Flume Tank Testing of a Vee Type Otterboard (Harmonisation Trials) EEC Funded Otterboard Project TE 1.214

Consultancy Services Report CR 14

November 1989

SEA FISH INDUSTRY AUTHORITY

Seafish Technology

FLUME TANK TESTING OF A VEE TYPE OTTERBOARD (HARMONISATION TRIALS) EEC FUNDED OTTERBOARD PROJECT TE 1.214

Consultancy Report No. 14

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J N Ward

SEA FISH INDUSTRY AUTHORITY
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SEA FISH INDUSTRY AUTHORITY
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Consultancy Report No. 14 November 1989

FLUME TANK TESTING OF A VEE TYPE OTTERBOARD (HARMONISATION TRIALS) EEC FUNDED OTTERBOARD PROJECT TE 1.214

SUMMARY

This report describes Flume Tank trials on a vee type otterboard (otterboard No. S.1) which are part of the EEC funded Otterboard Project TE 1.214.

It is intended that otterboard tests will be carried out in the three Flume Tanks of Seafish, IFREMER and DFTI.

In order to ensure that all three tanks give compatible results, a vee type otterboard was constructed by Seafish and will be tested in turn by all three Flume Tanks to ensure harmonisation of results.

Initially, the vee type otterboard was tested at two different weights in the Seafish Flume Tank. The higher of the two weights was found to give a very small reduction in the lift coefficient CL and efficiency CL/CD.

The principles of the analysis used are described as is the method of rigging of the otterboard in the Flume Tank.

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FLUME TANK TESTING OF A VEE TYPE OTTERBOARD (HARMONISATION TRIALS) EEC FUNDED OTTERBOARD PROJECT TE 1.214

1 INTRODUCTION

This report describes a Flume Tank trial on a model otterboard (otterboard No. S.1) undertaken by the Sea Fish Industry Authority as part of the EEC funded Otterboard Project TE 1.214.

As the project is to be carried out jointly by Seafish, IFREMER and DFTI it was decided that harmonisation trials should be carried out on one model otterboard in the three different Flume Tanks.

As each Flume Tank will carry out trials on selected otterboard models these harmonisation trials will ensure that results are directly compatible whichever tank carries out the experiment.

Seafish undertook to draw out a model vee type otterboard, the specification of which was forwarded to IFREMER and DFTI for agreement. Following the agreement of all parties the model was constructed and then tested in the Seafish Flume Tank.

2 METHOD OF TESTING

2.1 Principle of Tests and Rigging

The test procedure used by Seafish was developed under MAFF R&D Commission and is described in Ref 1.

A starboard door is held in a fixed position in the Flume Tank by a warp and bridle as shown in Fig 1. The warp is of a fixed length but the bridle length can be varied by pulling it through an aft towing block using a crane as shown in Fig 2.

The height of the forward towing block, the relative lengths of the twin backstrops and the attachment points of the warp and bridle to the otterboard may be adjusted to give the required angle of attack and heel.

By measuring the tensions and angles of the warp and bridle the forces can be resolved in the direction of and at right angles to the flow.

The coefficients of lift and drag, CL and CD, of the otterboard can then be calculated after measuring the water speed and nominal area using the formulae given in Section 5.

The warp and bridle angles measured are the angles projected onto the horizontal plane as seen by the video camera used to measure them as shown in Fig 2.

The declination angle of the warp is the angle in the vertical plane of the warp and is calculated by measuring the difference in height of two markers on the warp which are 3 metres apart. The bridle is always maintained in a horizontal position and therefore the camera views its true angle.

It should be noted that the warp and bridle angles are maintained at angles much larger than is found at sea in order to increase the accuracy of the results.

3 ANALYSIS OF RESULTS

3.1 Lift and Drag Coefficients, CL and CD

The steps and formulae used in the spreadsheet calculations are defined in Section 6. The symbols used in the formulae are given in Section 5.

Initially the warp and bridle loads are each resolved into forces in the direction of waterflow and at right angles to it in the horizontal plane. For the bridle this can be done directly because the bridle is horizontal. As the warp is inclined to the horizontal plane (declination angle) the resolved forces must be corrected using the declination angle to give true horizontal components.

The horizontal components of the warp and bridle are then added to give the horizontal forces of the door in the direction of, and at right angles to, the waterflow.

By also measuring the water speed and nominal otterboard area CL and CD can be calculated using the formulae given in Section 5.

3.2 Centre of Pressure

The centre of pressure CP is taken to be the point at which the forces acting in the horizontal plane can be taken to act on the otterboard.

The horizontal components of the warp and bridle loads act through a point X,Y as shown in Fig 3. These horizontal components also act through the points x_1, y_1 and x_2, y_2 which are the points at which the warp and bridle respectively are shackled to the otterboard.

In the case where the warp is shackled to a hinged chain or arm the point x_1, y_1 moves to point x_1, y_1' as the chain or arm pivots up due to the declination angle of the warp. If the warp is shackled to a fixed point then x_1, y_1 moves to point x_1, y_1' only due to the heel angle of the otterboard.

The steps used in the calculation are as follows:-

1. Define the points x_1, y_1 and x_2, y_2.

2. Modify x_1, y_1 to give x_1, y_1' depending on the type of warp attachment point on the otterboard.

3. Define the warp and bridles as equations $y = mx+c$.

4. Solve equations to find the point X,Y.

5. Using data on CL and CD define the drag angle which defines the total horizontal force line on the otterboard.

6. Define this total horizontal force line as equation $y = mx+c$ and solve for centre of pressure CP, that is when $y = 0$.

4 HARMONISATION TRIALS

4.1 Otterboard Model

The model chosen for the trials was a vee type otterboard of aspect ratio 0.65 (height/length ratio). A plan of the model is shown in Fig. 4.

The otterboard was 12.7kgs complete with towing chain, but two 1.5kg weights were also made so that the tests could be carried out at more than one weight.

The towing chain was located at the mid-height of the model and the vee angle was chosen as 30^{o}.

4.2 Flume Tank Results

Initially the otterboard was tested with no additional weight and was found to be slightly too light to keep the whole shoe length in contact with the Flume Tank belt.

The trials were then conducted with one and two weights added respectively over the full range of angles of attack (otterboards designated as Nos. S.1A and S.1B respectively).

At all times the otterboard was maintained at 0^{o} heel, which is defined as the top half of otterboard being vertical in this case.

Figs. 5 and 6 show the results obtained with 1.5kg and 3.0kg of weight added respectively. The spreadsheet calculations for each experiment are given in Appendix I and II. Page 1 of each Appendix gives the summary of the results and pages 2 and 3 are the detailed calculations.

