

AC NO: 25.253-1A

DATE: 12/27/76



ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION

SUBJECT: HIGH-SPEED CHARACTERISTICS

1. **PURPOSE.** This circular sets forth an acceptable means by which compliance may be shown with FAR 25.253 during certification flight tests. Due consideration will be given to any other means of determining compliance the applicant elects to present.
2. **CANCELLATION.** AC 25.253-1, dated 11/24/65, is cancelled.
3. **REGULATIONS AFFECTED.** These acceptable means of compliance refer to certain provisions of the recodified Federal Aviation Regulations (FARs), Part 25, effective February 1, 1965. They may also be used in showing compliance with the corresponding provisions of the former Civil Air Regulations (CARs) in the case of aircraft to which those regulations are applicable.

FAR 25.175(b) Demonstration of static longitudinal stability

FAR 25.251 Vibration and Buffeting

FAR 25.253 High Speed Characteristics

FAR 25.335(b) Design Dive Speed, V_D

FAR 25.1303(b)(1) and (c) Flight and Navigation Instruments

FAR 25.1505 Maximum Operating Limit Speed

4. **DISCUSSION.**

- a. The maximum flight demonstrated speed, V_{DF}/M_{DF} , is used when establishing V_{MO}/M_{MO} and the associated speed margins under the provisions of FAR 25.1505. Both V_{MO} and M_{MO} are then evaluated during flight tests for showing compliance with FAR 25.253.
 - b. The upset criteria of FAR 25.1505 is predicated on an upset in pitch while the operational upsets expected to occur in service envisaged under FAR 25.253 cover pitch, roll, yaw and combined upsets.
-

Initiated by: AFS-160

- c. In general, the same maneuvers should be accomplished in both the "q" (dynamic pressure) and "M" (Mach) critical ranges. All maneuvers in either range should be accomplished at thrust and trim points appropriate for the specific range. It must be realized that some maneuvers in the "M" range may be more critical for some aircraft due to drag rise characteristics.
- d. The airplane's handling characteristics in the high speed range should be investigated in terms of anticipated action on the part of the flight crew during normal and emergency conditions. Consideration should be given to their duties which not only involve piloting the airplane, but also the operational and navigational duties having to do with traffic control and computation of records pertaining to the progress of the flight.
- e. The following factors are involved in the flight test investigation of high-speed characteristics:
- (1) Effectiveness of longitudinal control at V_{MO}/M_{MO} and up to V_{DF}/M_{DF} .
 - (2) Effect of any reasonably probable mistrim on upset and recovery.
 - (3) Dynamic and static stability.
 - (4) The speed increase that results from likely passenger movement when trimmed at any cruise speed to V_{MO}/M_{MO} .
 - (5) Trim changes resulting from compressibility effects.
 - (6) Characteristics exhibited during recovery from inadvertent speed increase.
 - (7) Upsets due to vertical and horizontal gusts (turbulence).
 - (8) Speed increases due to horizontal gusts and temperature inversions.
 - (9) Effective and unmistakable aural speed warning at V_{MO} plus 6 knots, or M_{MO} plus 0.01M.
 - (10) Speed control during application of devices.

f. The factors outlined in FAR 25.335(b)(2) have been considered in establishing minimum speed margins during past type certification programs for the "M" and "q" ranges as follows:

- (1) Increment allowance for horizontal gusts (0.02M).
- (2) Increment allowance for penetration of jet stream or cold front (0.015M).
- (3) Increment allowance for production differences of airspeed systems (0.005M), unless larger differences are found to exist.
- (4) Increment allowance for production tolerances of overspeed warning errors (0.01M), unless larger tolerances or errors are found to exist.
- (5) Increment allowance ΔM due to speed overshoot from MMO established by upset during flight tests in accordance with FAR 25.253 should be added to the values for production differences and equipment tolerances, and the minimum acceptable combined value should not be less than .05M between MMO and MD/MDF. The value of MMO should then be not greater than the lowest value obtained from each of the following equations and from FAR 25.1505:

