:

(1) Unless the operator establishes a means to periodically check the availability of rated takeoff power such that deteriorated engines are not used.

(2) When the antiskid system is inoperative.

(3) On wet runways and runways contaminated with snow, slush or ice, unless suitable performance accountability is made for the increased acceleration and stopping distances on these surfaces.

f. Procedures for reliably determining and applying the reduced takeoff power value are simple, and the pilot is provided with information to easily enable him to obtain both the reduced power and rated takeoff power (or derated takeoff power if such is the performance basis) for each ambient condition.

g. The AFM provides adequate engine information to conduct the check required by paragraph e.(1) of this order.

h. Procedures and training are developed by the operator and FAA approved for the use of reduced power.

i. Application of reduced power in service is always at the discretion of the pilot.

j. Careful analysis should be made to determine the various effects of:

(1) The magnitude of change on each of the takeoff speeds;

(2) The obstacle clearance climb gradients;

(3) The increased acceleration distances; and

(4) The decreased stopping field lengths available when conducting reduced power takeoffs.

k. The power setting is not less than the approved maximum continuous power required for the ambient conditions to meet the takeoff path requirements.

(6) The following excerpts are from FAA Order 8000.47, "Deteriorated Power, Propeller-Powered Air Carrier/Air Taxi," dated June 5, 1981. This order provides guidance relative to certification, operation, and maintenance of turbopropeller-powered air carrier/air taxi airplanes with engines, which cannot develop maximum certificated power because of performance deterioration.

BACKGROUND. Recent discussion and correspondence regarding power deterioration and related factors make it necessary to outline pertinent guidance relative to turbopropeller-powered air carrier airplanes. This guidance should not be confused with that pertaining to reduced thrust takeoffs which is addressed in other directives. Reduced thrust takeoffs can be utilized only if engines are capable of attaining-the maximum takeoff power specified in the AFM; whereas deteriorated power refers to a situation in which engines are incapable of attaining the AFM specified maximum takeoff power, but are still airworthy. This guidance is based on requirements contained in the Federal Aviation Regulations (FAR).

The operating rules [FAR's 91.31, 135.399, 135.397(b), 121.189, and 121.191] require that no person may operate a civil aircraft without compliance with the operating limitations for that aircraft. The certification rules [FAR 23 plus certain special conditions, SFAR 23, FAR 135, Appendix A, Sections 19(b), 20(a), SR 422, and FAR 25.105] set forth the performance requirements which define takeoff weight limitations for aircraft required to comply with those certification requirements.

DETERIORATED POWER GUIDANCE. In view of the background and applicable FAR's, the following guidance is provided.

Operation at less than the minimum AFM specified torque or horsepower ratings for given ambient atmospheric and flight conditions is not legal. This applies to operation at deteriorated power levels as well as the original type certificated level.

A holder of an air carrier operating certificate that requests deteriorated power authorization for a specific aircraft must submit a program to its principal airworthiness inspector for approval.

Operation at deteriorated power ratings can only be approved if:

Approved performance data (weight, altitude, temperature, power, takeoff distance, accelerate-slow or stop distance, approach climb, landing climb, takeoff climb, and enroute climb) are available in the AFM which permit compliance with the takeoff and climb requirements of the airplane's certification basis. One engine inoperative and all engines operating data should be presented. Performance must be presented as a function of engine power available and must be based on the engine with the lowest indicated power; an average of the installed engines should not be used. Turbopropeller-powered air carrier/air taxi airplanes certified to CAR 3, CAR 4, FAR 23 plus applicable special conditions, SFAR 23, FAR 135 Appendix A, SFAR 41, SR 422, or FAR 25 are eligible for consideration under this order.