In order to compare the results with 1.5kg and 3.0kg of weight added, Fig. 7 was drawn.

With the greater weight added the lift coefficient CL is reduced very slightly but the CL/CD curve shows a greater reduction. The centre of pressure CP appears to be unaffected by the increase in weight.

5 DEFINITIONS

C_L	Spreading force (lift) coefficient	
C_D	Drag coefficient	
L	Spreading force	kg
D	Drag force	kg
p	Density of water (102)	$kg.sec^2/m^4$
l	Door length	m
h	Door height	m
S	Door area (l x h)	m^2
AR	Door aspect ratio h/l	
V	Water speed	m/sec

$C_L = L/(\frac{1}{2} p V^2 S)$

$C_D = D/(\frac{1}{2} p V^2 S)$

C_L/C_D = Door efficiency

W Warp load

B Bridle load

a Warp angle (projected onto horizontal plane)

b Bridle angle (projected onto horizontal plane)

d Warp declination (in plane of warp)

6 SPREADSHEET CALCULATION FORMULAE FOR CL AND CD

A of A	Angle of attack		
W. Load	Warp load	=	W
B. Load	Bridle load	=	B
W. Angle	Warp angle	=	a
B. Angle	Bridle angle	=	b
Decl.n	Warp delination	=	d
W. Lift	Warp lift	=	W x cos d x sin a
W. Drag	Warp drag	=	W x cos d x cos a
B. Lift	Bridle lift	=	B sin b
B. Drag	Bridle drag	=	B cos b
S. Lift	Sum of lifts	=	W x cos d x sin a + B sin b
S. Drag	Sum of drags	=	W x cos d x cos a - B cos b
CL	S. Lift/(0.5 x (1000/9.81) x S x V^2)		
CD	S. Drag/(0.5 x (1000/9.81) x S x V^2)		

7 CONCLUSIONS

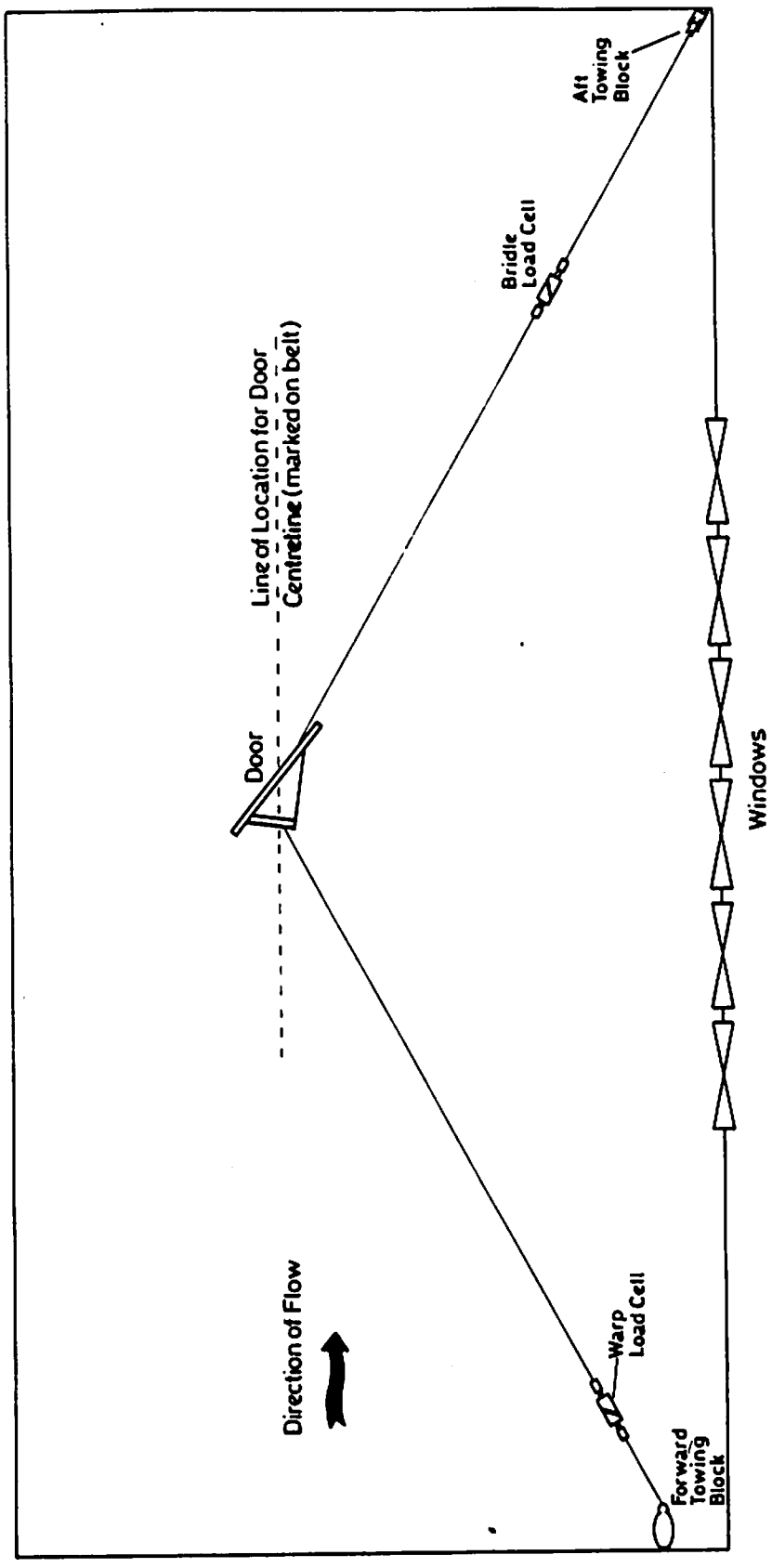
1. Maximum CL values are 0.96 at 28^{O} angle of attack with 1.5kg weight added and 0.94 at 28^{O} with 3.0kg weight added.

2. Corresponding CL/CD values are 1.65 at 28^{O} angle of attack with 1.5kg weight added and 1.60 at 28^{O} with 3.0kg weight added.

