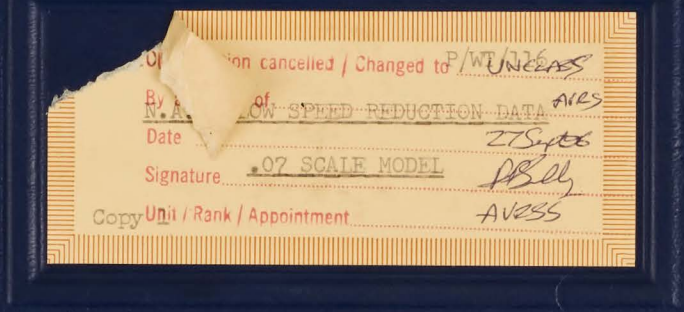
QCA
Avro
CF105
P-WT-116



A. V ROE CANADA LIMITED

MALTON ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: CF-105 REPORT NO. P/WT/116

FILE NO. NO. OF SHEETS

TITLE

N.A.E. LOW SPEED REDUCTION DATA

.07 SCALE MODEL

PREPARED BY J. P. C. Clark DATE Nov. 1956

CHECKED BY DATE

SUPERVISED BY DATE

APPROVED BY DATE

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

FORM 1316A

$$C_{M_{mean}} = \frac{1}{2}\left[\left(C_{M_{UD}} + C_{M_{ID}}\right) + C_{D_{UD}}\, y\, (R_U) + C_{D_{ID}}\, y\, (R_1)\right]$$

$$= \frac{1}{2}\left[\left(C_{M_{UD}} + C_{M_{ID}}\right) + \frac{.427}{\bar{c}}\left(C_{D_{UD}} - C_{D_{ID}}\right)\right]$$

$$= C_{M_{UD}} + \frac{1}{2}\left(C_{M_{ID}} - C_{M_{UD}}\right) - \frac{.427}{2\bar{c}}\left(C_{D_{ID}} + C_{D_{UD}}\right)$$

$\frac{1}{2}\left(C_{M_{ID}} - C_{M_{UD}}\right) - \frac{.427}{2\bar{c}}\left(C_{D_{ID}} + C_{D_{UD}}\right)$ is called ΔC_{M_A}

and represents a corrective moment about P_2.

Strut tare and interference values are found from ID & I runs.

$$\Delta C_{L_{STI}} = -\left(C_{L_{ID}} - C_{L_I}\right)$$

Similarly $\Delta C_{D_{STI}} = -\left(C_{D_{ID}} - C_{D_I}\right)$

and $\Delta C_{M_{STI}} = -\left(C_{M_{ID}} - C_{M_I}\right)$

These forces and moments are about point R_1

Tail sting corrections about R_B are

$$\Delta C_{L_{TS}} = -\left(C_{L_{BTS}} - C_{L_B}\right)$$

$$\Delta C_{D_{TS}} = -\left(C_{D_{BTS}} - C_{D_B}\right)$$

and $\Delta C_{M_{TS}} = -\left(C_{M_{BTS}} - C_{M_B}\right)$

$$C_{M_{CG}} = C_{M_U} + \Delta C_{M_A} + \Delta C_{M_{STI}} + \Delta C_{M_{TS}} + \frac{.4270}{\bar{c}} C_{D_U}$$

$$- \Delta C_{D_{STI}} \frac{.4270}{\bar{c}} + \Delta C_{D_{TS}} \left[\frac{.5364 - r_1 \sin(\gamma + \alpha_d)}{\bar{c}} \right]$$

$$- \Delta C_{L_{TS}} \frac{r_1}{\bar{c}} \cos(\gamma + \alpha_d)$$

$$+ C_{L_{CG}} \frac{\lambda}{\bar{c}} \cos(\phi - \alpha_d) - C_{D_{CG}} \frac{\lambda}{\bar{c}} \sin(\phi - \alpha_d)$$

Finally $\alpha_{CG} = \alpha_{P_2} = \alpha_d + \Delta\alpha_j$

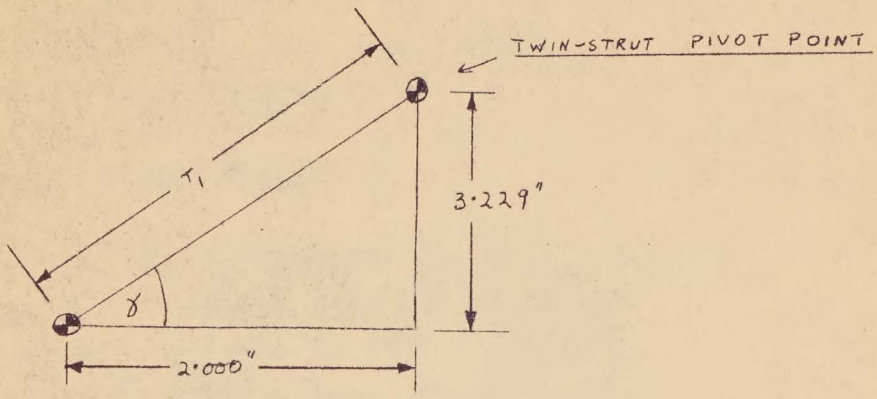
A, STI and ST corrections are evaluated in P/WT/97. Blockage corrections are found on Sheet 7 and the final reduction equations given on Sheet 8.

From a comparison of C_M vs C_L with Cornell runs (Sheet 9) it was decided to ignore all A corrections, which seemed somewhat unrealistic.

