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Test Report

TR-HYD-17

PROPELLER 90: PROPELLER OPEN WATER EXPERIMENTS

A.J. Simoes Re

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PROPELLER 90: PROPELLER OPEN WATER EXPERIMENTS

TR-HYD-17

A.J. Simoés Re

August 1987

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SUMMARY This report describes propeller open water experiments on both an HSVA stock propeller and an IMD copy of the same propeller.				
ADDRESS National Research Council Institute for Marine Dynamics P.O. Box 12093, Stn. 'A' St. John's, NF A1B 3T5 (709) 772-2479				

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PROPELLER 90: PROPELLER OPEN WATER EXPERIMENTS

1.0 INTRODUCTION

This report describes the propeller open water experiments carried out by the Institute for Marine Dynamics (IMD) on both a Hamburgische Schiffbau-Versuchsanstalt (HSVA) stock propeller and an IMD copy of the same propeller.

The main objective of the experiments was to compare the performance of HSVA's stock propeller with that of IMD's copy. In addition, the purchase of a new open water dynamometer for the St. John's towing tank gave the opportunity to re-test the IMD copy without the nozzle. For completeness, all the results are included in this report.

The original HSVA propeller was designated Propeller 1814 and the IMD copy Propeller 90. Details of the model propeller and test conditions are given in Table 1, while the Propeller/Nozzle arrangement is shown in Figure 1.

2.0 MODEL PROPELLER EXPERIMENTS

The experiments were carried out in the IMD tanks in Ottawa and St. John's. Results of individual experiments may be found from the List of Tables and the List of Figures.

2.1 Propeller Open Water Experiments

Propeller open water experiments were performed in Ottawa on propeller numbers 1814 and 90. Both propellers were tested inside an accelerating type nozzle without the measurement of duct thrust and with the apparatus shown in Figure 2. Propeller 90 was later retested in St. John's. However, the experiments had to be conducted without the nozzle, since the nozzle attachment for the new Propeller Open Water Dynamometer (POWD), Figure 3, was not available.

The measured values of thrust, torque, revolutions and carriage speed were plotted together as KT and KQ against J , and fair lines fitted through the data. Since there was no variation of KT and KQ against J with revolutions, the results were faired to give average values of KT and KQ against J .

3.0 DISCUSSION OF EXPERIMENT RESULTS

A comparison between propellers 1814 and 90 in the duct is presented in Figures 7 to 9. The Figures show that propeller 90 (IMD's Copy) has slightly lower values of KT , KQ and η_{A0} than propeller 1814 (HSVA's Original). The small difference between the two propellers may be attributed to the manufacturing technique used to copy the original propeller as well as small differences in test results. The HSVA model was

copied using a pantograph machine with a ratio of 1:1 between the pattern and the blade. The machine was designed for best results with a ratio of approximately 5:1. Thus, small errors in the pattern alignment would normally be reduced, but in this case they were not. It is worth noting that the difference between the propellers is fairly constant, which would seem to indicate that the copy had a lower pitch than the original. However, this can not be verified because the original propeller had to be returned to HSVVA and its pitch was never checked against its stated value.

The results of the experiments carried out with the new propeller open water dynamometer are given in figure 6. Although they cannot be compared directly with the Ottawa results, they do show similar amounts of scatter for the measured thrust and torque coefficients. Figures 10 and 11 show the effect of the nozzle on propeller 90. This shows that the efficiency of the propeller actually drops when working in the nozzle. Similar results were observed with propeller 68, Reference 1. A summary of the results of open water tests for propeller 68 are presented in Appendix A. The data in the appendix are the same as in Reference 1, but to compare with the data from propeller 90, the analysis was made without taking into account the duct thrust.

