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TSCF5E/RLB/00/2-6217

by authority of CG, AMC

DATE 29 Sept 49

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ARMY AIR FORCES  
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AIR TECHNICAL SERVICE COMMAND  
MEMORANDUM REPORT ON

SUBJECT: Compressibility Dive Tests Part I on North American P-51D Airplane (Mustang IV), AAF No. 44-14134 Date 27 February 1945

SECTION FLIGHT

SERIAL No. TSCF5E-1843

Classification changed to UNCLASSIFIED by authority of CG, AMC DATE 23 Nov 1949

Contract No. Expenditure Order No. Purchase Order No.

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A. Purpose

To determine the maximum safe Mach Number at which the P-51D may be flown.

B. Factual Data

1. A series of thirty-one dives was conducted by the Flight Research Branch between 3 August 1944 and 16 September 1944. These dives included high and low altitude tests and limited stability tests at high Mach Numbers.

2. The tests were conducted at the request of Inter-office Memorandum P. W. Nosker:FFC:51 dated 27 June 1944, and Lt. D. E. Parke:PC:51 dated 10 July 1944 from Chief, Aircraft Laboratory, Engineering Division, to Chief, Flight Section.

3. The results of tests and recommendations were forwarded by Inter-office Memorandum TSCF5E/RLB/mem, dated 9 October 1944 from Chief, Flight Section, to Chief, Aircraft Laboratory.

4. The airplane was flown to a maximum true Mach Number of 0.85 during the twenty-sixth dive on 9 September 1944 and to a maximum calibrated airspeed of 486 MPH during the twenty-eighth dive on 9 September 1944. Both dives were flown by Major Frederic A. Forsodi.

5. The airplane was flown to a Mach Number of 0.80 or over on ten different dives by Major Frederic A. Forsodi.

6. The airplane was flown in excess of 0.80 Mach Number on two dives by Major Emil L. Sorenson

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7. During various dives above 460 MPH calibrated airspeed excessive deflections of the ammunition and gun bay doors, wheel well fairing doors and elevator fabric were either recorded or observed.

8. Following a failure of the left landing gear fairing door and strut fairing, tests were conducted and results wired to the manufacturer resulting in North American Service Bulletin Number P-51-198A dated 27 October 1944 on maintenance of up-latches on P-51B, C, and D airplanes.

9. On the second dive on 3 August 1944 Major Frederic A. Borsodi observed what is believed to be the first visual evidence of compressed flow by light refraction ever obtained in actual flight and on five (5) subsequent flights successfully took motion pictures of the phenomena.

10. The largest part of the information on the tests is included in three appendixes as follows:

- |              |  |
|--------------|--|
| Appendix I   | Instrumentation Part I<br>Calibrations Part II |
| Appendix II  | Discussion of Tests and Results                |
| Appendix III | Test Results and Computed Data                 |

11. Close cooperation was maintained at all times with the Aerodynamics Branch of the Aircraft Laboratory. Excellent assistance was also rendered by the Flight Design Data Unit, Structures Branch of that Laboratory in calibrating and servicing the Flight Analyzer for all flights.

### C. Conclusions

1. It was concluded that the standard P-51D airplane may be safely flown to a Mach Number of 0.80, however, due to the critical nature of ammunition bay and gun bay door bulge, elevator fabric bulge and deflection of landing gear fairing doors at high indicated speeds, the manufacturer should be requested to demonstrate the airplane at an indicated airspeed of 505 MPH.

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2. The following conclusions were achieved concerning the handling characteristics at high Mach Number:

a. Porpoising: The P-51D airplane, at high speeds, is subject to the longitudinal instability commonly referred to as porpoising. The results to date indicate that the condition may be induced at a Mach Number of 0.70 and above, but may be encountered at somewhat lower Mach Numbers at low altitude. It is known that the fabric bulge in the elevator surfaces is more critical at low altitude and may be related to the airplane's increased tendency to porpoise at lower Mach Numbers in that range.