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. P/WT/97
SHEET No. 1.6

AIRCRAFT: C-105	SUPPORT	PREPARED BY: E.R.F.	DATE: 14th MARCH 1956
·07 SCALE MODEL	DIMENSIONS	CHECKED BY:	DATE:



$$T_1' = \sqrt{(2.000)^2 + (3.229)^2}\ " = 3.798" = .14964\,\bar{c}$$

WHERE $\bar{c} = 25.3829"$

$$\gamma = \tan^{-1}\frac{3.229}{2.000} = 58.23^\circ$$

A. V ROE CANADA LIMITED
MALTON ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO P/WT/97
SHEET NO 17

AIRCRAFT C-105 ·07 SCALE MODEL	BLOCKAGE CORRECTIONS	PREPARED BY	DATE 12 MARCH 56
		CHECKED BY	DATE

SOLID BLOCKAGE

$\varepsilon_s = \frac{\sqrt{\pi}}{2} \tau \frac{V}{C^{3/2}}$ – from Pankhurst P 344

$K_w = \frac{1}{(1-(M')^2)^{3/2}} \frac{K_1 \tau V_w}{C^{3/2}}$

$K_b = \frac{1}{\{1-(M')^2\}^{3/2}} \frac{K_3 \tau V_b}{C^{3/2}}$ } – from N.A.C.A. TR 995.

$\varepsilon_s = K_w + K_b = \frac{1}{\{1-(M')^2\}^{3/2}} \frac{\tau}{C^{3/2}} (K_1 V_w + K_3 V_b)$

$K_1 < .938$ – from TR 995 Table II

$K_3 \simeq .909$ – from TR 995 Table IV

$K_1 = K_3 = \frac{\sqrt{\pi}}{2} = .885$ – from Pankhurst

Formula taken as $\varepsilon_s = \frac{1}{\{1-(M')^2\}^{3/2}} \frac{\tau}{C^{3/2}} \left(\frac{\sqrt{\pi}}{2} V\right)$

τ taken as .94 for rectangular tunnel. – TR 995 Table I

τ for 9×7 rect. tunnel is .83 } Pankhurst P 341

τ for 9×7 octagonal tunnel is .75 }

Hence τ for octagonal tunnel is $.94 \times \frac{.75}{.83} = .85$

$V = 1.280$ cu ft $C = 49.6$ sq ft (without ground board)

$C = 45$ sq ft (with ground board)

Hence $\varepsilon_s = .0029$ (without ground board) or .0034 (with ground board)

WAKE BLOCKAGE

$\varepsilon_w = \frac{1}{4} \frac{S}{C} C_D' \left(\frac{1 + .4M^2}{1 - M^2}\right)$ – from TR 995

$S = 6.003$ sq. ft.

Hence $\varepsilon_w = .0324 C_D$ (without ground board) or .0354 (with ground board)

METHOD OF APPLICATION

$V_F = V_T(1+\varepsilon)$ – from Pankhurst P 348

V_F is free air speed and V_T is tunnel air speed. $\varepsilon = \varepsilon_s + \varepsilon_w$

A generalised force, or moment $C_F = f\left(\frac{1}{V^2}\right)$

$\therefore (C_F)_{\text{free air}} = \frac{1}{(1+\varepsilon)^2} (C_F)_{\text{in tunnel}}$

where $\varepsilon = .0029 + .0324 C_D$ (without ground board)

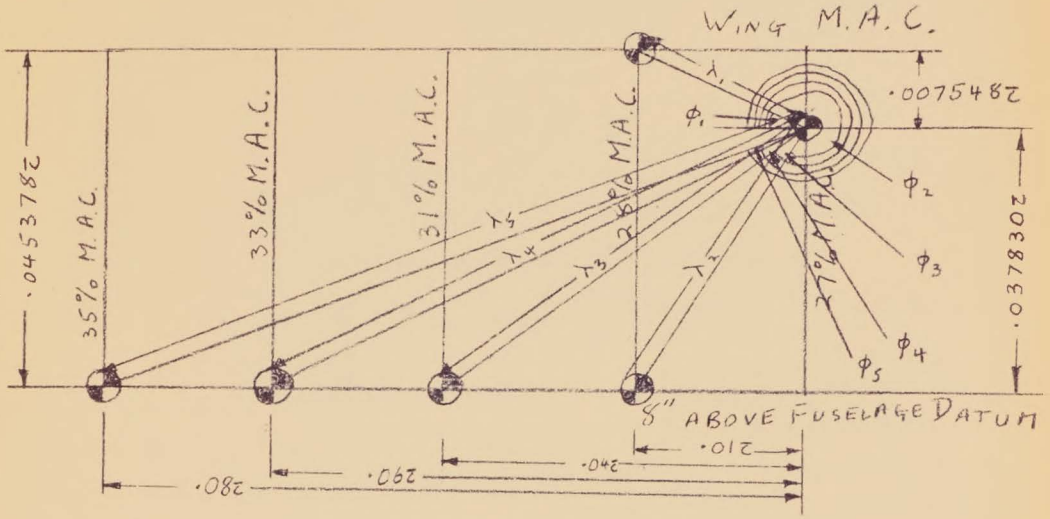
and $\varepsilon = .0034 + .0354 C_D$ (with ground board)

A. V. ROE CANADA LIMITED
MALTON ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No P/WT/97
SHEET No 2·5

AIRCRAFT: C-105	CENTRE OF GRAVITY
·07 SCALE MODEL	TRANSFER.

PREPARED BY	DATE
E R F.	14th MARCH 1958
CHECKED BY	DATE



$\lambda_1 = \sqrt{(\cdot01)^2+(\cdot007548)^2}\ 2 = \cdot012529\,2$

$\lambda_2 = \sqrt{(\cdot01)^2+(\cdot037830)^2}\ 2 = \cdot039129\,2$

$\lambda_3 = \sqrt{(\cdot04)^2+(\cdot037830)^2}\ 2 = \cdot055056\,2$

$\lambda_4 = \sqrt{(\cdot06)^2+(\cdot037830)^2}\ 2 = \cdot070931\,2$

$\lambda_5 = \sqrt{(\cdot08)^2+(\cdot037830)^2}\ 2 = \cdot088494\,2$

$\phi_1 = \left(\tan^{-1}\frac{\cdot007548}{\cdot01}\right)^\circ = \left(\tan^{-1}\cdot7548\right)^\circ = 37\cdot045^\circ$