3. The centre of pressure does not appear to be affected by the additional weight.

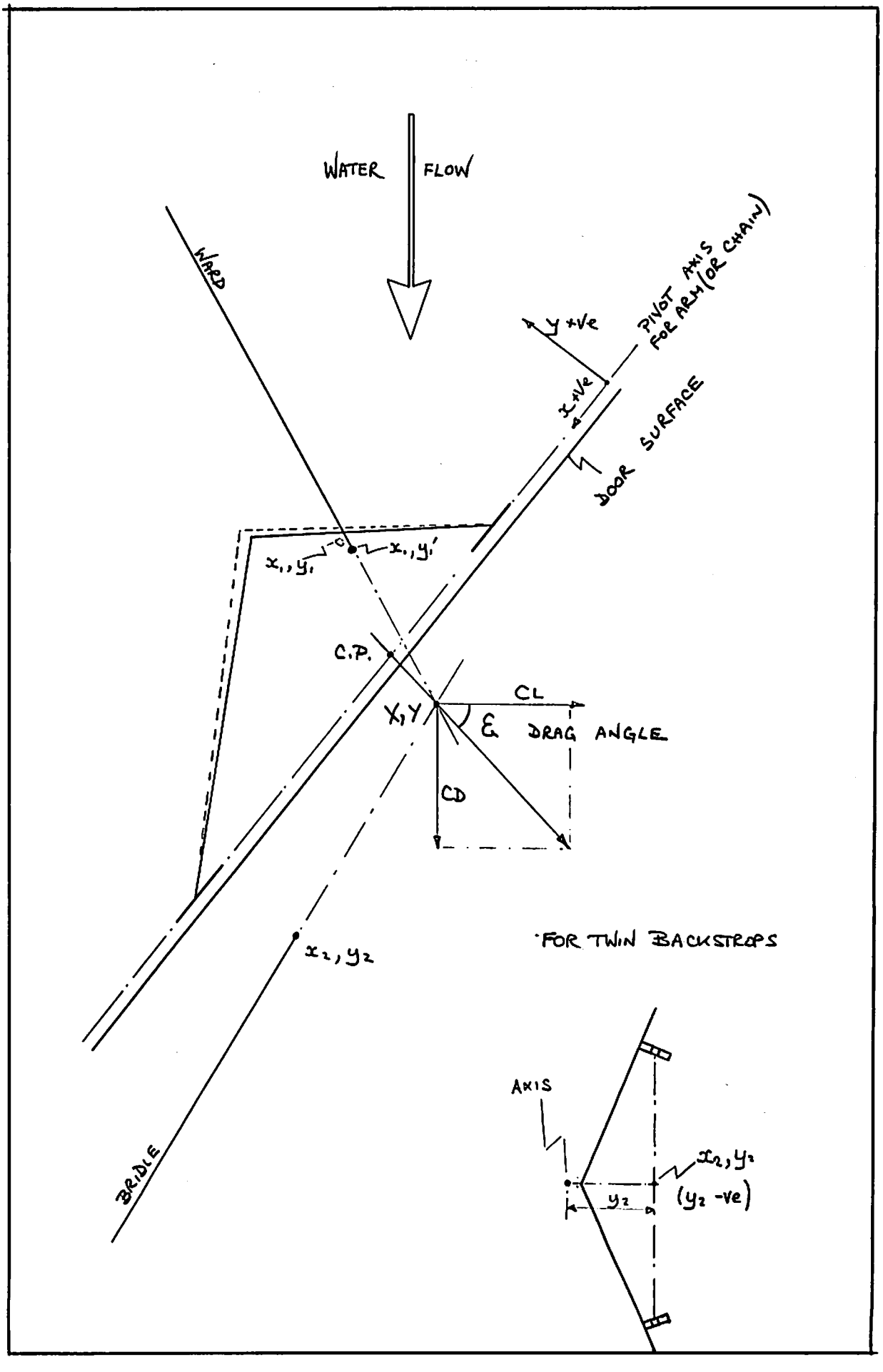
8 REFERENCES

1. WARD J.N., STRICKLAND A., 1988. Trawl Eoor Efficiency - Flume Tank Testing of 1:4 Scale Model Trawl Doors. Sea Fish Industry Authority, Technical Report No. 342.