The airworthiness of the engines in a condition corresponding to the lowest approved deteriorated power level is established by the engine type certificating region. Deteriorated engines are engines that have experienced gradual performance degradation due to normal wear and are considered to be airworthy but not capable of producing maximum certificated takeoff power. Power degradation due to other causes such as foreign object damage or mechanical or structural failures is not acceptable. No specific guidance is provided on how to establish airworthiness of engines at deteriorated power. This is the responsibility of the engine certifying regions in coordination with the engine lead region. In addition, an approved method of monitoring engine performance must be implemented to provide timely deteriorated power level information to flight crews and to preclude operation with unairworthy engines. Approval of this method must be at the regional level and concurrence must be obtained from the certificating region.

The lowest power level below which power is not permitted to deteriorate for the airplane is established by the airplane certificating region. The lowest power level shall not be less than that approved for the engine by the engine certificating and engine lead regions.

Use of deteriorated power does not result in loss or unsafe degradation of systems or functions that are normally operative for takeoff, such as propellers, automatic spoilers, engine failure warning, configuration warning or any other safety related system dependent on a minimum takeoff power setting or power lever position.

Use of deteriorated power does not adversely affect airplane handling qualities or engine response characteristics and does not increase the risk of exceeding any engine operating limits during normal operations.

The antiskid system (if installed and performance credit is given with deteriorated power) is operative.

Approved operating procedures and training are implemented by the operator for the use of deteriorated power.

An evaluation of noise is made for an acoustic change per FAR 21.93(b) to determine that applicable noise requirements are met.

An evaluation of emissions is made for compliance with SFAR-27.

. . .

d. An operator cannot use wet ratings to recover dry power lost through deterioration, unless approved deteriorated power performance information is available in the AFM and deteriorated power operation has been approved in accordance with paragraph 4 c. of this order.

e. If it is known that an engine does not reach dry power ratings, wet operation cannot be substituted for takeoff operation, unless approved deteriorated power performance information is available in the AFM and deteriorated power operation has been approved in accordance with paragraph 4 c. of this order. Maintenance procedures must be adopted and FAA approved for periodic dry power checks if engines are only operated wet at takeoff.

f. Operations at deteriorated power may not be conducted simultaneously with any other kind of reduced thrust operation.

(7) The following excerpts are from an internal FAA letter, which provides guidance on reduced thrust or power operations. More specifically, it provides guidance on the occasional use of reduced thrust for takeoff when operational considerations permit, as opposed to operation on an airplane with a full time derated engine installation. The stated purpose of this letter is to clarify and correct certain misunderstandings concerning reduced thrust or power operation with transport category aircraft.

Generally, reduced thrust or power operations fall into two categories-those with full time derated engine installations and the occasional use of reduced thrust for takeoff when operational considerations permit.

The basis for full time derated engine installations is § 25.1521 which specifies that "the powerplant limitations prescribed in this section, must *“ . . . not exceed the corresponding limits for which the engines or propellers are type certificated.*" CAR 4b.718 contained similar wording prior to recodification.

Engine ratings are, in essence, a function of engine limits and the degree of deterioration permitted. Although § 25.1521 does not directly address engine ratings, it does so indirectly via Part 1. Part 1 defines rated takeoff thrust as *.” . . the approved jet thrust that is developed statically under standard sea level conditions. . . within the engine operating limitations established under Part 33.”* Similar definitions are provided in Part 1 for rated takeoff power and for rated maximum continuous thrust or power.

That the applicant *may* select engine ratings that are less than those shown on the engine data sheet is confirmed by paragraph 32C of FAA Order 8110.4 (“Type Certification Process”), which states that for the aircraft data sheet, *"the rating may be less than, but must never exceed, the rating for the engine as shown on the pertinent engine specification."* The term “engine specification" is, of course, interpreted to include the later engine certificate data sheets. In order to obtain the most performance from the engines and, in turn, the airplane, the applicant generally selects limits equal to those established during engine certification and shown on the engine data sheet. The applicant may, however, select limits and resultant ratings that are less than those shown on the engine data sheet.

Applicants that chose to derate their engine installation during the reciprocating engine era generally did so to facilitate compliance with an airplane certification requirement such as stability, engine cooling or fuel flow. For turbine engine installations, the most common reason is to increase engine life. Because engine life is a direct function of turbine temperature, the applicant is sometimes contractually required by the engine manufacturer to derate the thrust or power.