4.0 REFERENCES

1. MOLYNEUX, W. D., " M.V. Arctic, Results of Resistance and Overload Experiments Including Measured Duct Forces, Model Hull 326, Propeller 68 ", IMD/NRC LTR-SH-349, May 1983, Limited

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LIST OF SYMBOLS

AE/AD	Blade Area Ratio
D	Propeller Diameter, m
ETA0	Open Water Propeller Efficiency
J	Advance Coefficient, V_A/ND
KQ	Torque Coefficient, $Q/\rho N^2 D^5$
KT	Thrust Coefficient, $T/\rho N^2 D^4$
N	Rate of Revolution, 1/s
Q	Propeller Torque, Nm
T	Propeller Thrust, N
Va	Speed of Advance of Propeller, m/s
Z	Number of Blades

Standard Values

g	Acceleration due to gravity	9.8066 m/s ²
ρ	Density of water, salt water at 15° C,	1025.88 N.s ² /m ⁴
	fresh water at 15°C,	998.84 N.s ² /m ⁴

SUMMARY OF PROPELLER MODEL CONDITIONS

PROPELLER 1814 AND PROPELLER 90

SCALE : 1/14

MATERIAL : Brass

PROPELLER MODEL TEST CONDITION

TEST #	3817	3832	026
PROPELLER #	1814	90	90
IMD TANK	Ottawa	Ottawa	St. John's
SHAFT IMMERSION	1.5 Prop. Dia.	1.5 Prop. Dia.	1.5 Prop. Dia.
RATES OF REVOLUTION (rps)	10,15,20	10,15,20	10,15,20
TEST CONDITION	With Nozzle	With Nozzle	Unshrouded

PROPELLER AND NOZZLE DESIGN PARTICULARS

PROPELLER 1814/90

SCALE		:	1/14
DIAMETER, m	(D)	:	2.800
PITCH AT 0.7R, m		:	2.716
PITCH RATIO AT 0.7R	(P/D)	:	0.970
BLADE AREA RATIO	(AE/A0)	:	0.660
NUMBER OF BLADES	(Z)	:	4
DIRECTION OF ROTATION		:	LH
DESIGN		:	HSVA Stock Prop./IMD Copy

NOZZLE

SCALE		:	1/14
INNER DIAMETER, m	(ID)	:	2.830
OUTER DIAMETER, m	(OD)	:	3.440
LENGTH OF NOZZLE, m	(LN)	:	1.410
DESIGN		:	BAECKER C470-0

RESULTS OF OPEN WATER TESTS

PROPELLER 1814: IN NOZZLE

P/D = 0.970

TEST DATE: 10-DEC-85

J	KT	10KQ	ETAO
0.000	0.263	0.456	0.000
0.025	0.262	0.453	0.023
0.050	0.260	0.450	0.046
0.075	0.259	0.446	0.069
0.100	0.257	0.443	0.092
0.125	0.255	0.439	0.116
0.150	0.253	0.435	0.139
0.175	0.250	0.430	0.162
0.200	0.247	0.426	0.185
0.225	0.244	0.421	0.208
0.250	0.241	0.416	0.230
0.275	0.237	0.411	0.252
0.300	0.233	0.405	0.275
0.325	0.229	0.399	0.296
0.350	0.224	0.393	0.318
0.375	0.219	0.387	0.339
0.400	0.214	0.380	0.359
0.425	0.209	0.372	0.379
0.450	0.203	0.365	0.399
0.475	0.197	0.357	0.418
0.500	0.191	0.348	0.436
0.525	0.184	0.339	0.453
0.550	0.177	0.330	0.469
0.575	0.169	0.320	0.484
0.600	0.161	0.309	0.498
0.625	0.153	0.298	0.511
0.650	0.144	0.287	0.521
0.675	0.135	0.274	0.529
0.700	0.126	0.262	0.535
0.725	0.116	0.248	0.538
0.750	0.105	0.234	0.536
0.775	0.094	0.219	0.529
0.800	0.082	0.203	0.516
0.825	0.070	0.187	0.494
0.850	0.058	0.170	0.459
0.875	0.044	0.152	0.407
0.900	0.030	0.133	0.329
0.925	0.016	0.113	0.208
0.950	0.001	0.092	0.012

