535

ARROW 2 72/PERF/12

CONDITIONS FOR BRAKE SPECIFICATION

UNCLASSIFIED

SECRET

PERFORMANCE GROUP JUNE 1958

AVRO AIRCRAFT LIMITED

MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

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S E C R E T

AIRCRAFT: ARROW 2

REPORT NO: 72/PERF/12 (EXTRACT)

FILE NO:

NO. OF SHEETS: 8

TITLE:

Classification cancelled/changed to ....
by authority of .... (date) ....
Signature .... Rank ....

27.51 x 10^6
51.14 x 10^6
88.9 x 10^6

ARROW 2 - CONDITIONS FOR BRAKE SPECIFICATION

Classification cancelled/changed to ....
by authority of .... (date) ....
Signature .... Rank .... F/L

PREPARED BY P Hollenberg. Performance Group DATE

CHECKED BY DATE

SUPERVISED BY R.G. Rose Senior Aerodynamicist DATE June 1958.

June 1958

APPROVED BY Chief of Performance Evaluation DATE June/58

ISSUE NO.	REVISION NO.	REVISED BY	APPROVED BY	DATE	REMARKS

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AVRO EA 1316 A

AVRO AIRCRAFT LIMITED MALTON · ONTARIO TECHNICAL DEPARTMENT		REPORT NO. 72/PERF/12 (EXTRACT) SHEET NO.	
		PREPARED BY	DATE
AIRCRAFT: ARROW 2	CONDITIONS FOR BRAKE SPECIFICATION	Performance Group	June 1958
		CHECKED BY	DATE

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ARROW 2 - CONDITIONS FOR BRAKE SPECIFICATION

This report has been drawn up as the result of R.C.A.F. letter ref. S36-38-105-8-2 (APO-1) dated May 9th. 1958.

The report contains details of the method used and the assumptions made for calculating Arrow 2 brake energy capacity, as required by MIL-W-5013C para. 3.3.1.1.2.1.

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ARROW 2

CONDITIONS FOR BRAKE SPECIFICATION

The following cases are covered in the brake specification:-

(1) 45 STOP CASE

Landing weight (W) = 55,000 lb., Touchdown speed (V_{T_D}) = 165 kts. (normal V_{T_D})

Braking force coefficient, $\mu = 0.4$ constant, 24 ft. diameter parachute.

80

(2) 5 STOP CASE

W = 55,000 lb. V_{T_D} = 165 kts. (normal V_{T_D})

$\mu = 0.4$ constant, No Parachute.

75

(3) 1 STOP CASE

W = 64,600 lb. V_{T_D} = 210 kts. (overspeed V_{T_D})

$\mu = 0.4$ constant, No Parachute.

The above cases are for determining energy only, not distance.

Brakes are applied and parachute is assumed fully open 4 seconds after T.D.

The undercarriage is assumed to be fully compressed at T.D., the A/C having 3° Tail clearance giving an angle of attack (α) = 11°.

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The nosewheel was assumed to be down 1 1/2 seconds after touchdown.

Air Brakes were extended throughout the landing run.

Fig. (1) shows the variation of drag coefficient (C_D) with lift coefficient (C_L) during landing. The curve is taken from N.A.E. low speed tunnel tests and includes ground effect.

The rolling C_L(nosewheel down) was assumed constant at 0.174 giving $C_D = 0.065$.

The rolling coefficient of friction was taken to be .03 constant

The parachute drag coefficient was 0.47 based on an area of 452 sq.ft. (i.e. 24 ft. diam.).

Fig. (2) shows the idling thrust variation with speed.

During the ground run 0.9 of the weight of the aircraft is assumed to be taken by the main U/C.

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METHOD OF CALCULATION

The calculations were carried out in two parts:-

(1) Taking increments of time from V_{T_D} to V_{BRAKE} (a total time of 4 seconds).

(2) Taking increments of velocity from V_{BRAKE} to V = 0.

FOR (1) the Drag Equation used was:-

$$C_{D_{TOTAL}} = C_{D_0} + C_{D_{U/C}} + C_{D_{\substack{DIVE\\BRAKES}}} + C_{D_i} + C_{D_{ROLLING}}$$

$$= \left[0.057 + 0.269\, C_L^2\right] + \frac{0.03}{q\,s}(W-L)$$

FOR (2) the Drag Equation used was:-

$$C_{D_{TOTAL}} = C_{D_0} + C_{D_{U/C}} + C_{D_{\substack{DIVE\\BRAKES}}} + C_{D_i} + C_{D_{\substack{BRAKES\\+\,ROLLING}}} + C_{D_{CHUTE}} \text{ (if used)}$$

$$= .009 + .032 + .016 + .269\, C_L^2 + \frac{W}{q\,s}(0.9\,\mu + .003)$$

$$- C_L(0.9\,\mu + .003) + .1736 \text{ (if drag chute is used)}$$

$$= \left[0.057 + 0.269\, C_L^2\right] - C_L(0.9\,\mu + .003) + 0.687\,\frac{W}{V^2}(0.9\mu + .003)$$

$$+ 0.1736 \text{ (if drag chute is used)}$$

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METHOD OF CALCULATION (Continued)

FOR (1) the calculation stages are:-

(1) V ft/sec. Starting at V_{T_D}.