Another reason for derating is the intermixing of engines of varying thrust or power on the same airplane. In that case, the power or thrust of the higher rated engine is generally reduced to equal that of the other engine (or engines).

The FAA certificating office must, of course, determine that the limits and resultant ratings do not exceed those shown on the engine data sheet for the engine model involved. Once this is accomplished, the engine data sheet has no further direct relevance to the installation. Each certification requirement related to thrust or power refers to the thrust or power obtained with the limits and ratings selected by the applicant and not those shown on the engine data sheet, if different. These include such considerations as performance, stability and controllability, engine cooling, instrument markings, noise, etc. The limits selected by the applicant become airplane limitations upon certification and are shown in the aircraft data sheet and/or airplane flight manual.

It must be noted that compliance with the airplane performance requirements of Part 25 is dependent on the availability of satisfactory engine performance data. Inasmuch as the engine performance data supplied by the engine manufacturer may not be entirely applicable for a derated installation, the applicant may have to provide additional engine performance data. This may preclude the applicant from derating the engine installation without the assistance of the engine manufacturer.

Engine derating must not allow unauthorized operation with deteriorated engines by default. The applicable maintenance procedures must, therefore, ensure that the engines are airworthy. FAA Order 8000.47 (“Deteriorated Power, Propeller-Powered Air Carrier/Air Taxi”) contains further guidance concerning operation of turbopropeller air carrier/air taxi airplanes with deteriorated engines. No corresponding policy to permit operation of turbojet aircraft with deteriorated engines has been developed to date.

Insofar as full time derated engine installations are concerned, the only authority and responsibility of the FAA with regard to the selection of engine limits and resultant ratings is that the airplane complies with each applicable Part 25 requirement. Beyond that, the relative merits of increased performance margin vs. increased engine life are conjecture and are a civil matter between the applicant and the engine manufacturer.

Order 8000.39 covers the occasional use of reduced thrust for takeoff when operational considerations permit, as opposed to operation on an airplane with a full time derated engine installation. Part 25 takeoff performance rules, and those of predecessor regulations, were predicated on the assumption that only a small percentage of takeoffs are performance limited and that exposure to marginal takeoff conditions was, therefore, very low. The indiscriminate use of reduced thrust for takeoff could, on the other hand, increase this exposure to as much as 100%. Order 8000.39 was, therefore, prepared to provide a level of safety equal to that provided by the takeoff performance requirements of Part 25. In this regard, subparagraph 3b(4) specifies that reduced takeoff thrust must be *." . . at least 75% of the rated takeoff thrust."* This wording is ambiguous in that *"rated takeoff thrust"* could refer to either the engine data sheet rating or to the aircraft data sheet engine rating. We understand this wording was chosen with the erroneous understanding that the two ratings were always equal. This, of course, is not true in the case of full time derated engine installations. Although this subparagraph has been interpreted to refer to the engine data sheet rating, this interpretation is not consistent with the preceding subparagraph 3b(2) which specifies that the reduced takeoff thrust setting *"is based on an approved engine takeoff (datasheet) rating for which airplane performance data [are] provided."* Inasmuch as airplane performance data are not provided for the engine data sheet rating with a derated installation, these paragraphs can only be interpreted to refer to the airplane data sheet rating. This is also the only interpretation that is consistent with paragraph 3f. This phrase would be further interpreted to man the engine rating shown on the supplemental type certificate if the engines were installed in accordance with a STC. Note, however, that the applicant must not be permitted to circumvent the intent of this Order by an indiscriminate reduction of an engine rating that does not result from a corresponding thrust parameter limitation change (e.g., EPR, EGT or fan speed), or engine design change.

It should be noted that Order 8000.39 pertains only to turbojet airplanes. No corresponding policy for reduced power takeoffs with turbopropeller or reciprocating airplanes has been developed to date. It should also be noted that Order 8000.39 does not apply to airplanes with automatic takeoff thrust control systems (ATTCS).