Plan of Tank Rigging Setup

Fig.1



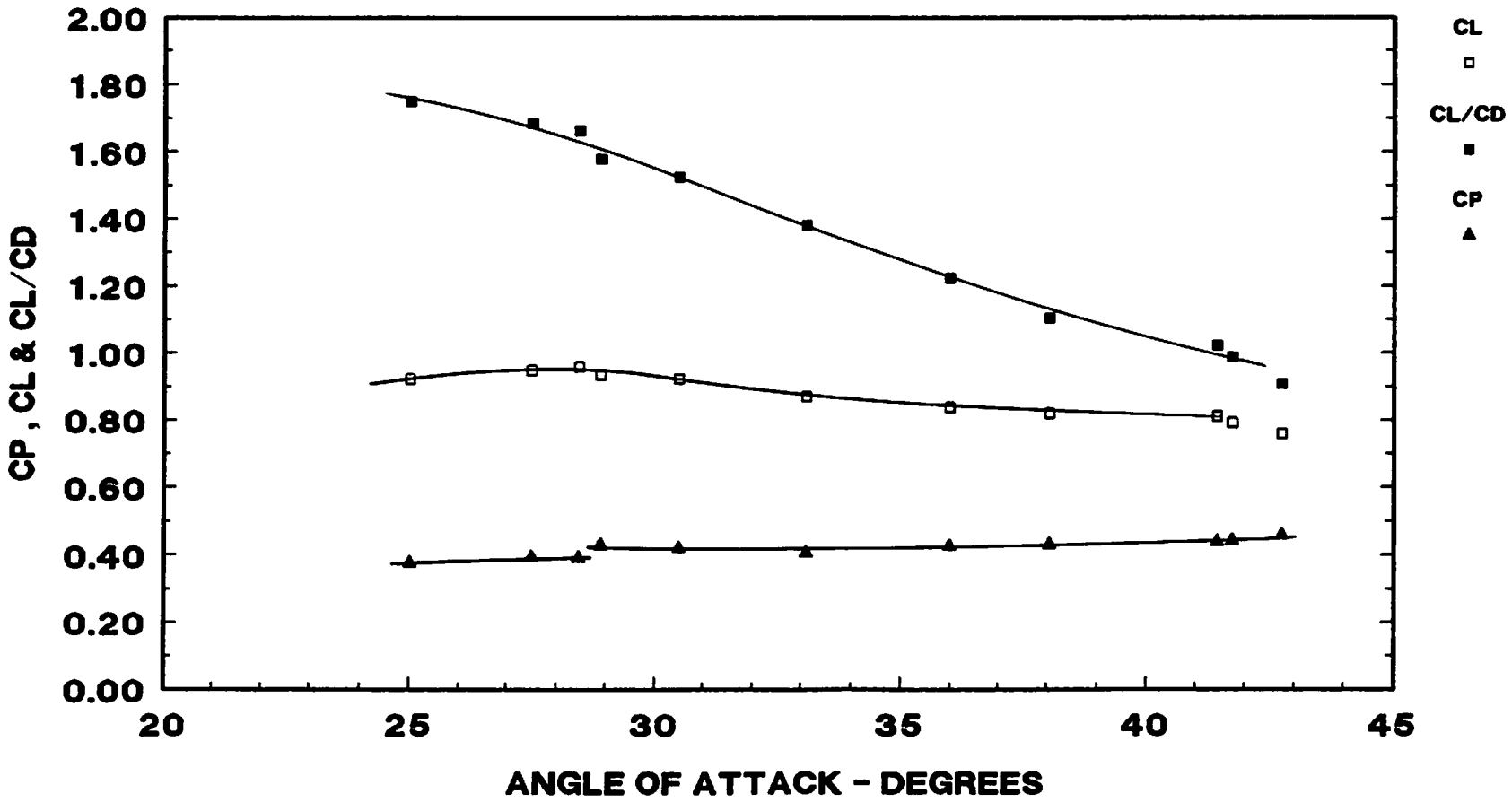
Definition of Centre of Pressure CP

Fig. 3

VEE TYPE OTTERBOARD AT 0° HEEL

(1.5KG WEIGHT ADDED)

OTTERBOARD NO. S.1A



CL AND CD BASED ON AREA = L*H

TEST NO. S.1A.1

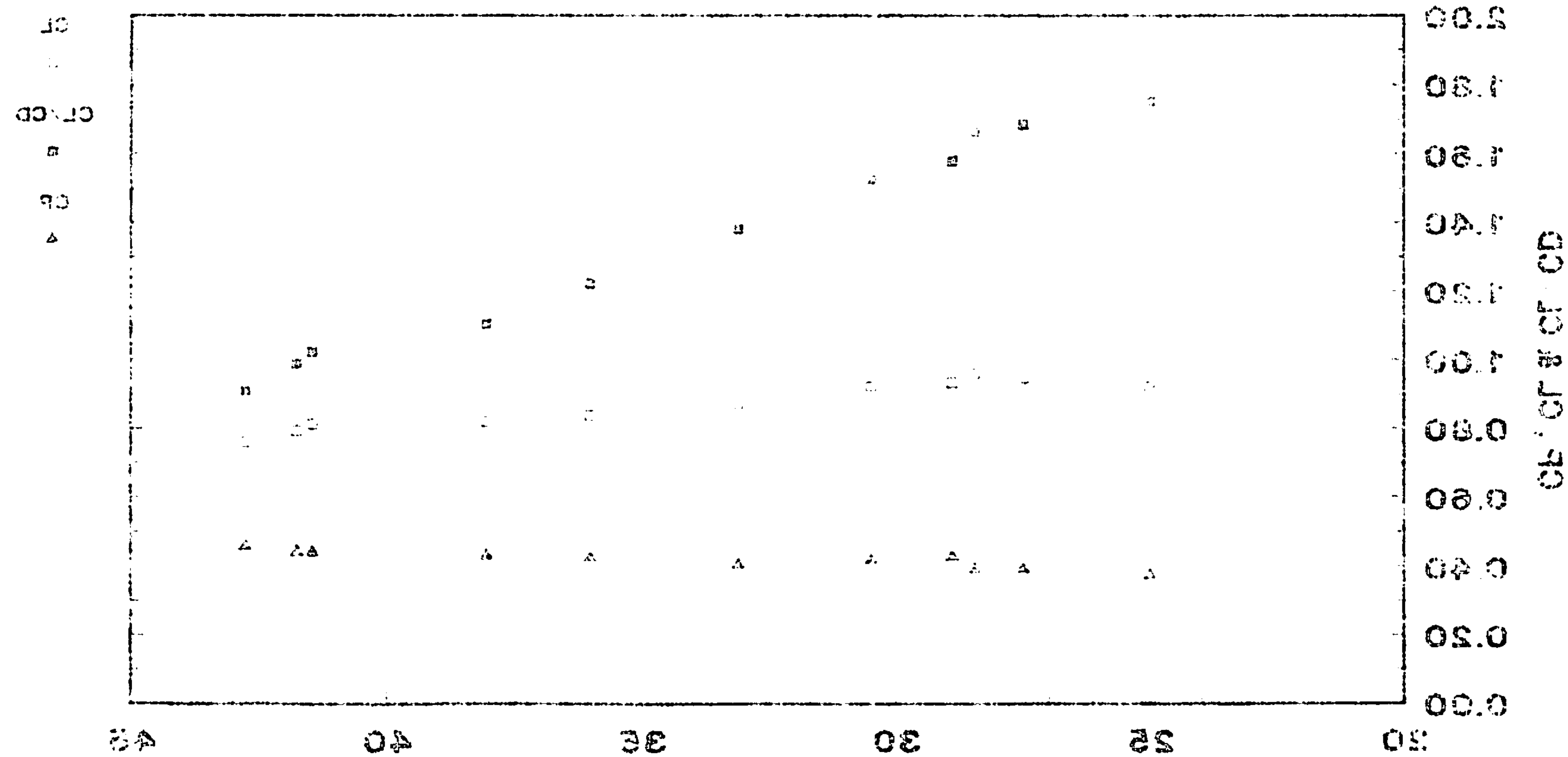
CL, CL/CD and CP Curves with 1.5kg added

Fig. 5

VEE TYPE OTTERBOARD AT 0° HEEL

(1.5KG WEIGHT ADDED)

