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Note on the Maintenance of Laminar-Flow Wings

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Introduction.—The maintenance of laminar-flow wings involves two problems:—

(1) The prevention of deterioration in the surface itself (*e.g.* cracking of the paint or filler, increase in roughness or waviness, etc., whether due to weathering, stresses in flight, or accidental damage).

(2) The prevention of contamination of the surface with flies, etc.

This Note gives an account of experience gained at the Royal Aircraft Establishment in dealing with these problems during flight tests on the characteristics of low-drag wings.

1. *Prevention of Surface Deterioration.*—At the commencement of the flight tests on the King Cobra, the region of wing under test (a section 3 ft 3 in. in span) was prepared as follows. The surface was first rubbed down thoroughly with carborundum paper to achieve as smooth a base as possible. Two coats of primer (Ref. 33B/208) and one coat of filler (Ref. KAF4362) were then sprayed on evenly. Local hollows were given extra coats of filler to reduce waviness, and the whole surface again rubbed smooth. The same filler was also used to produce a smooth surface at a skin-joint on the main spar where there was a gap of about 0·02 in. Finally the surface was carefully sprayed with cellulose (D.T.D. Spec. 83A) and rubbed down to as smooth a finish as possible.

This surface did not deteriorate appreciably over a period of six months, except at the skin-joint, where the filler tended to come out of the gap and had to be rubbed down at frequent intervals. This was due partly to the brittleness of the filler when dry, and partly, it is thought, to variations in the width of the gap in flight. The difficulty could have been overcome by redesign of the joint or possibly by the development of an improved filler. During the six months referred to, fifty flights were made, (about 40 hours) and the aircraft was exposed to weather for something of the order of 200 hours. During the remainder of the time it was kept in a hangar, but apart from this no special precautions were taken to prevent "weathering."

Experience with another King Cobra (FR408) at the R.A.E. suggests that much longer exposure to weather need not in itself cause serious deterioration of the surface. This aircraft crashed during some early tests on boundary-layer transition, and has been standing in the open for

over two years. The upper surface of the test section is now slightly chalky and rubs off on the hand, but it is still aerodynamically smooth, and rubbing down with fine scouring powder soon restores the original finish. On the under surface of the wing, only soap and water are needed to restore a perfect finish. There are however a number of cracks in the paint at skin-joints and rivets, mainly on the upper surface. At most of these cracks there was evidence of oil having come through the joints and rivets from inside the wing, and this may have been at least partly the cause of the cracking. This effect occurred on the top as well as the bottom surface, suggesting that oil vapour inside the wing may be responsible. It was noticed that there was no sign of oil at any of the rivets on the fin and that the paint over these rivets was still intact. It should be mentioned incidentally that there was no noticeable difference in the condition of parts of the wing which had been painted white, compared with the remainder, in spite of the fact that the white parts remain much cooler than the rest of the wing when exposed to sunlight. In hot climates the effect will be more marked.

Experience gained in tests on the Hurricane 1, 2 confirmed the above impressions. In this case the entire wing surface was finished to the standard required for laminar flow, and, over a period of six months (during which only 17 hours of flying were done) most of the surface remained in good condition. Some trouble was, however, experienced with several chord-wise skin-joints, along which the paint cracked and came away from the surface slightly. A similar cracking of the paint also occurred at a number of rivets near the leading edge. This effect was due to softening of the undercoating caused by oil finding its way through the joints and rivets, as in the case of the King Cobra mentioned above. There is a possibility however that in the case of the Hurricane the effect may have been due simply to traces of paraffin which had been used to clean the wing before painting, and which may have lodged in the joints and rivet holes.

Throughout the tests on Hurricane and King Cobra, efforts were made to impress upon the ground crews the importance of avoiding any accidental damage to the wing surface during handling and servicing. These efforts were completely successful. The ground crews became, in fact, enthusiastic custodians of the surface finish, and a wooden cover which had been used at the commencement of the King Cobra tests to protect the surface became unnecessary. It is doubtful, however, whether this standard of maintenance could be achieved in the day-to-day operation of civil or military aircraft. In the past the deterioration of aircraft in service has sometimes been very marked. The paint on Spitfires, for example, was often observed to have flaked off over large areas. It is not certain whether this was due to defects in the painting or to lack of care in handling and servicing. With regard to the former, the care taken in applying paint and filler in the R.A.E. tests was by no means prohibitive, and should be possible on service aircraft.* Care in handling and servicing has undoubtedly improved in recent years, but the standard necessary on laminar-flow wings is of course very high, although no higher than the care normally given by chauffeurs to private motor cars.