$$MMO \leq MD/MDF - \Delta M - .005M - .01M$$

or


$$MMO \leq MD/MDF - .05M$$

- (6) At altitudes where V_{MO} is limiting, the allowances of item (1) and (2) are applicable when the Mach number increment is converted to the units used in the presentation of V_{MO} .
- (7) At altitudes where V_{MO} is limited, the increment allowance for production differences of airspeed systems and production tolerances of overspeed warning errors are 3 and 6 knots, respectively, unless larger differences or errors are found to exist.
- (8) Increment allowance ΔV due to speed overshoot from V_{MO} established by upset during flight tests in accordance with FAR 25.253 should be added to the values for production differences and equipment tolerances. The value of V_{MO} should not be greater than the lowest obtained from the following equation and from FAR 25.1505:

$$V_{MO} \leq VD/VDF - \Delta V - 3 \text{ knots (prod. diff.)} - 6 \text{ knots (equip. tol.)}$$

5. ACCEPTABLE MEANS OF COMPLIANCE. Using the speeds V_{MO}/M_{MO} and V_{DF}/M_{DF} determined in accordance with FAR 25.1505 and 25.251, respectively, and the associated speed margins, the airplane should be shown to comply with the high-speed characteristics of FAR 25.253. Unless otherwise stated, the airplane characteristics should be investigated at the most critical speed up to and including V_{MO}/M_{MO} , and the recovery procedures used should be those selected by the applicant, except that the normal acceleration during recovery should be 1.5g (total).
- a. Center of Gravity Shift. The aircraft should be upset by the center of gravity shift corresponding to the forward movement of a representative number of passengers (and/or serving carts) depending upon the aircraft interior configuration. The aircraft should be permitted to accelerate until three seconds after V_{MO}/M_{MO} .
 - b. Inadvertent Control Movement. Simulate an evasive control application when trimmed at V_{MO}/M_{MO} , by applying sufficient forward force to the elevator control to produce 0.5g (total) for a period of five seconds, after which recovery should be affected at not more than 1.5g (total).
 - c. Gust Upset. In the following three upset tests, the values of displacement should be appropriate to the airplane type and should depend upon airplane stability and inertia characteristics. The lower and upper limits should be used for airplanes with low and high maneuverability, respectively.
 - (1) With the airplane trimmed in wings-level flight, simulate a transient gust by rapidly rolling to the maximum bank angle appropriate for the aircraft, but not less than 45° nor more than 60° . The rudder and elevator control should be held fixed during the time that the required bank is being attained. The rolling velocity should be arrested at this bank angle. Following this, the controls should be abandoned for a minimum of ten seconds, or three seconds after V_{MO}/M_{MO} , whichever occurs first.
 - (2) Perform a longitudinal upset from normal cruise. The airplane should be trimmed at V_{MO}/M_{MO} and not to exceed maximum continuous cruise power or thrust. This is followed by a decrease in speed after which an attitude of $6-14^\circ$ nose down is attained with the power/thrust and trim initially required for V_{MO}/M_{MO} in level flight. The airplane should be permitted to accelerate until three seconds after V_{MO}/M_{MO} occurs.
 - (3) Perform a two-axis upset, consisting of combined longitudinal and lateral upsets. Perform the longitudinal upset as in (2) above, and when the pitch attitude is set but before reaching V_{MO}/M_{MO} , roll the airplane $15-25$ degrees. The established attitude should be maintained until three seconds after V_{MO}/M_{MO} occurs.

- d. Leveling Off From Climb. Perform transition from climb to level flight without reducing power below the maximum value permitted for climb until V_{MO}/M_{MO} . Recovery should be accomplished by applying not more than 1.5g (total) with no reduction in power.
- e. Descent From Mach Airspeed Limit Altitude. A descent should be performed at the airspeed schedule defined by M_{MO} and permitted to descend until V_{MO} is reached where recovery should be accomplished by applying not more than 1.5g (total). The maneuver should be completed without exceeding $V_D/V_{DF} - 9$ kts. or $M_D/M_{DF} - .015M$, whichever is lesser.



R. P. SKULLY
Director, Flight Standards Service