(8) The following excerpts are from an internal FAA memorandum, dated July 29, 1983, which provides guidance on certification of the autothrottle. The stated purpose was to address the nationwide standard, "Certification of the Autothrottle Takeoff Mode," which was published on July 29, 1983, in order to prevent possible misunderstanding of the certification requirements, and to provide positive design guidance for future autothrottle systems. The following comments deserve consideration:

1. Takeoff performance and limits evaluations, as presented in the approved Airplane Flight Manual (AFM), are based on fixed-throttle between takeoff throttle-set and the end of takeoff 3rd segment, or the 5 minute engine takeoff limit, whichever occurs first. The time interval between autothrottle clamp velocity and throttle-set velocity is that time available to the flight crew to make any necessary minor adjustments in order to ensure achieving the minimum engine takeoff power, and consequently, the minimum airplane performance, as presented in the AFM.

   Design of the autothrottle system should permit adequate throttle adjustment time prior to the throttle-set velocity. For a particular airplane, throttle-set velocity is 60KIAS and while for other airplanes, throttle-set velocity is between 40-80 KIAS per the AFM. If the throttle-set velocity is changed by the applicant, the certification substantiation performance must be adjusted accordingly, as discussed in the subject memorandum, by revising such items as takeoff EPN/N1 lapse rates and associated minimum airplane performance, power setting charts, and compliance to the engine limits. Since these performance items impact flight crew response and airplane safety, they should not lightly be considered as negligible performance effects.

   The significant airplane performance items, which must be considered, are the takeoff field length and obstacle clearance as they are affected by the available minimum engine installed thrust/velocity relationship. Changing the installed thrust/velocity relationship will also require a reevaluation of the engine limits in order to ensure compliance with § 25.1521 (“Powerplant limitations”).

2. Independent of the number of drive/clutch packs within the autothrottle system or the controlling mechanism (i.e., PMS, EMS, etc.), each engine control system must be totally at the control option of the flight crew at all times in order to demonstrate compliance with the failsafe and engine isolation requirements of § 25.901 (Powerplant -- General, Installation”) and § 25.903 (“Engines”). Movement of the throttles following "throttle-set" is permitted only per § 91.1(b), which identifies justifiable immediate action by the flight crew, which deviates from the established rules, in case of an emergency.

3. The flight crew must, prior to brake-release, establish the correct AFM approved power setting value in order to ensure that the autothrottle, if used, performs its intended function of accurately setting the takeoff power. Undetected related system failures, such as a failed engine bleed valve, can affect the target power setting valve, the installed available thrust, and therefore the airplane performance. The flight crew is responsible for making necessary adjustments prior to throttle-set in order to ensure AFM minimum airplane performance.

4. Throttle movements or response of the autothrottle system should be sufficiently fast to permit compliance to the 8-second thrust go-around criteria of § 25.119 (“Landing climb: All-engine operating”), as required for the particular airplane, if the autothrottle system is equipped with a go-around mode. Although the go-around mode is separate from the takeoff mode, the actual go-around power setting chart and control logic within the autothrottle mechanism is identical to takeoff, as adjusted to an approach Mach number (i.e. 0.23 Mach), and therefore should exhibit identical response and accuracy considerations as the takeoff mode.

5. The question of accuracy deserves some consideration in a nationwide standard. The takeoff power setting chart value (i.e. n1 or FPP) is both minimum and maximum and is to be considered an engine limit. The AFM engine and subsequent airplane performance is based on the flight crew setting at least (minimum) the power setting chart value. That is, there is no permissible tolerance less than the power setting chart value that has been accounted for in the "minimum" airplane performance in the AFM. Likewise, the engine limits evaluations during certification do not account for any tolerance above (maximum) the power setting chart value. Recently, however, Boeing was required to account for a 0.02 unit EPP mis-set tolerance application for limits evaluation due to the flight crew inability to adequately set takeoff power because of the power management sensitivity of the JT90-7B4G2 engine. Arguments have been raised that "zero" tolerances on a safety related item is illogical. However, to date, the AFM and certification substantiation basis has not accounted for any tolerance, except as discussed above. Future autothrottle system certification will need to be either extremely accurate or a justifiable tolerance will need to be accounted for during the certification process.

