12th Part of Report No. A.& A.E.E./783.

3 SEP 1942

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT

BOSCOMBE DOWN.

Kittyhawk I's A.K.572 and A.L.229

Allison V.1710-F.3.R.

Engine cooling trials.

A.& A.E.E. Ref:- 4481/1-A.

M.A.P. Ref:- R.A.1871/D.A.N.A.1.

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

Progress of issue of report

Report No.	Title
7th Part of A.& A.E.E./783.	A.K.572 and A.L.229 - Radio trials - Communication sets.
8th do.	A.K.572 - Rate of climb and P.E. measurements.
9th do.	A.L.229 - Fuel consumption trials and range flight with a long range jettisonable ventral tank fitted.
10th do.	A.L.229 - Performance tests with an external fuel tank fitted.
11th do.	A.L.229 - Take-off and landing trials with and without an overload fuel tank.

Contents.

SUMMARY

Engine cooling tests were commenced on Kittyhawk I. A.K.572 but owing to this aeroplane becoming unserviceable they were completed on A.L.229. The results obtained on each aeroplane are included in this report. Details of the cooling system are also given in the report.

The results show that:-

(1) The oil and radiator inlet temperatures on the climb, at an initial climbing speed of 145 m.p.h. A.S.I., are within requirements for tropical summer conditions, with the gills fully open.

(2) The stabilised oil and radiator temperatures in maximum rich mixture cruising flight are within requirements for tropical summer conditions, with the gills in the minimum drag position.

(3) In maximum weak mixture cruising flight, the oil inlet temperature is within requirements with the gills in the minimum drag position. The radiator suitability is slightly below 1.0. Opening the gills $\frac{1}{8}$th of the available range, will bring the radiator suitability within requirements and cause a negligible reduction of speed.

1. Introduction.

Engine cooling tests were required on a Kittyhawk I aeroplane. The tests were started on Kittyhawk I A.K.572, but owing to the aeroplane becoming unserviceable were completed on A.L.229. The results obtained on both aeroplanes are included in this report. The tests were made during the period February - July 1942.

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2. Scope of tests.

Two climbs were made on A.K.572 at the best climbing speed (an initial speed of 145 m.p.h. A.S.I.) as found from tests in America, during which observations of oil inlet and radiator inlet temperatures were taken. Similar observations were taken in cruising flight on two flights at 15,000 ft. on one of which the radiator inlet thermometer was not read. The oil cooling results obtained on this flight are included in the report.

On A.L.229 the cooling test in cruising flight was repeated at 15,000 ft., to confirm the radiator suitability results. As the radiator temperatures were slightly above requirements a further test was made with the radiator duct gills ¼ open from their neutral position.

3. Condition of aeroplanes relevant to tests made.

A full description of A.K.572 has been given in 8th Part of Report A.& A.E.E./783 and this applies equally to these tests.

A.L.229 has been fully described in 10th Part of Report No.A.A.E.E/783. For all the tests on this aeroplane, the jettisonable fuel tank mentioned in the 10th Part of A.& A.E.E./783, was not fitted. For the tests with the radiator duct gills ¼ open from the neutral position, the steadies for the bomb were fitted; on the other test they were removed. Throughout the tests on this aeroplane, flame damping exhausts as described in 4th Part of Report No. A.& A.E.E./783, were fitted.

The radiator and oil cooler are in a duct under the nose, the oil cooler at the bottom in the centre, with the two coolant radiator blocks above. The oil cooler is to Drawing No.U-3385-D85 and the radiator to drawing No.87-50-015. The flow of air through the duct is controlled by four gill plates at the exit from the duct. These are under the control of the pilot. The indicator fitted has three positions marked, i.e. closed, neutral and open, but the gills can be set at any intermediate position. The mean gaps between the gill plates and the under side of the fuselage are given in Table I. In the closed position, the gills point inwards almost closing the duct and this position is used for rapid warming of the engine on the ground. In the neutral position the gills continue the line of the duct and this position is that normally used in cruising flight. This gill position is referred to as the minimum drag position in this report, although speed trials to prove this have not been made.
The air for heating the cockpit is taken from ducts behind the radiator. The tests were made with the cockpit heating "off" in all cases, since this gives a lower air flow through the radiator and oil cooler.and thus higher coolant and oil temperatures than with heating "on". The engine limitations which applied when these tests were made are given in Table II.