The porpoising is not a severe condition and can be controlled. In the first place, the condition is usually induced by the pilot since any non-uniform elevator stick force will result in the porpoising at high Mach Numbers. Any effort on the part of the pilot to counteract this effect will result in increasing the amplitude. It may actually be stopped by holding the stick firmly in one position or, in fact, eliminated by trimming forward gradually to near zero forces as the dive is entered, thus reducing the amount of forward stick force necessary to maintain the dive angle.

b. Rolling: As a Mach Number of 0.75 is approached, a slight amount of rolling may become apparent with a simultaneous reduction in aileron sensitivity. This rolling does not become severe and may be easily controlled.

c. Vibration: At a Mach Number of 0.70 a true effect of compressibility becomes evident in the form of a complete vibration of the airplane. This vibration is caused by a combination of compressibility effects on the wing and the horizontal stabilizer. The condition becomes increasingly severe as the Mach Number increases and could eventually cause a primary structural failure.

d. Maximum Limit for Combat: In each case the pilots reported that the vibration became extremely heavy beyond 0.80. In each dive to 0.84 or above the vibration became so severe that the airplane was damaged. The leading edge skin of the wing flap was buckled between rivets, a coolant radiator cracked and hydraulic line broken due to vibration on various dives to 0.84 and above. In extreme war emergency the airplane can be dived to a Mach Number of 0.83 (400 MPH Indicated Airspeed at 25,000 feet) if a very gradual pull-out is made. A relatively low acceleration could result in a primary structural failure if applied during the vibration.

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e. Entering a Dive: Relative to starting a dive, no difficulties are encountered in nosing over or in entering from a diving turn, however, extreme care should be exercised in starting from a half roll since high Mach Numbers may be reached within a few seconds. Entry of a dive (at rated power) from a half roll above 30,000 feet would probably result in a primary structural failure, providing such a dive were maintained in a near vertical attitude for 8,000 to 10,000 feet before recovery was attempted.

f. Recovery Techniques: Recovery in any case must be gradual and executed with extreme caution since relatively light elevator stick forces or rapid application of trim may very easily result in the application of excessive load factors. As acceleration is applied at the beginning of the pull-out some increase in vibration may occur. This will gradually decrease as the recovery is completed. In no case is elevator trim necessary to aid recovery. The normal pull-out distances stated in Pilots' Information File apply. The pull-out distances stated in Section II, Par. 21, page 26 of Pilots' Operating Instructions, AN-OL-605E-1, are not correct.

g. Effect of Yaw and Change of Power: In no case has the airplane tended to "Tuck-Under" when power was either increased or decreased. The rudder becomes stiff in the compressibility range but the airplane exhibits no unusual tendencies when force is applied to either right or left.

#### D. Recommendations

1. It was recommended that all standard P-51D airplanes be placarded with the following limit diving speeds corresponding to a Mach Number of 0.80. The structural limit of 505 MPH indicated governs below 12,000 feet.

Pressure Altitude (Feet)	Pilots IAS (MPH)
40,000	275
35,000	310
30,000	345
25,000	385
20,000	425
15,000	470
10,000	505
5,000	505

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2. It was recommended that the information of Paragraph 2, Conclusions, regarding handling characteristics, be made available for Pilots Operating Instructions.

3. It is recommended that the airplane be equipped with the following preparatory to additional dives:

- a. Metal covered elevators.
- b. A long-boom pitot system.
- c. A long-dog-leg pitot system (P-51B system).
- d. A 35 mm motion camera at wing surface level.
- e. Elevator force and position indicators.

These dives, Part II, would be primarily for the purpose of correlating the shock wave position and investigating the handling characteristics of the airplane when equipped with metal elevators.

4. It was recommended that the manufacturer demonstrate the airplane at an indicated airspeed of 505 MPH (ATSC wire TSBPR-375-10-81, dated 31 October 1944).

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