6. Throttle stagger is not covered in the regulation. For design guidance, a maximum of one knob stagger is considered acceptable during autothrottle acceleration (advance) and less than one-half knob is considered desirable at stabilized takeoff power. This is the present accepted general production practice for transport category aircraft.

7. Some single-drive autothrottle systems have been approved for multi-engine aircraft and are presently in service. However, they may not comply with part 25 regulations for a fully automated system. The problem areas that are associated with present angle-drive systems include:

   a. The interval between autothrottle clamp velocity and throttle-set velocity does not provide adequate time for the flight crew to make necessary adjustments in order to ensure minimum airplane approved AFM performance per § 25.101 ("Performance -- General").

   b. Takeoff power setting logic within the single-driven autothrottle system has been that the first engine to reach takeoff power stops the system drive. This means that the other engines are "below" the minimum takeoff power and, therefore, the minimum airplane approved performance. On four-engine aircraft, this requires exceptional skill from the flight crew in order to properly set takeoff power on all engines prior to the AFM throttle-set velocity in order to achieve minimum airplane performance. This is in non-compliance with § 25.101(h) and § 25.105(b) ("Takeoff").

   c. The flight crew must constantly monitor the autothrottle throttle movement in order to prevent a single system failure of the drive system from affecting the engine isolation requirements of § 25.903(b). This, again, may require exceptional flight crew skill.

   These systems have only been approved as nonessential control systems, and the flight crew responsibility for responsively and accurately setting takeoff power has not been reduced by the single-drive autothrottle operation. In the future, these single-drive autothrottle systems should be avoided.

8. In compliance with the turbine engine operating characteristic requirements of § 25.930(a), any autothrottle system must be investigated to ensure that the throttle movement will not induce any adverse engine characteristics that may produce a hazardous airplane operation under both normal and emergency conditions. Compliance with powerplant controls requirements specified in § 25.1141 ("Powerplant controls -- General") and § 25.1143 ("Engine controls") must be maintained.

Finally, the subject memorandum indirectly implies that an autothrottle system meeting the "critical system" criteria of § 25.1100 "may be approved without pilot-in-the-loop involvement. Based on the foregoing discussions, we suggest that a follow-up letter to all Directorates and ACO's should be prepared and distributed, highlighting the information is this letter and to caution the interested parties that autothrottle systems inherently, due to the design aspects of airplane response and throttle (not engine) control logic, cannot comply with all powerplant control requirements and should not be approved as a critical system, thereby, emphasizing pilot-in-the-loop as a requirement for design approval.

(9) Current transport category airplane compliance material for this section has been contained in Advisory Circular 25 -13, "Reduced and Derated Takeoff Thrust (Power) Procedures," dated May 4, 1988. However, AC 25-13 has now been cancelled with the issuance of this Propulsion Mega AC and its material has been incorporated in total below. (See also Section 25.1521.)

Advisory Circular 25-13

REDUCED AND DERATED TAKEOFF THRUST (POWER) PROCEDURES

1. **PURPOSE.** This advisory circular (AC) provides guidance for the certification and use of reduced thrust (power) for takeoff and derated takeoff thrust (power) on turbine powered transport category airplanes. It consolidates FAA guidance concerning this subject and serves as a ready reference for those involved with airplane certification and operation. These procedures should be considered during airplane type certification and supplemental type certification activities when less than engine rated takeoff thrust (power) is used for takeoff.