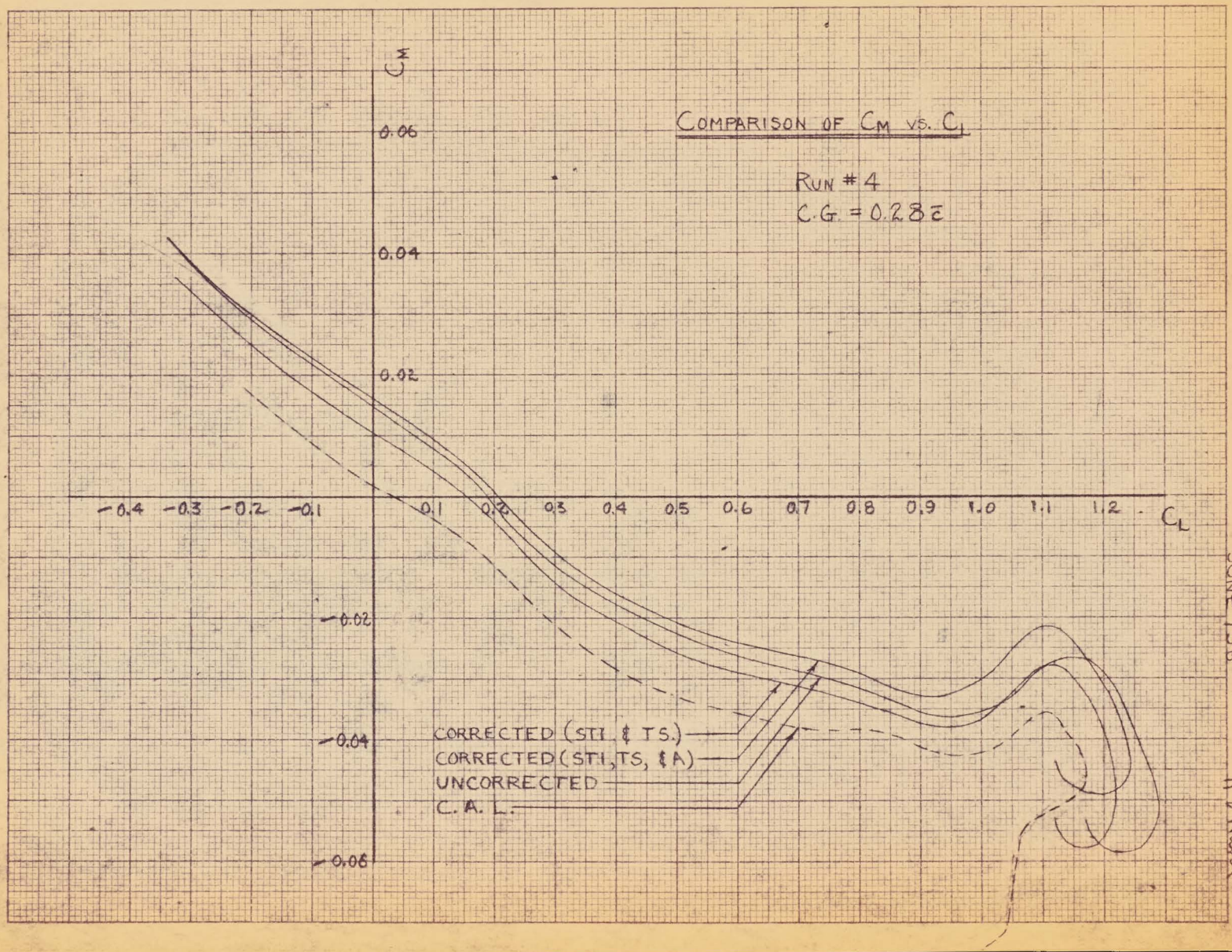
$\phi_2 = 360^\circ - \left(\tan^{-1}\frac{\cdot037830}{\cdot01}\right)^\circ = 360^\circ - \left(\tan^{-1}3\cdot7830\right)^\circ = 284\cdot807^\circ$

$\phi_3 = 360^\circ - \left(\tan^{-1}\frac{\cdot037830}{\cdot04}\right)^\circ = 360^\circ - \left(\tan^{-1}\cdot94575\right)^\circ = 316\cdot597^\circ$

$\phi_4 = 360^\circ - \left(\tan^{-1}\frac{\cdot037830}{\cdot06}\right)^\circ = 360^\circ - \left(\tan^{-1}\cdot63050\right)^\circ = 327\cdot768^\circ$

$\phi_5 = 360^\circ - \left(\tan^{-1}\frac{\cdot037830}{\cdot08}\right)^\circ = 360^\circ - \left(\tan^{-1}\cdot47288\right)^\circ = 334\cdot692^\circ$