RESULTS OF OPEN WATER TESTS

PROPELLER 90: IN NOZZLE

P/D = 0.970

TEST DATE: 15-APR-86

J	KT	10KQ	ETA0
0.000	0.249	0.426	0.000
0.025	0.247	0.424	0.023
0.050	0.246	0.421	0.046
0.075	0.244	0.419	0.070
0.100	0.242	0.416	0.093
0.125	0.240	0.412	0.116
0.150	0.238	0.409	0.139
0.175	0.236	0.405	0.162
0.200	0.233	0.401	0.185
0.225	0.230	0.396	0.208
0.250	0.226	0.391	0.230
0.275	0.223	0.386	0.253
0.300	0.219	0.380	0.275
0.325	0.215	0.374	0.297
0.350	0.210	0.368	0.319
0.375	0.205	0.361	0.340
0.400	0.200	0.353	0.361
0.425	0.195	0.345	0.381
0.450	0.189	0.337	0.401
0.475	0.182	0.328	0.420
0.500	0.176	0.319	0.439
0.525	0.169	0.309	0.457
0.550	0.161	0.298	0.473
0.575	0.153	0.287	0.489
0.600	0.145	0.275	0.503
0.625	0.136	0.263	0.515
0.650	0.127	0.250	0.525
0.675	0.117	0.236	0.532
0.700	0.106	0.221	0.536
0.725	0.096	0.206	0.535
0.750	0.084	0.190	0.528
0.775	0.072	0.174	0.514
0.800	0.060	0.156	0.487
0.825	0.047	0.138	0.445
0.850	0.033	0.119	0.376
0.875	0.019	0.099	0.265
0.900	0.004	0.079	0.073