(2) C_L Assuming 1.0 g.

(3) C_D from fig. (1)

(4) q S

(5) D = (3) x (4)

(6) 2 F_n from fig. (2)

(7) Lift = (2) x (4)

(8) Rolling Drag = .03 (W-L)

(9) Total Drag = (5) + (8) - (6)

(10) a = g/W x(-(9))

(11) Δt secs. (Chosen increments)

(12) ΔV = (10) x (11) Hence obtain V_{BRAKE}

FOR (2) the calculation stages are:-

(1) V ft/sec. (Chosen increments)

(2) V^2

(3) $(0.9\ \mu + .003)$

(4) $C_L(0.9\ \mu + .003)$

(5) (3) x $\frac{.687\ W}{V^2}$

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METHOD OF CALCULATION (Continued)

(6) (5) - (4)

(7) q S

(8) (6) x (7) = Brake Force

(9) $2\ F_n$ from fig.(2)

(10) .065 x (7) [+ 0.1736 x (7) (if drag chute used)]

(11) (8) + (10) - (9)

(12) $V/a = \frac{W}{g} \times \frac{(1)}{(11)}$

(13) ΔV

(14) $(8)_{MEAN}$

(15) $(12)_{MEAN}$

(16) $\Delta E_B = (13) \times (14) \times (15)$

(17) Σ (16) = Brake Energy ft. lb.