2. *Surface Contamination.*—Contamination of the wing surface with flies and other insects during and immediately after the take-off has been by far the most serious problem experienced in trying to achieve far-back transitions in flight. During tests on the King Cobra in the spring of 1945 for example, it was found that as the days got warmer, the number of flies picked up in each flight increased, until finally the number became prohibitive even when flights were confined to early morning.

The difficulty was overcome on the King Cobra by covering the front part of the test section with a sheet of paper stretched tightly round the leading edge and extending to about $0{\cdot}3c$ on top and bottom surfaces. The width of the test section was only 3 ft 3 in., so that the sheet

* The only difficulty with paint met with at the R.A.E. was in some tests on the Mustang, when deterioration of the paint was found to be due to interaction between two different types of paint.

of paper required was not large. The pilot could jettison the paper when the aircraft had reached a height beyond the limit at which insects were normally found (about 5000 ft) by pulling a string looped through the paper at the leading edge and passing into the cockpit through a piece of pitot tubing. Apart from a few minor initial troubles, no great difficulty was experienced in using this device on the short test section of the King Cobra. The development of a similar technique to cover the whole of the leading edge and capable of use under normal civil or military conditions would, however, clearly entail great difficulties particularly on large aircraft. Unfortunately the successful application of low-drag wings in practice appears to be completely dependent on the solution of the fly problem, since the flies and insects picked up in one take-off (or landing) under unfavourable conditions could cause the drag of a laminar-flow wing to be almost doubled, with a consequent reduction in range (at the same speed) of about 30 per cent on a clean all-wing aircraft. Chemistry Department at the R.A.E. has done some preliminary work on the possibility of coating the wing surface with a chemical which would come away from the surface soon after the take-off, taking the flies with it. This method is perhaps the most promising one yet suggested, but more work is needed on it before it can be tried out in flight.

Contamination of the wing surfaces with dust, etc., between flights was easily dealt with in the R.A.E. tests by cleaning before each flight. Scratching of the surfaces was avoided by using water, and on the King Cobra a liquid polish was also used. All this presented no difficulty on small aircraft like the King Cobra and Hurricane, but would not be so easy on large aircraft.

Difficulties due to mud, etc., being splashed on the wing during take-off were experienced on only a few occasions, during very bad weather. Nothing was done about this problem, other than to instruct the pilots to avoid dirty patches wherever possible during taxing. The chance of contamination of this kind would of course be somewhat reduced on large aircraft. It should be mentioned incidentally that the use of white paint facilitates the detection of contamination and imperfections.

3. *Conclusions.*—(1) The main difficulty experienced in maintaining the wing surfaces themselves in the R.A.E. tests on Hurricane and King Cobra was in preventing deterioration at joints and rivets, where the filler used to produce a smooth finish needed frequent renewing or rubbing down. Apart from this the surfaces, which in each case had been carefully painted, remained in good condition, even after two years exposure to weather in one case.

(2) The precautions taken to avoid accidental damage to the surfaces by impressing upon the ground crew the need for care in handling and servicing, were completely effective.

(3) Contamination of the surface with flies and other insects during take-off was found to be a serious problem, and no really satisfactory solution has yet been developed which would be applicable in practice to large civil or military aircraft.

REFERENCES

No.	*Author*	*Title, etc.*
1	F. Smith, D. J. Higton and T. A. R. Bramwell	Flight Tests on a Hurricane II Z3687 Fitted with Special Wings of a "Low-drag" Design. R. & M. 2546. September, 1946.
2	R. H. Plascott	Profile Drag Measurements on Hurricane II Z3687 Fitted with "Low-drag" Section Wings. R. & M. 2546. September, 1946.
3	W. E. Gray	A Chemical Method of Indicating Transition in the Boundary Layer. A.R.C. Report 8034. July, 1944. (To be published).

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