FORM 1739A



COMPARISON OF C_M VS. C_L

RUN #4

C.G = 0.28 $\bar{c}$

JUNE 1956

A.S. Arnold 1.10

C-105 NAE WIND TUNNEL TESTS [illegible] 55 ~

CORRECTIONS TO BE APP[illegible] TO

	1	2	3	4	5	6	7	8	9	10	
α DIAL	−6°	−4	−2	0	2	4	6	8	[illegible]	12	[illegible]
$\Delta C_{L\,TS}$	.0065	.0059	.0054	.0051	.0049	.0048	.0048	.0050	[illegible]	.0056	[illegible]
$\Delta C_{L\,STI}$	.0052	.0057	.0061	.0064	.0067	.0068	.0069	.0068	[illegible]	.0058	[illegible]
$\Delta C_{D\,TS}$	−.0048	−.0045	−.0041	−.0039	−.0035	−.0033	−.0030	−.0027	[illegible]	.0023	[illegible]
$\Delta C_{D\,STI}$	−.0068	−.0063	−.0058	−.0054	−.0050	−.0046	−.0042	−.0039	[illegible]	.0036	[illegible]
$\Delta C_{m_{STI}} + \Delta C_{m_{TS}}$ $\delta_e = 10°$	.0072	.0069	.0066	.0064	.0061	.0058	.0055	.0053	[illegible]	.0047	[illegible]
5°	.0062	.0059	.0057	.0055	.0053	.0050	.0048	.0046	[illegible]	.0042	[illegible]
2.5°	.0060	.0058	.0056	.0054	.0051	.0048	.0046	.0044	[illegible]	.0040	[illegible]
0°	.0062	.0059	.0057	.0054	.0051	.0048	.0046	.0043	[illegible]	.0038	[illegible]
−2.5°	.0067	.0064	.0061	.0057	.0053	.0050	.0047	.0043	[illegible]	.0036	[illegible]
−5°	.0073	.0069	.0064	.0060	.0055	.0052	.0048	.0043	[illegible]	.0034	[illegible]
−10°	.0085	.0079	.0073	.0067	.0061	.0056	.0050	.0044	[illegible]	.0032	[illegible]
−15°	.0094	.0089	.0084	.0077	.0071	.0065	.0059	.0053	[illegible]	.0041	[illegible]
−20°	.0098	.0093	.0088	.0083	.0078	.0072	.0067	.0062	[illegible]	.0052	[illegible]
−25°	.0093	.0089	.0083	.0078	.0073	.0067	.0061	.0057	[illegible]	.0047	[illegible]
−30°	.0070	.0065	.0060	.0054	.0049	.0044	.0039	.0033	[illegible]	.0023	[illegible]
~~ΔC_{L_A}~~	~~.0125~~	~~.0114~~	~~.0107~~	~~.0100~~	~~.0098~~	~~.0099~~	~~.0105~~	~~.0116~~	[illegible]	[illegible]	[illegible]
~~ΔC_{D_A}~~	~~.0008~~	~~.0006~~	~~.0004~~	~~.0002~~	~~0~~	~~.0001~~	~~.0001~~	~~0~~	[illegible]	~~.0005~~	[illegible]
~~ΔC_{m_A}~~	~~.0068~~	~~.0066~~	~~.0064~~	~~.0063~~	~~.0061~~	~~.0060~~	~~.0059~~	~~.0058~~	[illegible]	[illegible]	[illegible]

DEC 55 ~ JAN 56

... TO C_{L_u}, C_{D_u} AND C_{M_u}

AVRO AIRCRAFT
MALTON, ONTARIO
ENGINEERING DIVISION

AIRCRAFT C-10...
~~WEIGHT~~ MODEL
C. G. POSITION

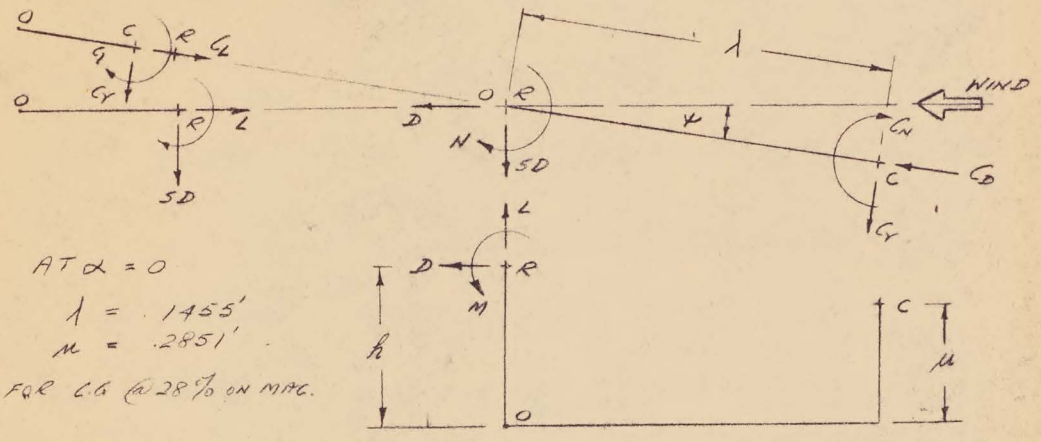
	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	12	14	16	18	20	22	24	26	28	30	32	34	35	
	0056	0052	0043	0027	0017	0011	0008	0008	0010	0012	0017	0022	0026	
	0058	0051	0052	0080	0121	0124	0116	0109	0110	0119	0134	0150	0159	
	-0023	-0021	-0020	-0019	-0018	-0017	-0017	-0016	-0015	-0015	-0015	-0014	-0014	
	0036	-0036	-0037	-0027	0	0009	0015	0022	0033	0049	0071	0096	0110	
	0047	0044	0041	0039	0036	0033	0030	0028	0025	0022	0019	0016	0015	
	0042	0040	0038	0036	0034	0031	0028	0026	0024	0021	0019	0017	0016	
	0040	0038	0036	0034	0032	0029	0026	0024	0022	0019	0016	0013	0012	
	0038	0035	0032	0029	0027	0024	0021	0018	0016	0013	0010	0007	0006	
	0036	0031	0027	0023	0018	0014	0009	0004	0001	0007	0012	0017	0019	
	0034	0028	0023	0018	0012	0008	0002	0004	0009	0015	0020	0025	0028	
	0032	0026	0020	0014	0008	0003	0003	0009	0015	0021	0027	0033	0036	
	0041	0034	0029	0023	0018	0011	0007	0003	0002	0008	0013	0018	0021	
	0052	0047	0042	0037	0032	0026	0021	0016	0011	0006	0001	0004	0006	
	0047	0042	0037	0032	0027	0021	0015	0010	0005	0001	0004	0009	0012	
	0023	0018	0013	0007	0002	0003	0008	0014	0019	0024	0029	0034	0036	
	~~0148~~	~~0151~~	~~0111~~	~~0177~~	~~0174~~	~~0176~~	~~0164~~	~~0140~~	~~0095~~	0038	0009	0001	0	
	~~0005~~	~~0008~~	~~0013~~	~~0016~~	~~0019~~	~~0020~~	~~0018~~	~~0013~~	~~0002~~	0010	0023	0035	0040	
	~~0066~~	~~0056~~	0055	~~0055~~	~~0056~~	~~0058~~	~~0065~~	~~0075~~	~~0087~~	~~0095~~	~~0098~~	~~0100~~	~~0100~~	

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. P/WIND TUNNEL/116
SHEET No. 2.1.

AIRCRAFT: C-105 .07 SCALE MODEL.	NAE LOW SPEED W.T. TESTS YAW RUNS	PREPARED BY: CLARK.	DATE: JULY 1956
		CHECKED BY	DATE

REDUCTION DATA.