2. **APPLICABLE FEDERAL AVIATION REGULATIONS.** The applicable sections of 14 CFR part 25 are:

   § 25.101 "Performance, General"

   § 25.1521 "Powerplant limitations"

   § 25.1581 "Airplane flight manual, General"

3. **BACKGROUND.** Takeoff operations conducted at thrust (power) settings less than the maximum takeoff thrust (power) available may provide substantial benefits in terms of engine reliability, maintenance, and operating costs. These takeoff operations generally fall into two categories: those with a specific derated thrust (power) level, and those using the reduced thrust (power) concept, which provides a lower thrust (power) level that may vary for different takeoff operations. Both methods can be approved for use, provided certain limitations are observed. The subjects discussed herein do not pertain to in-flight thrust cutback procedures that may be employed for noise abatement purposes.

4. **DEFINITIONS.** Customarily, the terms "thrust" and "power" are used, respectively, in reference to turbojet and turboprop installations. For simplicity, only the term "thrust" is used throughout this AC. For turboprop installations, the term "power" should be substituted. For purposes of this AC the following definitions apply:

   a. Takeoff thrust.

      (1) Rated takeoff thrust, for a turbojet engine, is the approved engine thrust, within the operating limits established by the engine type certificate under the provisions of Part 33, and is limited to periods of not more than five minutes for takeoff operations.

      (2) Takeoff thrust, for an airplane, is normally the engine rated takeoff thrust, corrected for any installation losses and effects, that is established for the airplane under Part 25. Some airplanes use a takeoff thrust setting that is defined at a level that is less than that based on the engine rated takeoff thrust. Section 25.1521 requires that the takeoff thrust rating established for the airplane not exceed the takeoff thrust rating limits established for the engine under Part 33. The value of the takeoff thrust setting parameter is presented in the Airplane Flight Manual (AFM) and is considered a normal takeoff operating limit.

   b. Derated takeoff thrust, for an airplane, is a takeoff thrust level less than the maximum takeoff thrust, for which exists in the AFM a set of separate and independent, or clearly distinguishable, takeoff limitations and performance data that complies with all the takeoff requirements of Part 25. When operating with a derated takeoff thrust, the value of the thrust setting parameter which establishes thrust for takeoff is presented in the AFM and is considered a normal takeoff operating limit.

c. Reduced takeoff thrust, for an airplane, is a takeoff thrust less than the takeoff (or derated takeoff) thrust. The airplane takeoff performance and thrust setting are established by approved simple methods, such as adjustments, or by corrections to the takeoff or derated takeoff thrust setting and performance. When operating with a reduced takeoff thrust, the thrust setting parameter which establishes thrust for takeoff is not considered a takeoff operating limit.

d. A wet runway is one that is neither dry nor contaminated.

e. A contaminated runway is a runway where more than 25 percent of the required field length, within the width being used, is covered by standing water or slush more than 0.125 inch (3.2 mm) deep, or that has an accumulation of snow or ice. However, in certain other situations it may be appropriate to consider the runway contaminated. For example, if the section of the runway surface that is covered with standing water or slush is located where rotation and liftoff will occur, or during the high speed part of the takeoff roll, the retardation effect will be far more significant than if it were encountered early in the takeoff while at low speed. In this situation, the runway might better be considered “contaminated” rather than “wet.”

5. **REDUCED THRUST: ACCEPTABLE MEANS OF COMPLIANCE**. Under §§ 25.101(c), 25.101(f), and 25.101(h) of the regulations, it is acceptable to establish and use a takeoff thrust setting that is less than the takeoff or derated takeoff thrust if:

a. The reduced takeoff thrust setting:

(1) Does not result in loss of systems or functions that are normally operative for takeoff such as automatic spoilers, engine failure warning, configuration warning, systems dependent on engine bleed air, or any other required safety related system.

(2) Is based on an approved takeoff thrust rating or derating for which complete airplane performance data is provided.

(3) Enables compliance with the applicable engine operating and airplane controllability requirements in the event that takeoff thrust, or derated takeoff thrust (if such is the performance basis), is applied at any point in the takeoff path.