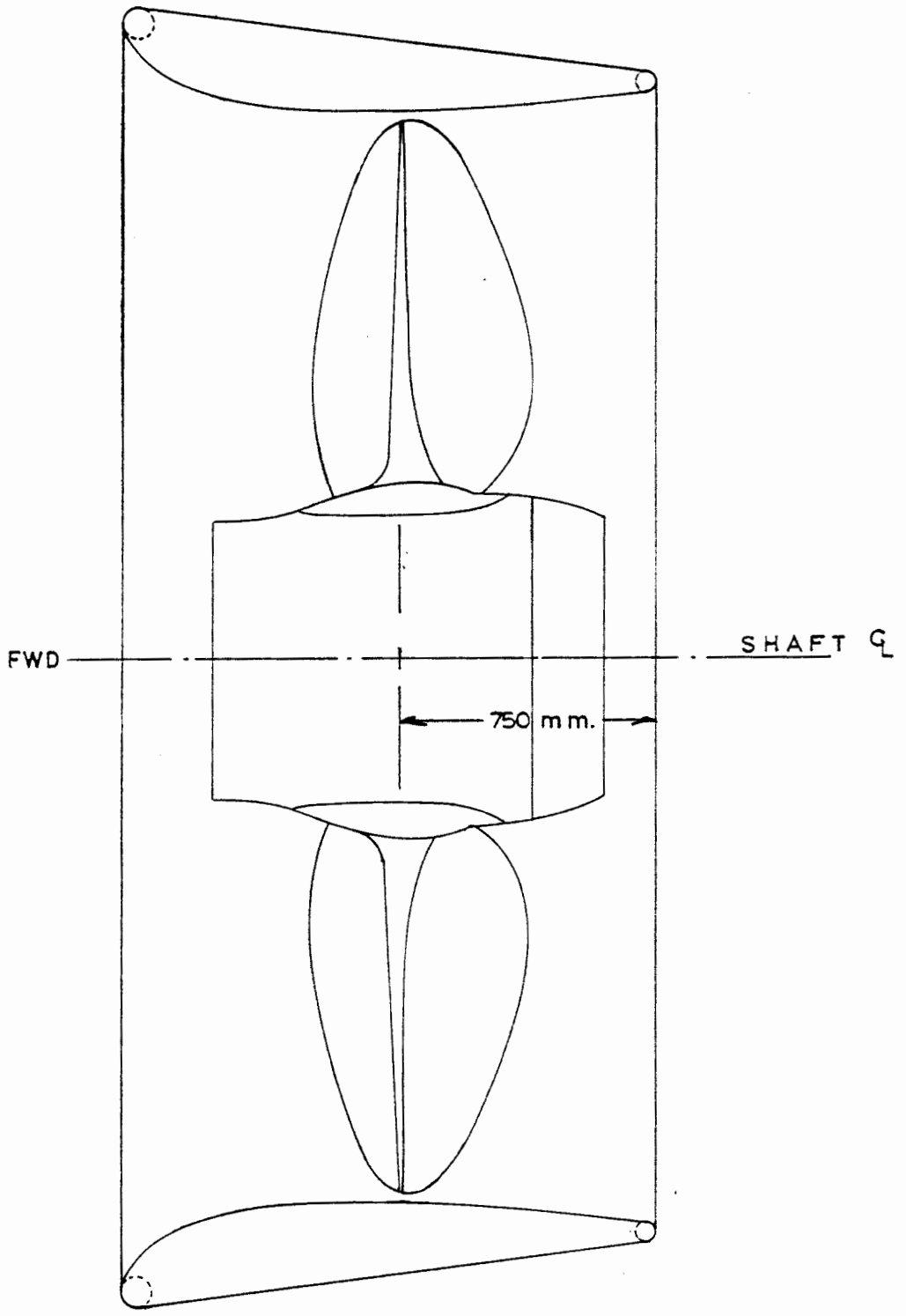
RESULTS OF OPEN WATER TESTS

PROPELLER 90: UNSHROUDED