AT $\alpha = 0$

$\lambda = .1455'$

$\mu = .2851'$

FOR CG @ 28% ON MAC.

O = SINGLE STRUT SUPPORT PIVOT POINT

R = BALANCE RESOLUTION POINT.

C = CENTER OF GRAVITY.

$$C_L = \frac{L}{qS}$$

$$C_D = \frac{1}{qS}\left(D\cos\alpha - SD\sin\alpha\right) + \Delta C_{D_j}$$

$$C_Y = \frac{1}{qS}\left(SD\cos\alpha + D\sin\alpha\right) + \Delta C_{Y_j}$$

$$C_M = \frac{1}{qSc}\left[PM + D(L-\mu)\right]\cos\alpha - \frac{1}{qSc}\left[RM + SD(L-\mu)\right]\sin\alpha - \frac{L\lambda}{qSc}$$

$$C_N = \frac{1}{qSb}\left(YM - \lambda SD\cos\alpha - D\sin\alpha\right)$$

$$C_\ell = \frac{1}{qSb}\left[PM + SD(L-\mu)\right]\cos\alpha - \frac{1}{qSb}\left[PM + D(L-\mu)\right]\sin\alpha$$

FORM 1319A

VALUE OF h AND q

RUN	h	q Eqn.	RUN	h	q Eqn.
50-54	.5364	1	105	.4401	2
55-81	.5333	1	106,107	.4635	2
82	.4635	2	108	.4583	2
83	.4583	2	109-123	.5333	1
84	.4505	2	124	.4635	2
85,86	.4401	2	125	.4583	2
87	.4505	2	126	.4505	2
88	.4583	2	127,128	.4401	2
89,90	.4635	2	129	.4505	2
91	.4583	2	130	.4583	2
92	.4505	2	131,132	.4635	2
93,94	.4401	2	133	.4583	2
95	.4505	2	134	.4505	2
96	.4583	2	135	.4401	2
97,98	.4635	2	136	.2036	3
99	.4583	2	137	.2132	3
100	.4505	2	138	.2214	3
101	.4401	2	139	.2266	3
102	.4635	2	140-174	.5333	1
103	.4401	2	175-181	.4270	1
104	.4583	2			

VALUES OF m AND Ø

Single Strut Support (B)			m	Ø
Case 1	C.G. at 28% $\bar{c}$	on M.A.C.	.3201	62.96°
2	28% $\bar{c}$	8" above F.D.	.2387	52.44
3	31% $\bar{c}$	8" above F.D.	.2062	66.54
4	35% $\bar{c}$	8" above F.D.	.1892	90.79

Twin Strut Support (U)			m	Ø
Case 5	C.G. at 28% $\bar{c}$	on M.A.C.	.0265	142.96°
6	28% $\bar{c}$	8" above F.D.	.0828	255.19
7	31% $\bar{c}$	8" above F.D.	.1164	223.40
8	35% $\bar{c}$	8" above F.D.	.1872	205.31

Note

Comparison of twin strut and single strut support runs show some wide discrepancies particularly in C_M. To correct the single strut support runs a ΔC_M, ΔC_L and ΔC_D have been found by subtracting the twin strut values from the single strut.

These corrections appear on Sheets 2.5 to 2.7 for the range of elevator angles.

Rather than apply these corrections directly to basic data it was thought simpler to apply them to longitudinal results after reduction to C.G. position and stability axes, and as separate corrections to β derivatives after the uncorrected slopes had been read.

$$\Delta C_N = -\frac{\Delta D}{qSb}\, l \sin \varepsilon$$

$$\Delta C_{N_\beta} = \frac{\Delta C_D}{b}\, l \quad \text{PER RADIAN}$$

$$\Delta C_Y = \frac{\Delta D}{qS} \sin \varepsilon$$

$$\Delta C_{Y_\beta} = -\Delta C_D \quad \text{PER RADIAN}$$

$$\Delta C_l = \frac{1}{qSb}\left[\Delta P_M + \Delta D\,(k-u)\right] \sin \varepsilon$$

$$\Delta C_{l_\beta} = -\frac{1}{b}\left[\Delta C_{M_E} + \Delta C_D\,(k-u)\right]$$