ARROW 2

C_D ~ C_L DURING GROUND RUN

I.E. INCLUDING GROUND EFFECT

$C_D = C_{D_0} + C_{D_i} + C_{D_{U/C}} + C_{D_{AIR\ BRAKES}}$ REF P/PERF/131

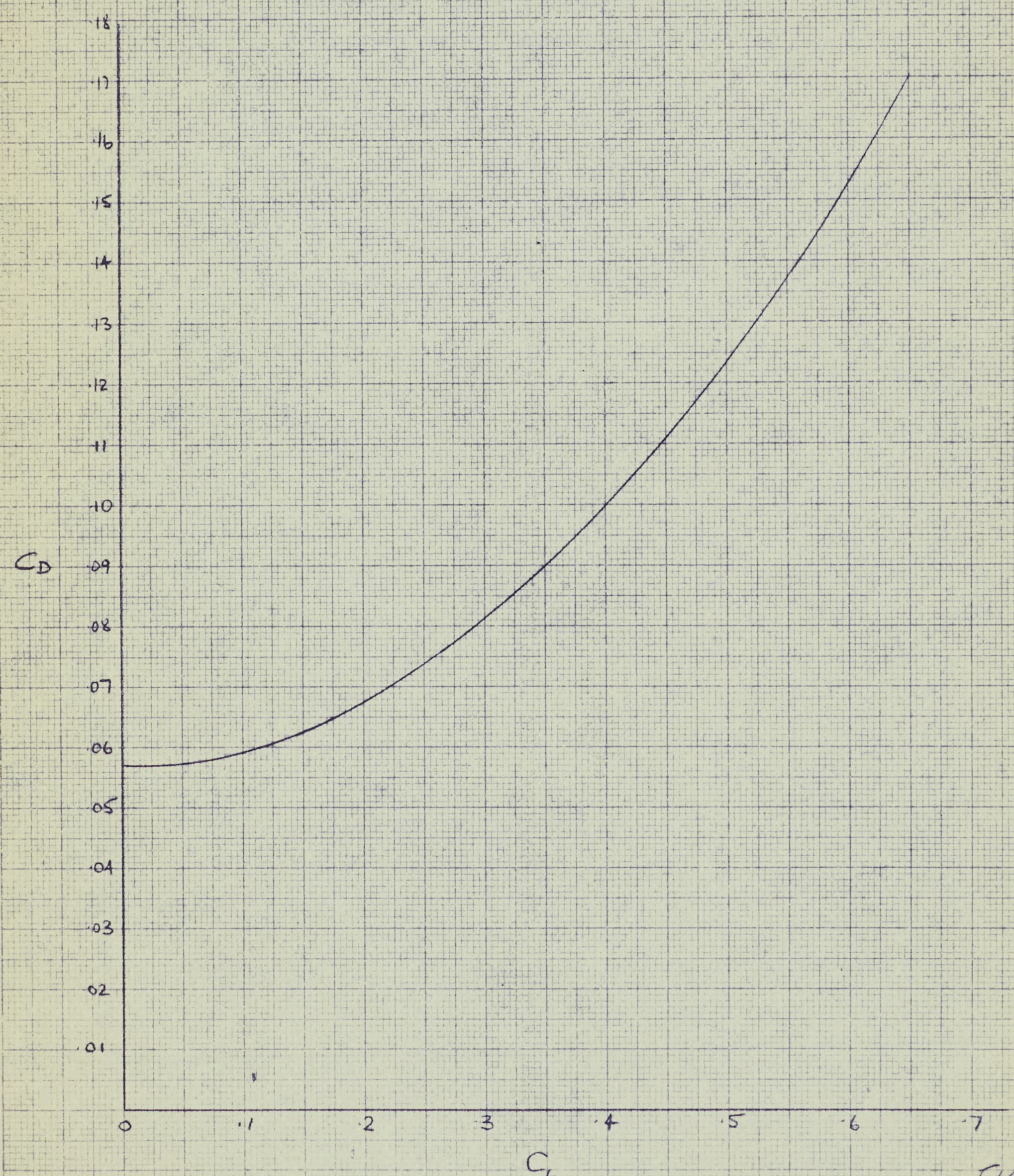

FIG 1.

P.H. MAY 58

72/PERF/12

IROQUOIS IDLING THRUST

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S.L. STANDARD DAY

N_L = 2100 RPM

NO EJECTOR EFFECT AND
100% PRESSURE RECOVERY ASSUMED

ONE ENGINE

REF P/PERF/131

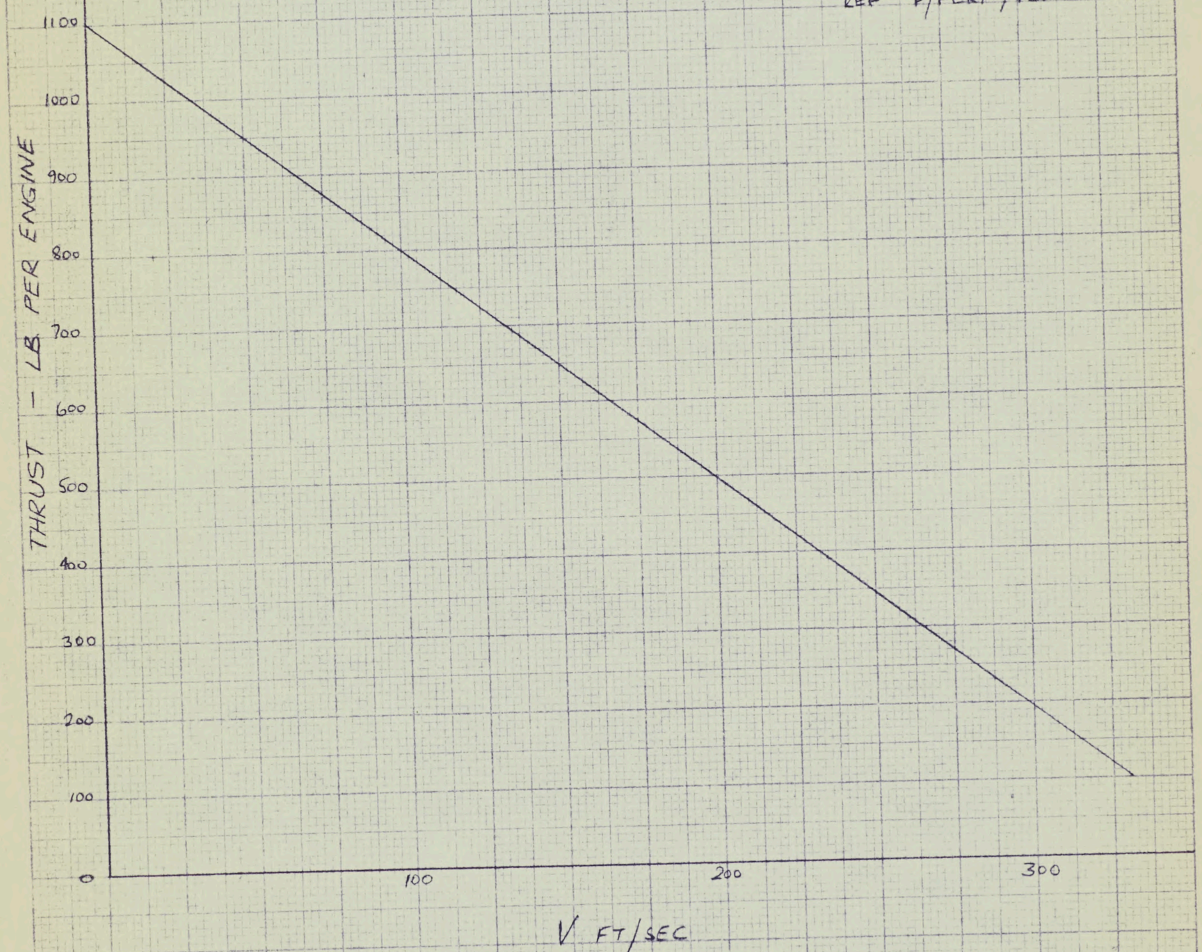

FIG 2