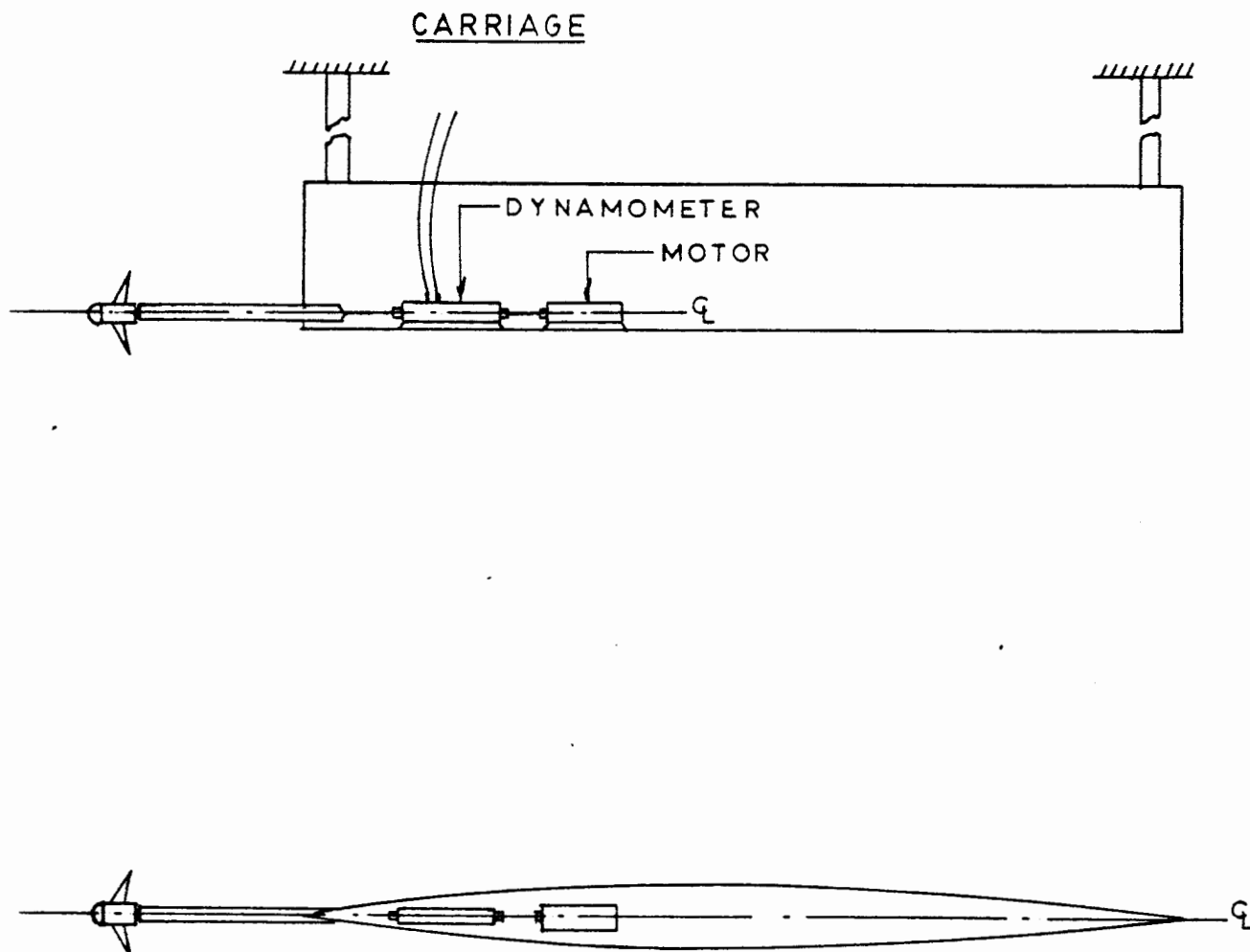
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TEST DATE: 25-NOV-86