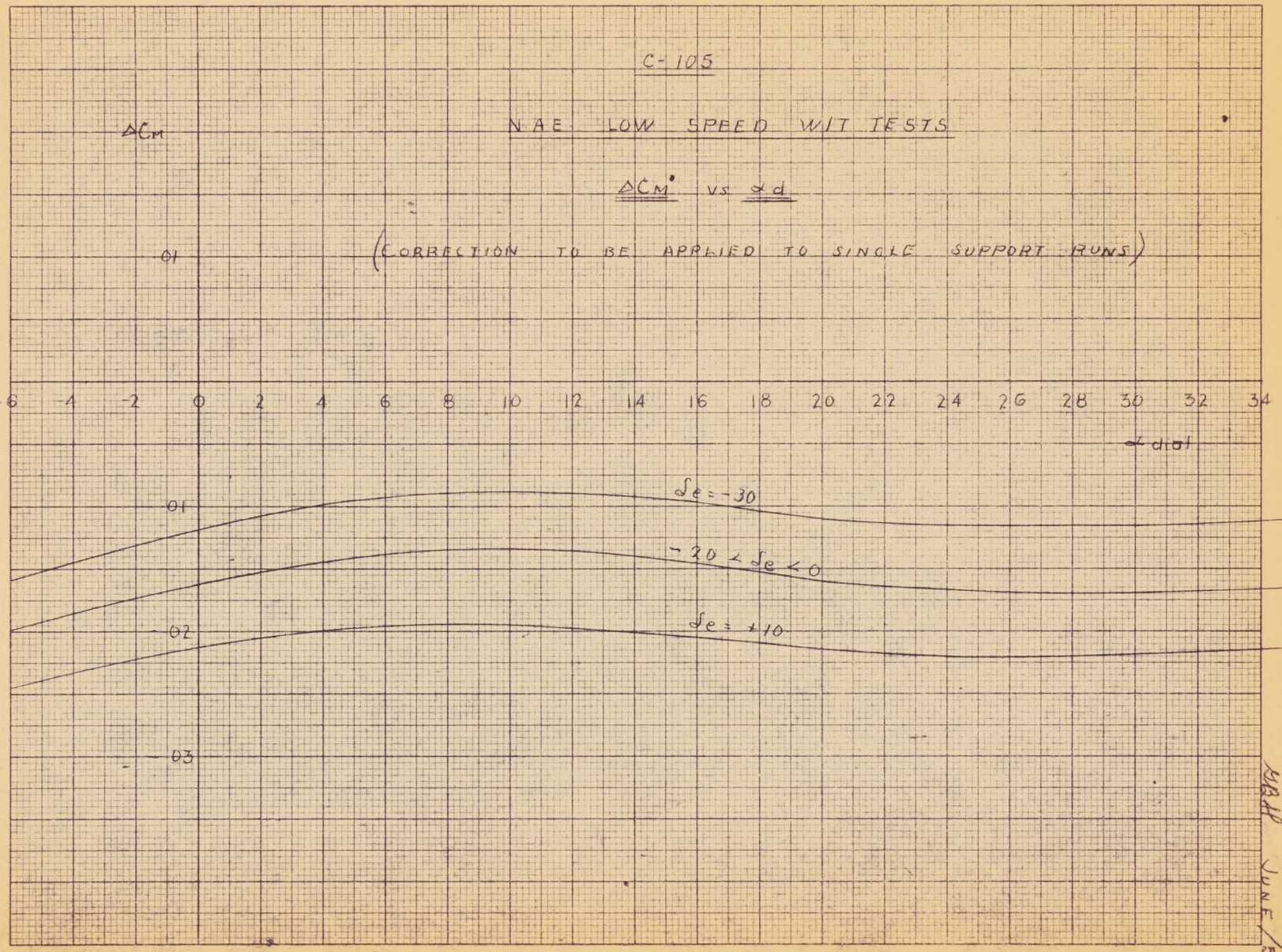
ΔC_{M_E} & ΔC_D ARE GIVEN ON SHEETS 2.8 & 2.9

C-105

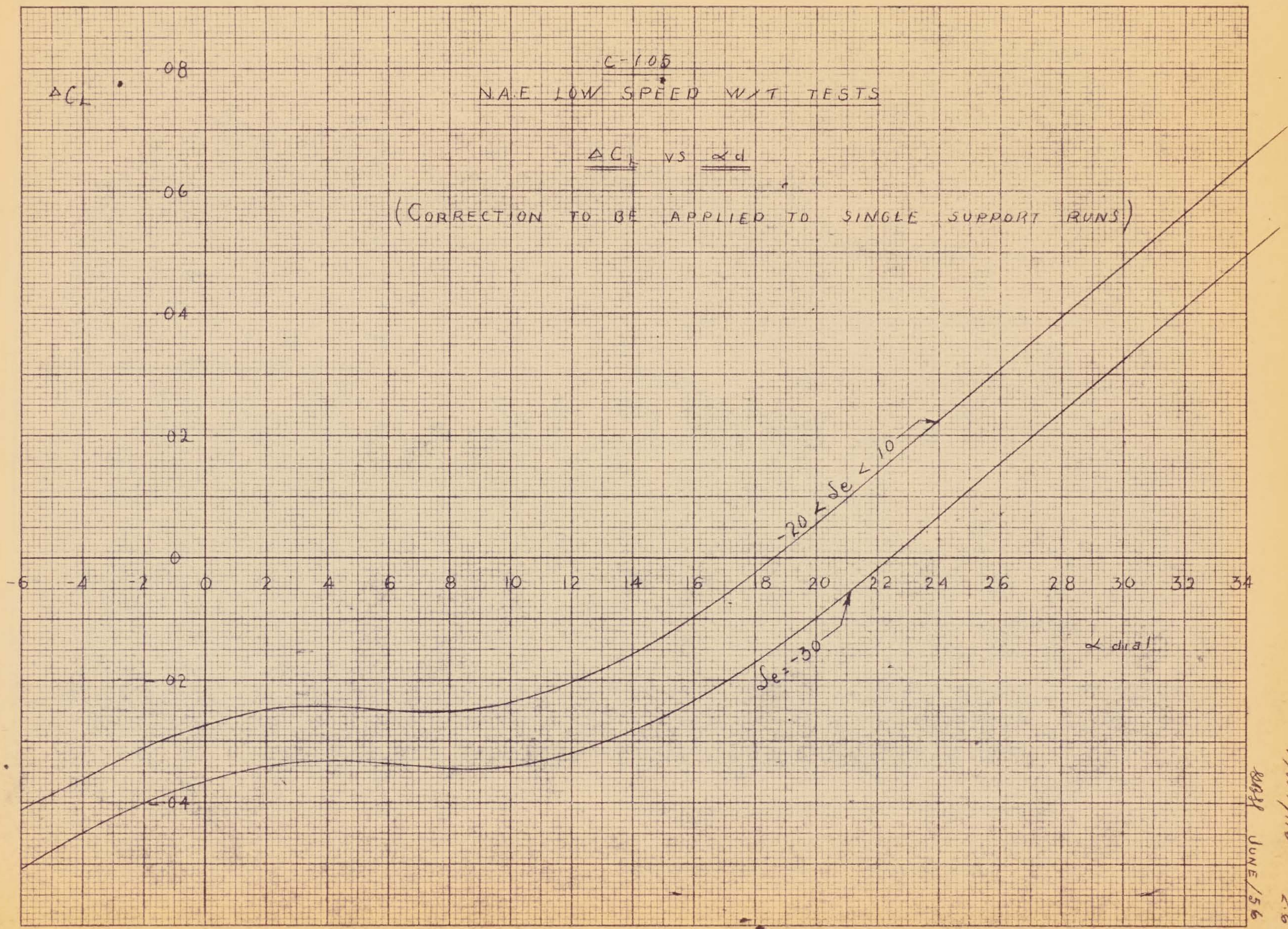
NAE LOW SPEED WIT TESTS

ΔC_M vs α_d

(CORRECTION TO BE APPLIED TO SINGLE SUPPORT RUNS)