4. Results of tests.

The results obtained are given in full in tables III to VIII and in figures 1 to 3 of the Appendix. These are summarised below.
The oil inlet temperatures have been corrected to temperate and tropical summer conditions, by adding 70% of the difference of the appropriate standard from the observed air temperature.

Radiator suitability is given by

Suitability ratio = $\frac{T_n - T_s}{T_o - T_a}$ where

T_n = Normal maximum permissible coolant temp.
T_s = Appropriate standard air temp.
T_o = Observed engine outlet temp.
T_a = Observed air temp.

/(a) Climb.

(a) Climb. Height of r... inlet temp... minimum rad... ability.

(a) Climb.

Height of maximum oil inlet temperature and minimum radiator suitability.	Oil inlet temperature °C corrected to		Radiator Suitability (T_n = 115°)	
	Temperate Summer conditions.	Tropical Summer conditions.	Temperate Summer conditions	Tropical Summer conditions
20,000 ft.	85	95	1.13	1.01

Permissible oil inlet temperature :- 95°C

(b) Cruising level flight at 15,000 ft. with cooling gills in minimum drag position.

Mixture Control	R.P.M.	Boost lb/sq. in.	A.S.I.	Oil inlet temperature °C corrected to		Radiator suitability (T_n = 115°C)	
				Temperate Summer Conditions	Tropical Summer Conditions	Temperate Summer conditions	Tropical Summer Conditions.
Weak	2300	30½	225	74	84	1.115	.985
Rich	2600	34½	243	75	85	1.135	1.000

Permissible oil inlet temperature:- 85°C.

(c) Cruising level flight at 15,000 ft. with gills ¼ open from neutral position.

Mixture Control	R.P.M.	Boost lb/sq. in.	A.S.I. m.p.h.	Oil inlet temperature °C corrected to		Radiator suitability (T_n = 115°C)	
				Temperate Summer conditions	Tropical Summer conditions	Temperate Summer Conditions	Tropical Summer Conditions
Rich	2600	34	231	-	-	1.20	1.055

It is seen from these results that under rich mixture cruising conditions, opening the gills ¼ from the minimum drag position, increases the radiator suitability by .055. A similar increase in suitability would be obtained in weak mixture cruising flight, so that a gill opening of ⅛ from the neutral position will give adequate cooling under this condition.

The resultant decrease in speed due to a gill opening of ⅛ has been estimated from the speed measurements on one aeroplane with the gills closed, ¼ open, and ½ open, and is only about 1 m.p.h. A.S.I. It should be noted that the speed given in Para.4(c) was obtained with the bomb supports on, and this accounts for the apparent inconsistency in speed.

5. Conclusions.

1. The oil and radiator inlet temperatures on the climb are within requirements for tropical summer conditions, with the gills fully open.

2. The stabilised oil and radiator inlet temperatures in maximum rich mixture cruising flight are within requirements for tropical summer conditions, with the gills in the minimum drag position.

3. In maximum weak mixture cruising flight, the oil inlet temperature is within requirements with gills in the minimum drag position. The radiator suitability is slightly below 1.0. Opening the gills ⅛ open from this position will bring the radiator temperature within requirements and causes a reduction in speed of only about 1 m.p.h. A.S.I.

/TABLE I.

TABLE I

Gap between the trailing edge of the radiator duct gill plates and the under surface of the fuselage.

Indicator reading	Mean gap inches
Closed	0.3
Neutral i.e. minimum drag	3.0
¼ open	7.8
Full open	12.1

TABLE II

Engine limitations used in tests

	R.P.M.	Boost Inches of Hg.
Maximum permitted for take-off	3000	44½
" " " climbing	2600	37
" " " all-out level flight (5 minute limit)	3000	42
" " " continuous cruising (automatic rich mixture)	2600	37
" " " continuous cruising (automatic weak mixture)	2300	30½

Maximum permissible oil inlet temperature using Summer Grade Oil.

Maximum for cruising 85°C

Maximum for climbing 95°C

Emergency maximum 95°C

Maximum permissible radiator inlet temperature = 125°C

T_p used in calculating radiator suitability on climb = 115°C
" " " " " " in level flight 115°C.

CIRCULATION LIST

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/APPENDIX .