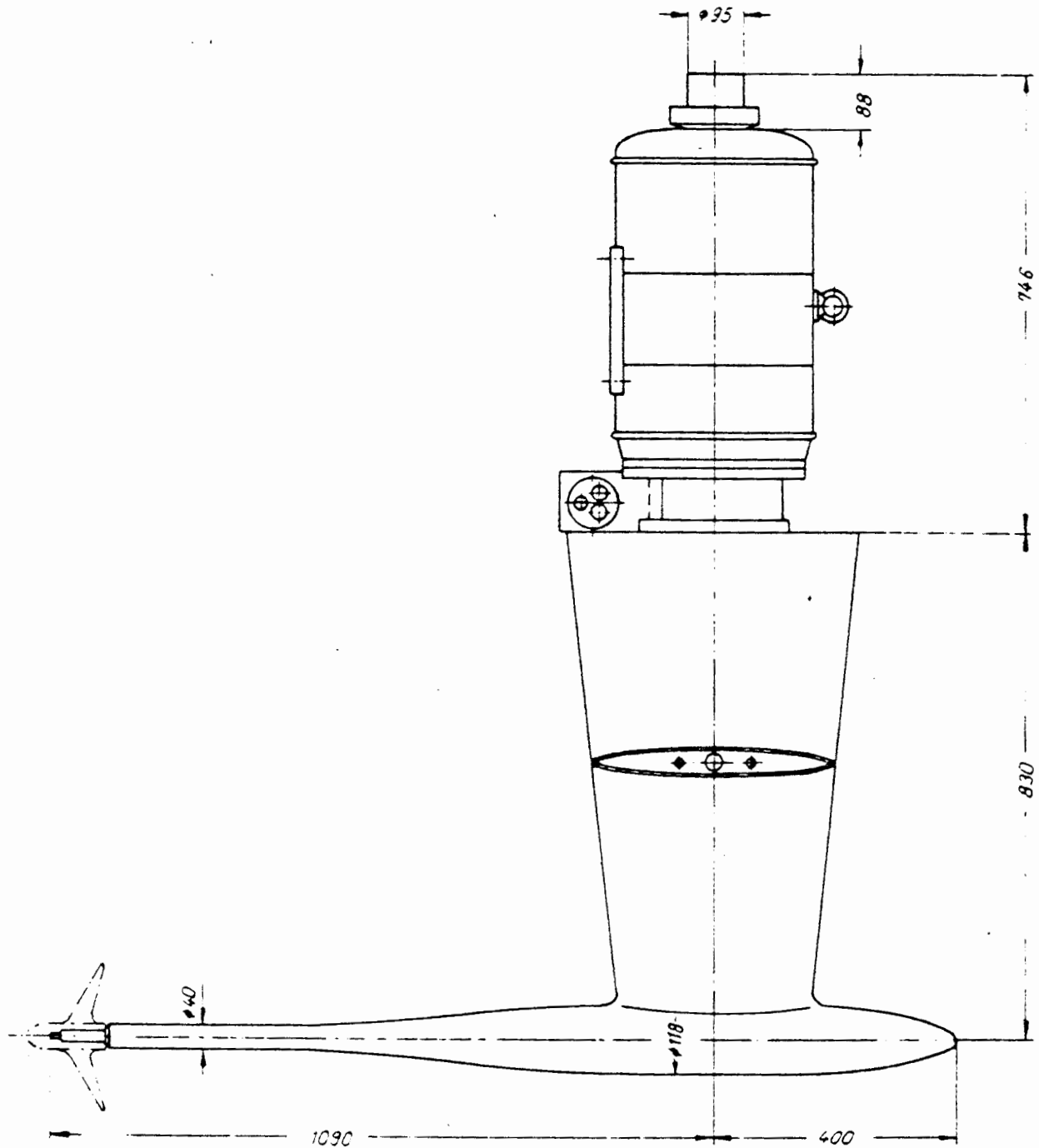
J	KT	10KQ	ETA0
0.000	0.486	0.760	0.000
0.025	0.478	0.747	0.025
0.050	0.468	0.733	0.051
0.075	0.459	0.719	0.076
0.100	0.449	0.704	0.102
0.125	0.438	0.688	0.127
0.150	0.428	0.672	0.152
0.175	0.417	0.656	0.177
0.200	0.405	0.639	0.202
0.225	0.394	0.622	0.227
0.250	0.382	0.604	0.252
0.275	0.370	0.587	0.276
0.300	0.358	0.569	0.300
0.325	0.345	0.551	0.324
0.350	0.333	0.533	0.348
0.375	0.320	0.514	0.371
0.400	0.307	0.496	0.394
0.425	0.294	0.477	0.417
0.450	0.281	0.458	0.439
0.475	0.268	0.440	0.460
0.500	0.254	0.421	0.481
0.525	0.241	0.402	0.500
0.550	0.227	0.383	0.519
0.575	0.214	0.365	0.536
0.600	0.200	0.346	0.552
0.625	0.186	0.327	0.567
0.650	0.173	0.308	0.579
0.675	0.159	0.290	0.589
0.700	0.145	0.271	0.596
0.725	0.131	0.252	0.600
0.750	0.117	0.234	0.600
0.775	0.104	0.215	0.594
0.800	0.090	0.196	0.581
0.825	0.076	0.178	0.560
0.850	0.062	0.159	0.526
0.875	0.048	0.140	0.475
0.900	0.034	0.122	0.400
0.925	0.020	0.103	0.286
0.950	0.006	0.084	0.108