PINT/116
HABP JUNE/56
2.5

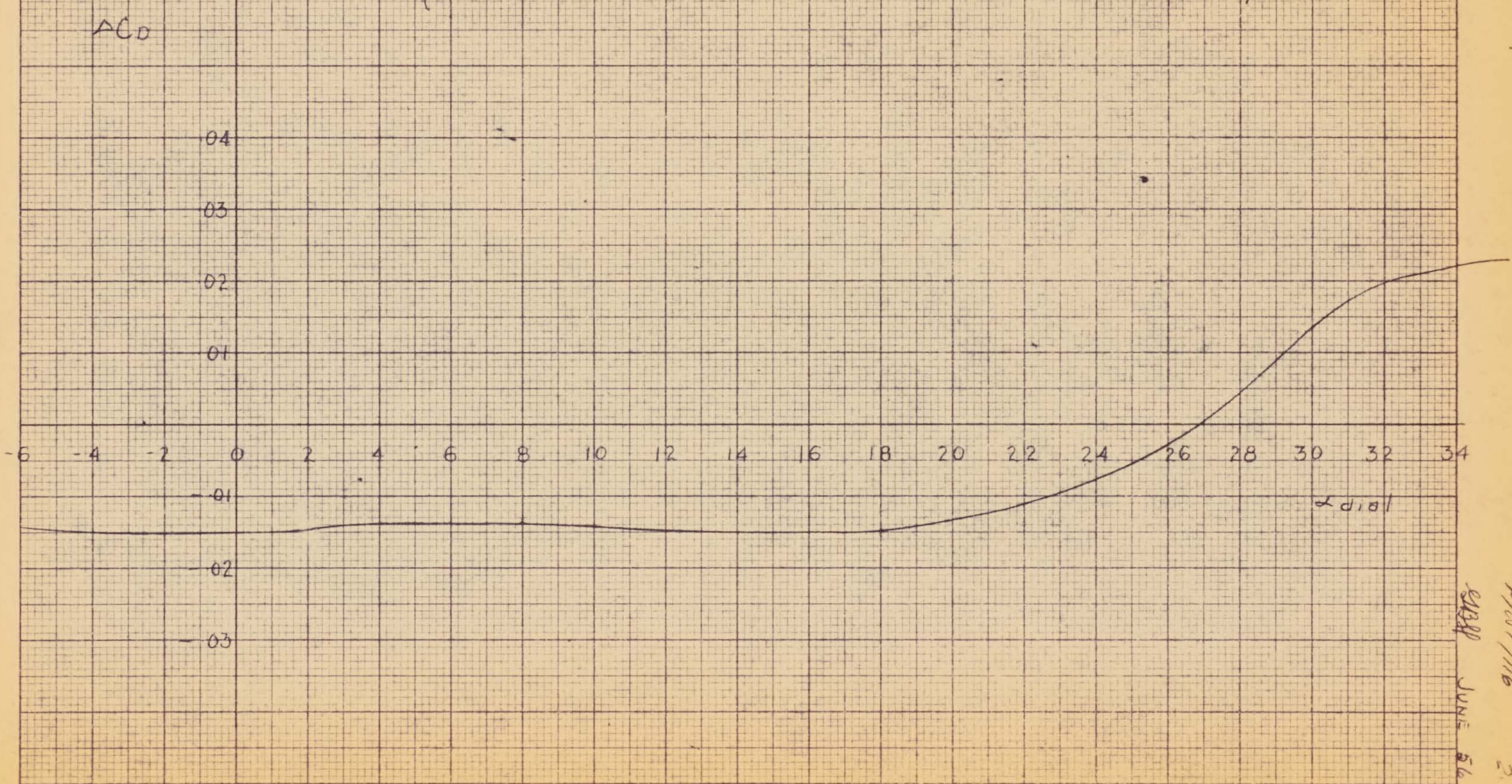


C-105

NAE LOW SPEED W/T TESTS

ΔC_D vs α_d

(CORRECTION TO BE APPLIED TO SINGLE SUPPORT RUNS)



