RESTRICTED. 49th Part of Report No. A.&A.E.E./692,m

AIRCRAFT AND ARMAMENT EXPERIMENTAL ESTABLISHMENT
BOSCOMBE DOWN.

This report deals with the a/c or equipment as tested. Action to remedy defects or decisions to accept items not in strict compliance with the specification are matters for decision & action by the Ministry of Aircraft Production.

# Spitfire LF Mk.IX ML.186 (Merlin 66)

## Handling with rear fuselage tank and metal elevators.

A.&A.E.E. ref: 5717,a/84/JF
M.A.P. ref: B.156011/RDL1,a
RA.6895 /
Period of tests: January - February, 1945.

Progress of issue of report.

| Report No. | Title |
|---|---|
| 44th Part of A&AEE/692,m | MK.210 - Handling trials with increased internal fuel capacity and two underwing drop tanks. |
| 45th do. | MA.648 - Fuel consumption tests with Rolls Royce Mk.II S.U. injection pump. |
| 46th do. | MH.477 - Rocketry trials with American M.10 Tube Cluster launchers. |
| 47th do. | BS.352 - Pitot error measurements. |
| 48th do. | TA.822 - Gun heating tests with N.A.F.D.U. barrel cooling scheme. |


## Summary.

Tests have been carried out on this aircraft fitted with a rear fuselage fuel tank and metal-covered elevators to assess its suitability for service use. The handling qualities were tested at various c.g. positions to determine the maximum quantity of fuel that could be carried in the rear fuselage tank for full combat manoeuvres. Further tests were carried out with an inertia weight in the elevator circuit in an attempt to improve the longitudinal stability at the aftmost acceptable c.g.

The aircraft was considered acceptable with full rear fuel, for escort flying but not for tight formation or instrument flying. Fuel should be used from the rear tank for take-off and climb and no violent manoeuvres should be attempted before 34 gallons have been used.

It was concluded that the aftmost acceptable c.g. position for full combat manoeuvres was 9.9 ins. aft of datum (U/C up) (i.e.,with 34 gallons of fuel used from the rear tank) and the addition of an inertia weight was not recommended.


## 1. Introduction.

Handling trials have been made on Spitfire IX ML.186, fitted with a 75 gallon rear fuselage fuel tank, and a hand made metal-covered elevator. The centre of gravity of the aircraft at full load was 12.6 ins. aft of datum (undercarriage up).

Since the tests with a full rear tank showed the aircraft to be dangerously unstable for combat flying, further tests were made to determine how much fuel had to be used from the rear tank before the aircraft became satisfactory for full combat manoeuvres.

A special inertia weight was fitted in the elevator circuit and further trials were carried out at the previously determined aftmost acceptable c.g. to assess any improvement in the longitudinal stability and control characteristics.

Preliminary results of trials were forwarded to M.A.P. by letters, references AAEE/AS.56/84/S of P/DF and AAEE/5717,a/84/- dated 30th January and 2nd March, 1945, respectively.

## 2. Condition of aircraft relevant to tests.

2.1 General. The following were the principal features of the aircraft :-

/cont.

Normal full span wings.
Two 20 mm. Hispano guns, two 0.5 ins. Browning guns, ports and ejector chutes sealed with fabric.
Multi-stub ejector exhausts.
Rear view mirror with hemispherical fairing.
Balloon type cockpit hood (non rear-view)
Whip aerial behind cockpit.
VHF type 90 aerial beneath starboard wing.

The control surfaces were normal for Spitfire Mk.IX aircraft, with the exception of the elevator which was a hand made metal-covered prototype.

The rear fuselage tank had a nominal capacity of 75 gallons.

The inertia weight fitted in the elevator circuit for some of the tests was 7¼ lb. on a moment arm of 3½ ins.

2.2 Loading. The aircraft was flown at the following take-off loadings :-

| Loading | Condition | All up weight | C.G. Position | | | |
|---|---|---|---|---|---|---|
| | | | U/C down | | U/C up | |
| | | | ins. aft of datum | % SMC | ins. aft of datum | % SMC |
| A | Full fighter load(74 galls. in rear tank) | 8145 | 12.2 | 39.2 | 12.6 | 39.7 |
| B | Full fighter load (less 34 galls. in rear tank) | 7915 | 9.5 | 35.7 | 9.9 | 36.3 |

Consumption of all the rear fuselage fuel moves the c.g. 5.2 ins. forward from loading A.

2.3 ASI system. The ASI used during the tests was connected to the pitot and static sides of a Mk.VIII pressure head mounted in the normal position under the port wing.

3. Scope of tests.

Handling tests were carried out at loading A to assess qualitatively the handling characteristics of the aircraft when fitted with a full rear fuselage fuel tank. An assessment was also made of the maximum quantity of fuel in the rear fuselage tank to give satisfactory handling characteristics for full combat manoeuvres.

Further handling flights were made at the previously determined aftmost acceptable c.g. (loading B) with an inertia weight fitted in the elevator circuit to assess any improvement in the longitudinal stability and control characteristics.

4. Results of tests.

4.1 Take-off and initial climb. At loading A the take-off was straightforward, the tail taking longer to rise than is usual for standard Spitfire IX aircraft. The aircraft became airborne cleanly and the initial climb was satisfactory although there was a tendency to pitch. This was easy to check with the elevator under conditions of calm air and good visibility.

4.2 Level flight. At loading A the aircraft was markedly longitudinally unstable, stick free, under all conditions of level flight and it was impossible to fly "hands off" for even short periods at normal cruising speeds. On abandoning the control column, the aircraft diverged immediately, the rate of divergence building up rapidly. In conditions of bumpy air, continual fore and aft checking with the control column was required to maintain level flight and the aircraft was considered most tiring to fly.