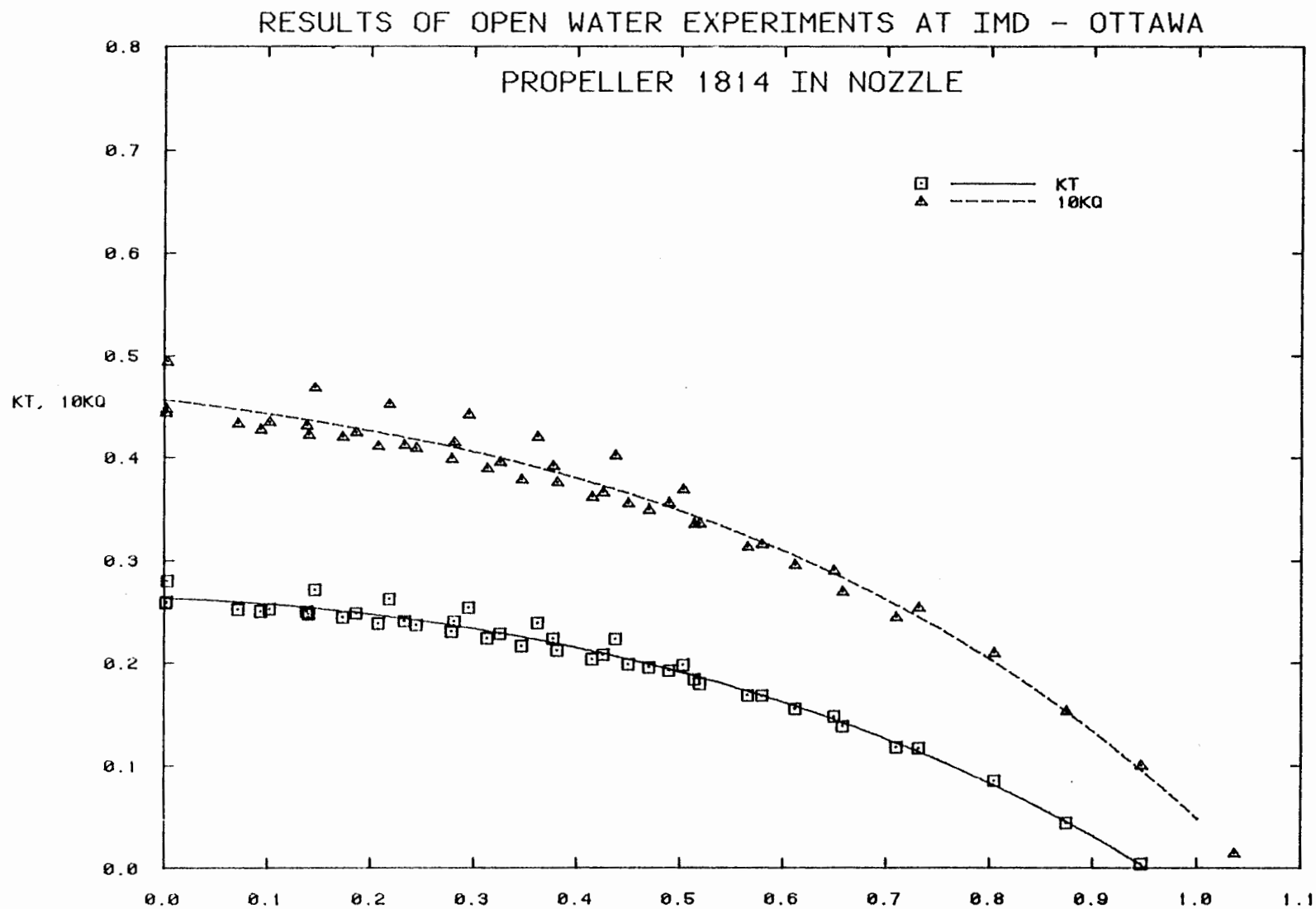
PROPELLER/NOZZLE