OTTERBOARD NO. S.1A



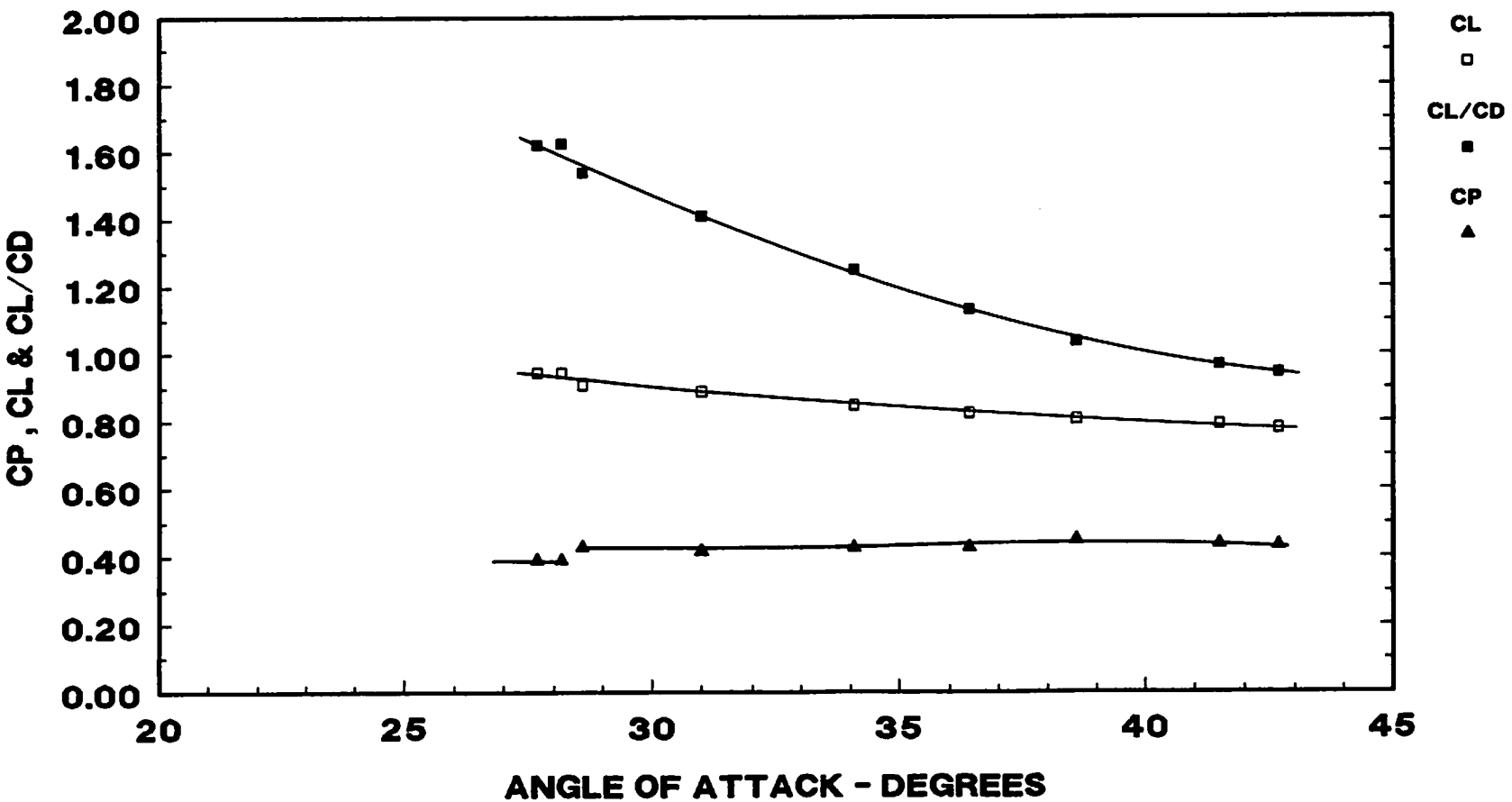
TEST NO. S.1A.1

CL AND CD BASED ON AREA = L*H

VEE TYPE OTTERBOARD AT 0° HEEL

(3.0KG WEIGHT ADDED)