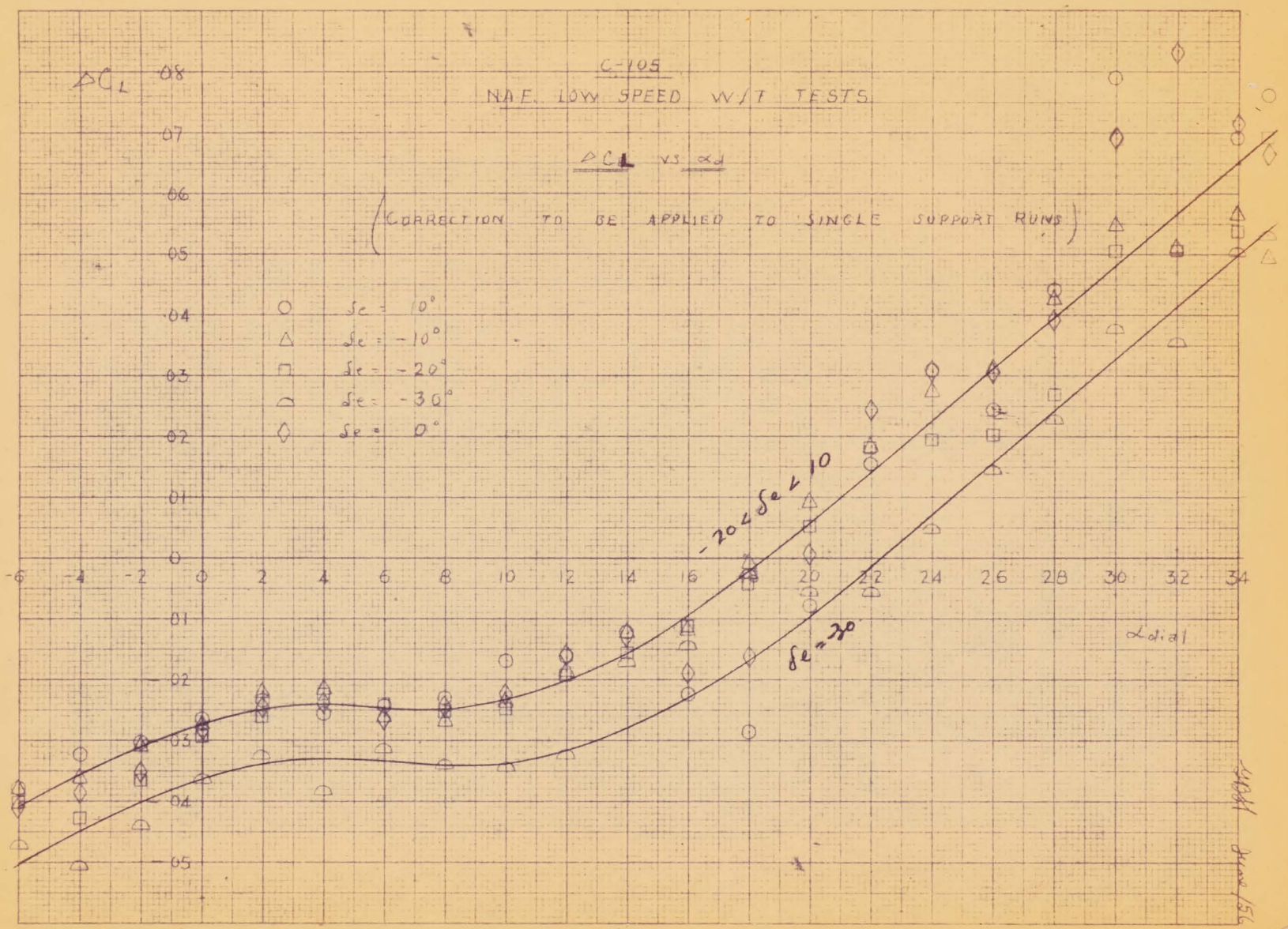
P/WT/116 27
GBSS JUNE 56

C-105

N.A.E. LOW SPEED W/T TESTS

ΔC_L VS α_d

(CORRECTION TO BE APPLIED TO SINGLE SUPPORT RUNS)

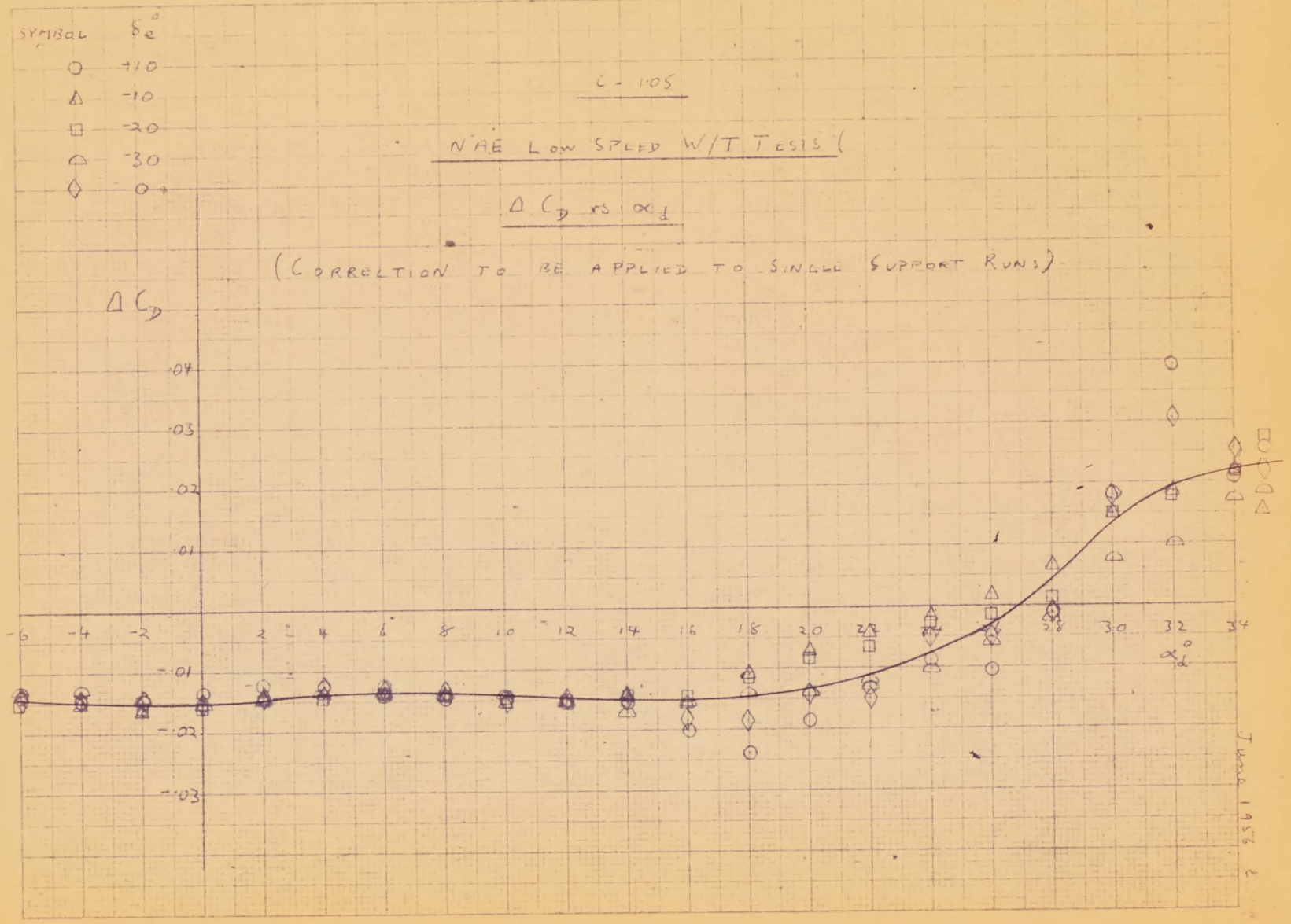


C - 1·05

NAE Low Speed W/T Tests (

ΔC_D vs α_1

(Correction to be applied to single support runs)



June 1956 E