

# Federal Aviation Agency



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AIRCRAFT

EFFECTIVE :

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**SUBJECT :** EXTRAPOLATION OF TAKEOFF AND LANDING DISTANCE DATA OVER A RANGE OF ALTITUDE FOR TURBINE-POWERED TRANSPORT AIRPLANES

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1. PURPOSE. This circular sets forth acceptable means, but not the sole means, by which compliance may be shown with the requirements of the following regulations for the establishment of takeoff and landing distances applicable to high altitude airports.
  2. REFERENCE REGULATIONS.
    - a. CAR 4b

4b.100(a) Proof of compliance
    - b. SR-422B
      - (1) 4T.115 Accelerate-stop distance
      - (2) 4T.117 Takeoff distance and takeoff run
      - (3) 4T.122 Landing distance
      - (4) 4T.123(a)(3) Accelerate-stop distance, takeoff distance, and takeoff run
      - (5) 4T.123(b) Information
  3. DISCUSSION.
    - a. Since the introduction of the transport category requirements, the takeoff and landing distance performance of reciprocating engine airplanes has been extrapolated from one set of basic flight test data obtained at one airport elevation over an altitude range extending from sea level to 8,000 feet. The calculation methods were standardized to a great extent, and many subsequent years of operating experience on the older airplanes has indicated no particular grounds for doubting the soundness of this procedure. When approval for operation at altitudes higher than 8,000 feet was desired, then additional tests at a high altitude were conducted.
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- b. Upon the introduction of turbine-powered airplanes, the allowable range of takeoff and landing distance performance extrapolation was reduced. The reasons for the reduction were that the turbine-powered airplanes had many new design features that were considerably different from those on previous type certificated reciprocating engine airplanes. The engine features that were different included larger ambient air effects on maximum power, idling power characteristics, engine acceleration and operating characteristics, etc. The airplane features that were different included sweptwings, high lift devices, control systems, wing spoilers, bogey landing gears, take-off and landing speeds, ground control and acceleration characteristics, etc. In the early stages, the effects of these various engine and airplane features on performance were not substantiated to the necessary degree of accuracy for the turbine-powered airplanes.
- c. In the meantime, a number of turbine-powered type airplanes have been type certificated and a large amount of varied operating experience has been accumulated. Some of the performance calculation methods on certain model airplanes have been standardized and substantiated by high altitude tests and subsequent operating experience. This provides reasonable justification for increasing the allowable extrapolation range for altitude at this time when substantiated performance methods are used.
- d. The overall objective of CAR 4b.100(a) should be observed in applying performance calculation methods. The stated objective is to allow the use of calculation methods based on the minimum amount of direct flight testing that will result in performance information accuracy that is equivalent to direct flight test performance measurements.

#### 4. ACCEPTABLE MEANS OF COMPLIANCE.

- a. When proven testing and data reduction methods previously verified by high altitude tests are used.
  - (1) Extrapolation of performance data for a range of altitudes. The basic test data should be obtained at an airport elevation of approximately 2,000 feet or less. These data may be extrapolated for a range of airport elevations from 3,000 feet below the test altitude to 6,000 feet above the basic test altitude when well-known and proven test and data reduction methods are used. If data approval is desired for a greater range of airport elevations, the performance may be calculated from the basic test data up to the maximum airport elevation, provided verifying tests are conducted at appropriate elevations to substantiate the validity of the calculations. The actual airplane performance data from the verifying tests should correspond closely to the calculated performance values. Wind velocities during

tests should not exceed eight knots. The acceptable ranges of airport elevation for expansion of performance data are summarized in the following table:


Basic Tests -	Between sea level and 2,000 feet elevation (approx.)
Maximum Extrapolation -	6,000 feet above test elevation 3,000 feet below test elevation
* Verifying Tests -	at least 1,000 feet above elevation of basic tests
Maximum Extrapolation -	6,000 feet above test elevation 3,000 feet below test elevation

- \* The verifying tests should include three takeoffs (either with all engines operative or one engine inoperative, whichever distance limits the takeoff weight), and three landings at maximum weights for elevation tested.

(2) Extrapolation of performance data for a range of altitudes when verifying tests are not conducted. The approval of performance data for airport elevations beyond the maximum elevation permitted by the basic tests specified in paragraph 4.a.(1) may be allowed without conducting verifying tests if the calculated data include a conservative factor. This conservatism should result in an increase of the calculated takeoff and landing distances at the desired airport elevations by an amount equal to zero percent for the highest airport elevation approved on the results of the basic tests, and an additional accumulative two percent incremental factor for each 1,000 feet of elevation above the highest airport elevation approved from test data. The two percent incremental factor should have a straight line variation with altitude. When performance data are calculated for the effects of altitude under this procedure, the following provisions are applicable:

- (a) Previously established calculation procedures should be used, taking into account all known variables.
- (b) The calibrated installed engine power for the pertinent speed and altitude ranges should be used.
- (c) The brake kinetic energy limits established by airplane ground tests should not be exceeded.
- (d) There should be no change to the airplane configurations other than those associated with approved basic test data.

- b. When unproven testing and/or data reduction methods unverified by previous high altitude tests are used.
- (1) Extrapolation of performance data for a range of altitudes.  
The basic test data should be obtained at an airport elevation of approximately 2,000 feet or less. These data may be extrapolated for a range of airport elevations from 2,000 feet below the test altitude to 2,000 feet above the basic test altitude. Wind velocities during tests should not exceed eight knots.
- (2) Extrapolation of performance data for a range of altitudes when verifying tests are not conducted. The approval of performance data for airport elevations beyond the maximum elevation permitted by the basic tests specified in paragraph 4.b.(1) may be allowed without conducting verifying tests if the calculated data include a conservative factor. The conservatism should result in an increase of the calculated takeoff and landing distances at the desired airport elevations by an amount equal to zero percent for the maximum airport elevation approved on the results of the basic tests, and an additional accumulative five percent incremental factor for each 1,000 feet of elevation above the maximum airport elevation approved from test data. The five percent incremental factor should have a straight line variation with altitude. When performance data are calculated for the effects of altitude under this procedure, the following provisions are applicable:
- (a) Theoretically sound calculation procedures should be used, taking into account all known variables.
- (b) The calibrated installed engine power for the pertinent speed and altitude ranges should be used.
- (c) The brake kinetic energy limits established by airplane tests should not be exceeded.
- (d) There should be no change to the airplane configurations other than those associated with approved basic test data.

  
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