OTTERBOARD NO. S.1B



CL AND CD BASED ON AREA = L*H

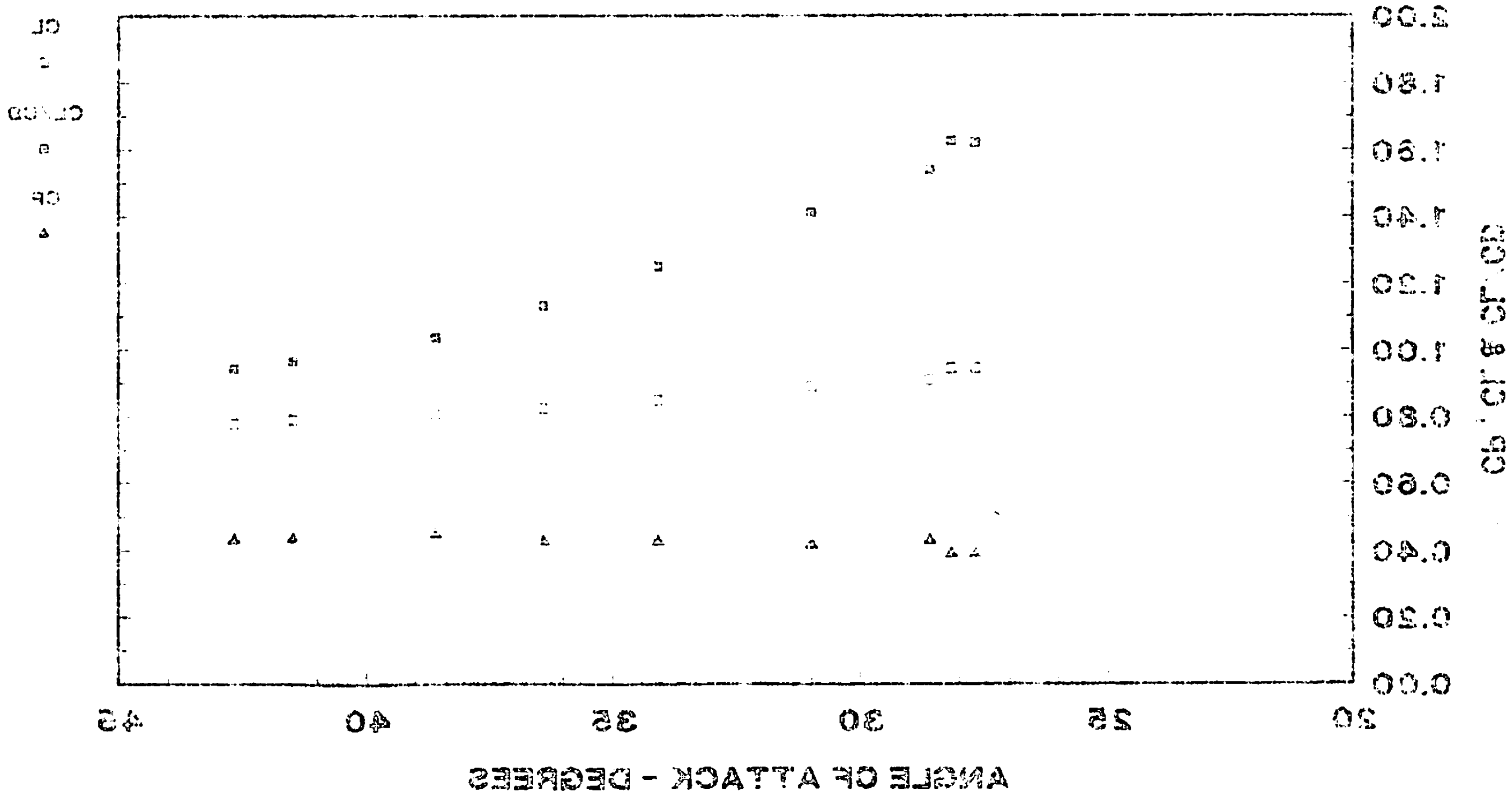
TEST NO. S.1B.1

Fig. 6 CL, CL/CD and CP Curves with 3.0kg added

VEE TYPE OTTERBOARD AT 0° HEEL

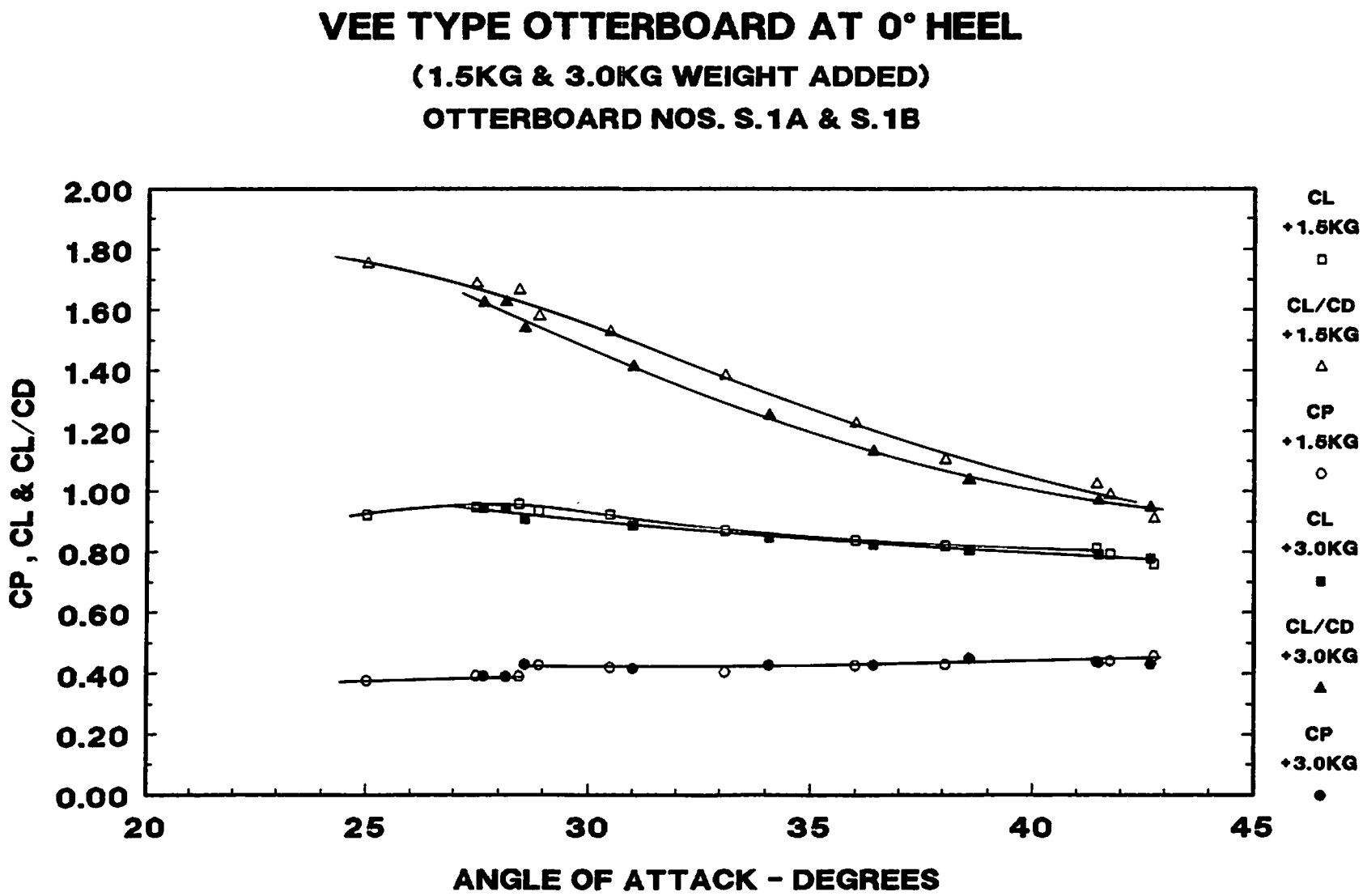
(3.0KG WEIGHT ADDED)