(4) Is at least 75 percent of the takeoff thrust, or derated takeoff thrust if such is the performance basis, for the existing ambient conditions.

(5) For turboprop installations, is predicated on an appropriate analysis of propeller efficiency variation at all applicable conditions.

b. Relevant speeds (VEF, VMC, V1, VR, and V2) used for reduced thrust takeoffs are not less than those which will comply with the required airworthiness controllability criteria when using the takeoff thrust (or derated takeoff thrust, if such is the performance basis) for the ambient conditions, including the effects of an Automatic Takeoff Thrust Control System (ATTCS). It should be noted, however, that in determining the takeoff weight limits, credit should not be given for an operable ATTCS.

c. The airplane complies with all applicable performance requirements, including the criteria in paragraphs a and b above, within the range of approved takeoff weights, with the operating engines at the thrust available for the reduced thrust setting selected for takeoff. However, the thrust settings used to show compliance with the takeoff flight path requirements of § 25.115 and the final takeoff climb performance requirements of § 25.121(c) should not be greater than that established by the initial thrust setting.

d. Appropriate limitations, procedures, and performance information are established and are included in the AFM.

e. A periodic takeoff demonstration is conducted using the airplane's takeoff thrust setting and the event is logged in the airplane's permanent records. An approved engine maintenance procedure or an approved engine condition monitoring program may be used to extend the time interval between takeoff demonstrations.

f. The AFM states, as a limitation, that takeoffs utilizing reduced takeoff thrust settings:

   (1) Are not authorized on runways contaminated with standing water, snow, slush, or ice, and are not authorized on wet runways unless suitable performance accountability is made for the increased stopping distance on the wet surface.

   (2) Are not authorized when the antiskid system, if installed, is inoperative.

   (3) Are not authorized unless the operator establishes a means to verify the availability of takeoff or derated takeoff thrust to ensure that engine deterioration does not exceed airplanes equipped with an ATTCS, whether operating or not, provided no performance credit is allowed for the one-engine-inoperative thrust increase.

g. The AFM states that:

   (1) Application of reduced takeoff thrust in service is always at the discretion of the pilot.

   (2) When conducting a takeoff using reduced takeoff thrust, takeoff thrust may be selected at any time during the takeoff operation.

h. Procedures for reliably determining and applying the value of the reduced takeoff thrust setting and determining the associated required airplane performance are simple (such as the assumed temperature method). Additionally, the pilot is provided with information to enable him to obtain both the reduced takeoff thrust and takeoff thrust, or derated takeoff thrust if such is the performance basis, for each ambient condition.

i. Training procedures are developed by the operator for the use of reduced takeoff thrust.

6. **DERATED THRUST: ACCEPTABLE MEANS OF COMPLIANCE.** For approval of derated takeoff thrust provisions, the limitations, procedures, and other information prescribed by § 25.1581, as applicable for approval of a change in thrust, should be included as a separate Appendix in the AFM. The AFM Limitations section should indicate that when operating with derated thrust, the thrust setting parameter should be considered a takeoff operating limit. However, in-flight takeoff thrust (based on the maximum takeoff thrust specified in the basic AFM) may be used in showing compliance with the landing and approach climb requirements of §§ 25.119 and 25.121(d), provided that the availability of takeoff thrust upon demand is confirmed by using the thrust-verification checks specified in paragraph 5e above.

■■

END OF ADVISORY CIRCULAR 25-13

e. **References.**

(1) Civil Air Regulations 4b, September 1962.

(2) Notice of Proposed Rulemaking 75-10 (40 FR 10802, March 7, 1975).

(3) Advisory Circular 25-XX, “Turbojet Operations At High Altitude,” [Incorporated into this Mega AC].

(4) FAA Order 8000.47, “Deteriorated Power, Propeller-Powered Air Carrier/Air Taxi,” June 5, 1981.

(5) FAA Order 8000.58, “Reduced Power Takeoffs - Turbopropeller Powered Transport Airplanes,” June 28, 1983.