As fuel was used from the rear tank, there was a noticeable improvement in the longitudinal behaviour of the aircraft. After about 34 gallons had been used (c.g. 9.9 ins. aft, undercarriage up), the aircraft could be flown level with a reasonable degree of comfort although it was still unstable in phugoid motion and was very "touchy" longitudinally, making accurate trimming difficult.

/4.3

4.3 Turns. At loading A the aircraft tightened up very markedly in turns and a heavy push force was required to prevent the accelerometer reading building up to excessive values. Gentle turns of 2 'g' accelerometer reading could be made but a push force was required to hold the turn.

As fuel was used up from the rear tank the degree of tightening in the turn became less pronounced but with 34 gallons used (c.g. 9.9 ins. aft, undercarriage up) the aircraft still tightened up in turns at accelerometer readings above 2g at 20,000 ft. It was considered, however, that, if due care were exercised, satisfactory combat manoeuvres could be carried out at this loading without unduly heavy stick forces being involved in checking the build up of normal acceleration.

4.4 Dives. The aircraft was dived to a maximum speed of 400 mph ASI, at loading A, when trimmed for maximum cruising conditions (270 mph ASI, 2650 rpm, +7 lb/sq.in. boost) at 12,000 ft. The elevator force required to hold the aircraft in the dive was neutral. There was a definite tendency to diverge in bumps, which had to be constantly checked. On reducing speed, the change of trim was in the reverse sense, i.e., the nose tended to rise, and nose down movement of the trimmer was required.

At loading B the aircraft was dived from combat level flight at 25,000 ft. (255 mph ASI) to 360 mph ASI. At 20,000 ft. a very light push force was required to hold the aircraft in the dive. On releasing the control column at 360 mph ASI the acceleration built up quickly.

4.5 Stalls. As the aircraft had particularly badly fitting wing-root panels and cowlings, the stalling speeds given cannot be regarded as accurate owing to the bad pre-stall buffet.

At loading A the buffet started at 102 mph ASI, flaps and undercarriage up. As speed was reduced, a forward force was required on the control column. When the buffet started the control column was about 2 ins. forward of neutral. The aircraft stalled at 95 mph ASI. With flaps and undercarriage down the buffet started at 84 mph ASI and the aircraft stalled at 76 mph ASI. Again a light push force was required on the control column to prevent an incipient stall. In all other respects the characteristics were normal at this loading.

At loading B the stalling characteristics were similar to those at loading A with the exception that the elevator forces were in the correct sense and the self stalling qualities were therefore not present.

4.6 Approach and landing. Although there is little likelihood of the aircraft landing at these loadings in service, i.e., with a full or almost full fuel load, landings were made in this condition and the results are included in this Report to cover such cases.

In the approach at loading A with flaps down, the aircraft had a tendency to pitch and also to self stall, making landing very unpleasant, if not dangerous. Landing at this loading was not recommended except in an emergency.

The approach at loading B was quite normal, the elevator being very effective. The aircraft required a considerable amount of power to maintain a suitable flight path and on closing the throttle the aircraft sank rapidly with very little float at about 85 mph ASI.

4.7 Results with inertia weight in elevator circuit. Further tests were carried out at a c.g. position of 9.9 ins. aft of datum, i.e., loading B, with an inertia weight in the elevator circuit.

The aircraft was tested in climbs, level flight, turns and dives and showed no noticeable improvement.

5. Conclusions and recommendations.

5.1 General. This aircraft was fitted with a hand made metal elevator the tolerances of which were likely to be considerably more accurate than those of the production version. It was considered that small errors in manufacture might cause serious deterioration in the longitudinal stability and control characteristics of the type with the result that the aftmost c.g. of ML.186 may not be realised on future production aircraft.

/5.2

5.2 Loading A (full rear fuel). If the aircraft were restricted to straight and level flight and gentle turns it was not considered that it would be dangerous for an experienced Spitfire pilot in conditions of good visibility. It was considered that the aircraft would be dangerous for instrument or formation flying with full rear fuel.

The aircraft was acceptable however, for combat duty at this take-off loading provided take-off and climb were made on the rear tank and no violent manoeuvres were attempted before 34 gallons of the rear fuel were used.

5.3 Loading B (34 gallons of fuel used from rear tank, c.g. 9.9 ins. aft of datum, undercarriage up). Although the aircraft could not be considered satisfactory as a fighter by present day standards, it was not considered dangerous if flown by experienced pilots. Full combat manoeuvres could be carried out at this loading without difficulty, although care was necessary to prevent excessive normal accelerations building up. It should be noted, however, that the handling characteristics were unsatisfactory under these conditions and the loading is recommended only as an operational necessity. In peace-time operation the fuel carried in the rear tank should be kept to a minimum.

5.4 Effect of inertia weight. The fitting of an inertia weight in the elevator control circuit was not recommended as it caused no noticeable improvement in the handling characteristics of the aircraft.

Circulation List.

C.R.D.
D.T.D.
D.D.T.D.
D.O.R.
D.D.R.D.A.
D.D.R.D.T.
A.D.R.D.T.1.
A.C.A.S.(T.R.)
D.D.A.P.9.
D.R.A.E. 6 copies
D. Arm. D.
R.D.T.3.
A.D.R.D.L.1. 2 copies (1 for action)
A.F.E.E.
T.F.2.
Chief Overseer
C.I. Accidents
R.D.T. Accidents
D.P.A.
O.C. Handling Squadron
R.T.P.(TIB) 60 copies + 1
R.T.O. Vickers Armstrong 2 copies

for Senior Handling Technical Officer.

Supt. of Flying.

Supt of Performance.