OTTERBOARD NO. 3.18



TEST NO. 3.18.1

CL AND CD BASED ON AREA = L*H



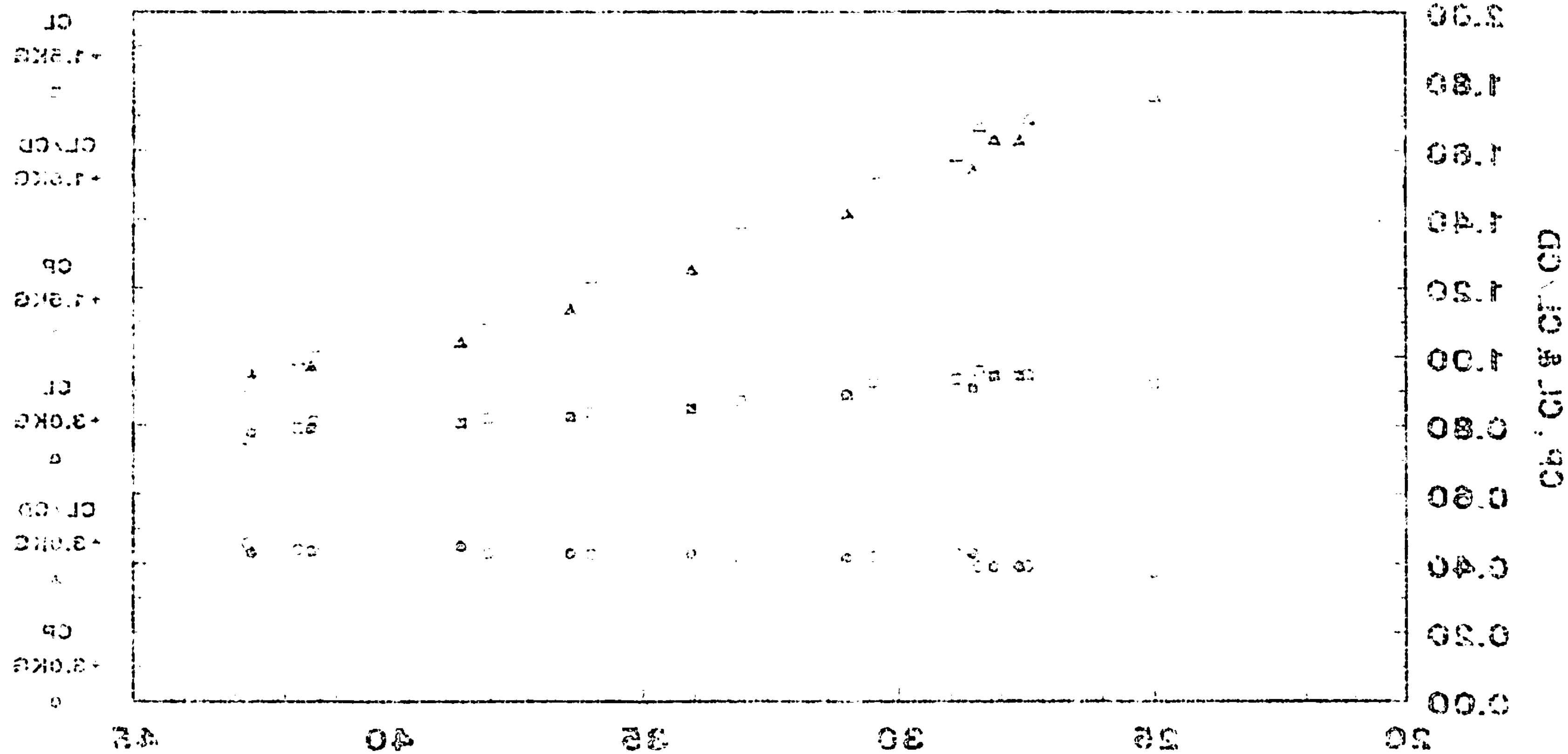
Comparison of Curves with 1.5kg and 3.0kg added

Fig. 7

VEE TYPE OTTERBOARD AT 0° HEEL

(1.5KG & 3.0KG WEIGHT ADDED)

OTTERBOARD NOS. S.1A & S.1B



CL AND CD BASED ON AREA = LxH

TEST NOS. S.1A.1 & S.1B.1

APPENDIX I

VEE TYPE OTTERBOARD AT 0° HEEL (+1.5KG WEIGHT)

OTTERBOARD NO. S.1A
TEST NO. S.1A.1

LENGTH	-M	0.740
HEIGHT	-M	0.480
AREA	-M²	0.355
ASPECT RATIO		0.649
WEIGHT	-Kgs	14.200

A of A deg	Heel deg	CL	CD	CL/CD	Centre of Pressure x/L
25.000	0	0.922	0.526	1.751	0.377
28.450	0	0.958	0.575	1.665	0.391
30.500	0	0.923	0.604	1.527	0.420
33.100	0	0.870	0.630	1.382	0.406
36.000	0	0.837	0.684	1.224	0.427
38.050	0	0.820	0.742	1.105	0.430
41.450	0	0.811	0.792	1.024	0.440
42.750	0	0.760	0.836	0.909	0.458
41.750	0	0.793	0.803	0.988	0.442
28.900	0	0.934	0.592	1.579	0.429
27.500	0	0.947	0.561	1.686	0.393

VEE TYPE OTTERBOARD AT 0° HEEL (+1.5KG WEIGHT)

OTTERBOARD NO. S.1A
TEST NO. S.1A.1

LENGTH	-M	0.740	
HEIGHT	-M	0.480	
AREA	-M²	0.355	(L*H)
ASPECT RATIO		0.649	
WEIGHT	-Kgs	14.200	

Area M²	Speed M/Sec	Heel deg	A of A deg	W.Load Kgs	B.Load Kgs	W.Angle deg	B.Angle deg	Decl.n deg
0.355	0.890	0	25.000	25.827	18.029	16.000	20.100	9.594
0.355	0.905	0	28.450	27.417	18.839	15.950	20.950	7.662
0.355	0.906	0	30.500	27.250	18.149	15.750	20.600	8.048
0.355	0.906	0	33.100	26.238	16.696	15.750	20.650	8.434
0.355	0.908	0	36.000	25.812	15.447	15.900	20.750	6.700
0.355	0.903	0	38.050	25.815	14.703	15.650	20.650	6.123
0.355	0.906	0	41.450	26.066	14.167	15.750	20.670	4.014
0.355	0.906	0	42.750	25.493	12.915	15.550	20.250	2.292
0.355	0.900	0	41.750	25.810	13.858	15.600	19.850	3.440
0.355	0.918	0	28.900	28.069	18.970	15.750	20.670	7.662
0.355	0.908	0	27.500	27.534	19.074	15.750	20.670	8.241

W.Drag Kgs	B.Drag Kgs	W.Lift Kgs	B.Lift Kgs	S.Drag Kgs	S.Lift Kgs	CL	CD	CL/CD
24.479	16.931	7.019	6.196	7.548	13.215	0.922	0.526	1.751
26.126	17.594	7.467	6.736	8.533	14.203	0.958	0.575	1.665
25.969	16.989	7.324	6.386	8.980	13.709	0.923	0.604	1.527
24.980	15.623	7.045	5.888	9.356	12.933	0.870	0.630	1.382
24.655	14.445	7.023	5.473	10.210	12.496	0.837	0.684	1.224
24.716	13.758	6.924	5.185	10.958	12.109	0.820	0.742	1.105
25.026	13.255	7.058	5.001	11.771	12.059	0.811	0.792	1.024
24.540	12.117	6.829	4.470	12.423	11.299	0.760	0.836	0.909
24.814	13.035	6.928	4.706	11.780	11.634	0.793	0.803	0.988
26.774	17.749	7.551	6.696	9.025	14.247	0.934	0.592	1.579
26.227	17.846	7.397	6.733	8.380	14.130	0.947	0.561	1.686

VEE TYPE OTTERBOARD AT 0° HEEL (+1.5KG WEIGHT)

OTTERBOARD NO. S.1A
TEST NO. S.1A.1

CENTRE OF PRESSURE CALCULATION

IS TOW ARM/CHAIN HINGED? Yes=1,No=0 1

WARP POS.N x1	y1	BRIDLE POS.N x2	y2	A of A rads	W.Angle rads	B.Angle rads	Decl.n rads
0.112	0.093	0.500	-0.078	0.436	0.279	0.351	0.167
0.130	0.110	0.500	-0.078	0.497	0.278	0.366	0.134
0.154	0.123	0.500	-0.078	0.532	0.275	0.360	0.140
0.160	0.131	0.500	-0.078	0.578	0.275	0.360	0.147
0.182	0.146	0.500	-0.078	0.628	0.278	0.362	0.117
0.195	0.150	0.500	-0.078	0.664	0.273	0.360	0.107
0.215	0.161	0.500	-0.078	0.723	0.275	0.361	0.070
0.234	0.160	0.500	-0.078	0.746	0.271	0.353	0.040
0.234	0.160	0.560	-0.078	0.729	0.272	0.346	0.060
0.154	0.123	0.560	-0.078	0.504	0.275	0.361	0.134
0.130	0.110	0.560	-0.078	0.480	0.275	0.361	0.144

Drag A rads	Arm Ang rads	y1'	X	Y	Centre of Pressure x/L
0.519	0.264	0.090	0.284	-0.059	0.377
0.541	0.195	0.108	0.292	-0.051	0.391
0.580	0.198	0.121	0.313	-0.045	0.420
0.626	0.199	0.128	0.302	-0.034	0.406
0.685	0.150	0.144	0.317	-0.028	0.427
0.736	0.134	0.149	0.320	-0.022	0.430
0.773	0.084	0.160	0.326	-0.012	0.440
0.833	0.047	0.160	0.340	-0.012	0.458
0.792	0.072	0.160	0.326	0.016	0.442
0.565	0.194	0.121	0.320	-0.043	0.429
0.535	0.215	0.107	0.293	-0.046	0.393

APPENDIX II

VEE TYPE OTTERBOARD AT 0° HEEL (+3.0KG WEIGHT)

OTTERBOARD NO. S.1B
TEST NO. S.1B.1

LENGTH	-M	0.740	
HEIGHT	-M	0.480	
AREA	-M²	0.355	(L*H)
ASPECT RATIO		0.649	
WEIGHT	-Kgs	15.700	

A of A deg	Heel deg	CL	CD	CL/CD	Centre of Pressure x/L
28.580	0	0.909	0.590	1.541	0.431
31.000	0	0.890	0.631	1.412	0.418
34.080	0	0.849	0.678	1.251	0.429
36.410	0	0.825	0.728	1.133	0.429
38.580	0	0.807	0.779	1.037	0.451
42.670	0	0.780	0.824	0.946	0.432
41.500	0	0.791	0.816	0.970	0.438
28.160	0	0.946	0.581	1.627	0.391
27.670	0	0.945	0.582	1.624	0.392

VEE TYPE OTTERBOARD AT 0° HEEL (+3.0KG WEIGHT)

OTTERBOARD NO. S.1B
TEST NO. S.1B.1

LENGTH	-M	0.740	
HEIGHT	-M	0.480	
AREA	-M²	0.355	(L*H)
ASPECT RATIO		0.649	
WEIGHT	-Kgs	15.700	

Area M²	Speed M/Sec	Heel deg	A of A deg	W.Load Kgs	B.Load Kgs	W.Angle deg	B.Angle deg	Decl.n deg
0.355	0.907	0	28.580	26.990	17.994	15.670	20.670	9.594
0.355	0.899	0	31.000	26.155	16.841	15.820	20.670	6.892
0.355	0.902	0	34.080	26.048	15.829	15.750	20.330	7.855
0.355	0.907	0	36.410	26.239	15.220	15.500	20.500	6.892
0.355	0.908	0	38.580	26.216	14.416	15.500	20.670	6.315
0.355	0.900	0	42.670	25.835	13.545	15.410	19.820	4.589
0.355	0.910	0	41.500	26.456	14.033	15.500	20.080	4.589
0.355	0.913	0	28.160	28.085	19.138	15.920	20.330	8.434
0.355	0.901	0	27.670	27.065	18.434	15.750	21.080	8.627

W.Drag Kgs	B.Drag Kgs	W.Lift Kgs	B.Lift Kgs	S.Drag Kgs	S.Lift Kgs	CL	CD	CL/CD
25.623	16.836	7.188	6.352	8.788	13.540	0.909	0.590	1.541
24.982	15.757	7.079	5.945	9.226	13.023	0.890	0.631	1.412
24.835	14.843	7.004	5.499	9.992	12.504	0.849	0.678	1.251
25.102	14.256	6.961	5.330	10.846	12.292	0.825	0.728	1.133
25.109	13.488	6.963	5.089	11.621	12.052	0.807	0.779	1.037
24.826	12.743	6.843	4.593	12.084	11.436	0.780	0.824	0.946
25.412	13.180	7.047	4.818	12.232	11.865	0.791	0.816	0.970
26.716	17.946	7.620	6.649	8.770	14.269	0.946	0.581	1.627
25.754	17.200	7.263	6.630	8.554	13.894	0.945	0.582	1.624

VEE TYPE OTTERBOARD AT 0° HEEL (+3.0KG WEIGHT)

OTTERBOARD NO. S.1B
TEST NO. S.1B.1

CENTRE OF PRESSURE CALCULATION

IS TOW ARM/CHAIN HINGED? Yes=1,No=0 1

WARP POS.N x1	y1	BRIDLE POS.N x2	y2	A of A rads	W.Angle rads	B.Angle rads	Decl.n rads
0.154	0.123	0.560	-0.078	0.499	0.273	0.361	0.167
0.160	0.131	0.560	-0.078	0.541	0.276	0.361	0.120
0.182	0.146	0.560	-0.078	0.595	0.275	0.355	0.137
0.195	0.150	0.560	-0.078	0.635	0.271	0.358	0.120
0.215	0.161	0.560	-0.078	0.673	0.271	0.361	0.110
0.234	0.160	0.560	-0.078	0.745	0.269	0.346	0.080
0.215	0.161	0.500	-0.078	0.724	0.271	0.350	0.080
0.130	0.110	0.500	-0.078	0.491	0.278	0.355	0.147
0.130	0.110	0.560	-0.078	0.483	0.275	0.368	0.151

Drag A rads	Arm Ang rads	y1'	X	Y	Centre of Pressure x/L
0.576	0.247	0.119	0.323	-0.045	0.431
0.616	0.167	0.129	0.312	-0.033	0.418
0.674	0.183	0.144	0.319	-0.019	0.429
0.723	0.155	0.148	0.318	-0.009	0.429
0.767	0.138	0.159	0.334	-0.005	0.451
0.813	0.095	0.159	0.318	0.024	0.432
0.801	0.096	0.160	0.325	-0.009	0.438
0.551	0.216	0.107	0.292	-0.049	0.391
0.552	0.224	0.107	0.293	-0.047	0.392