ARRANGEMENT

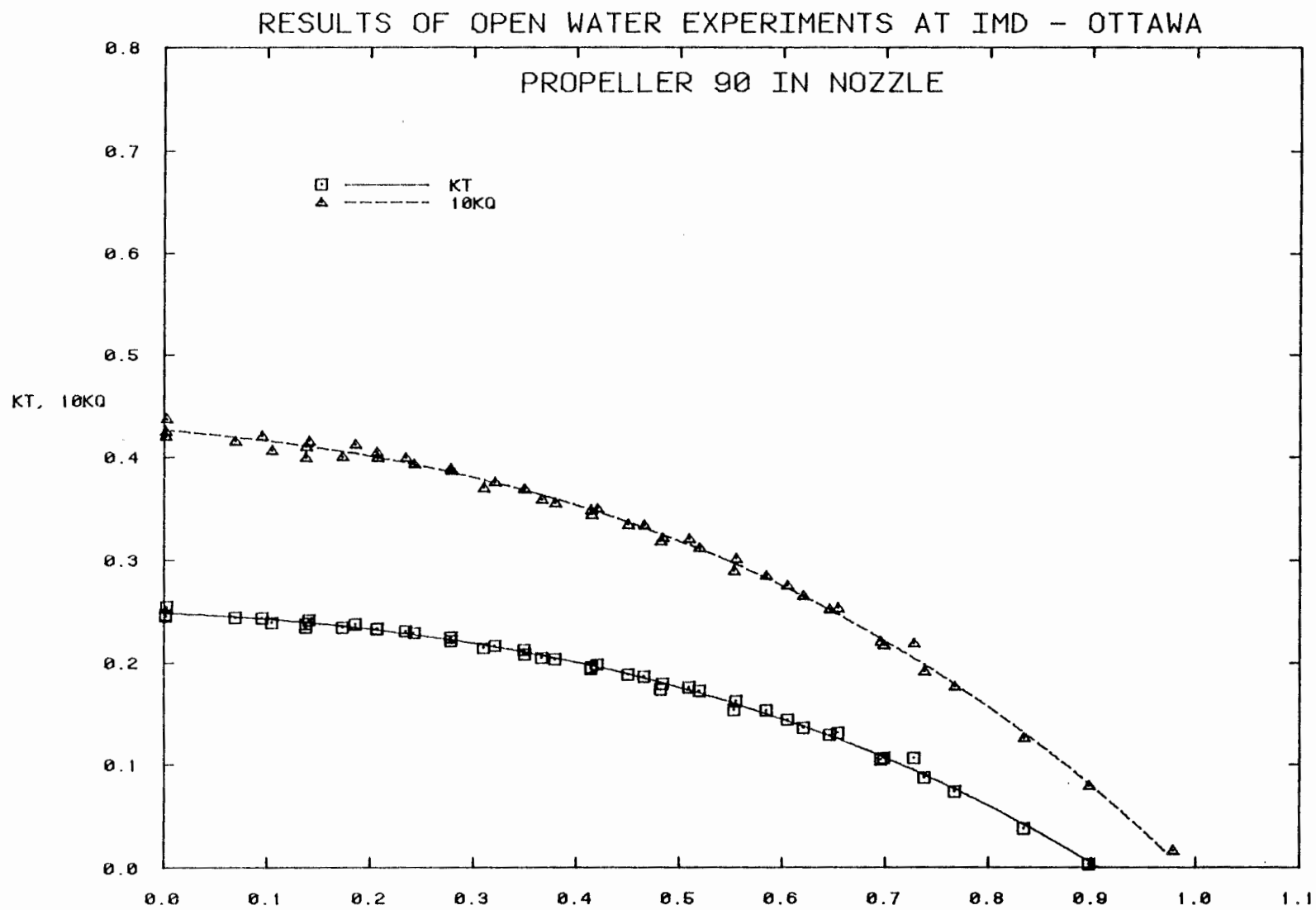


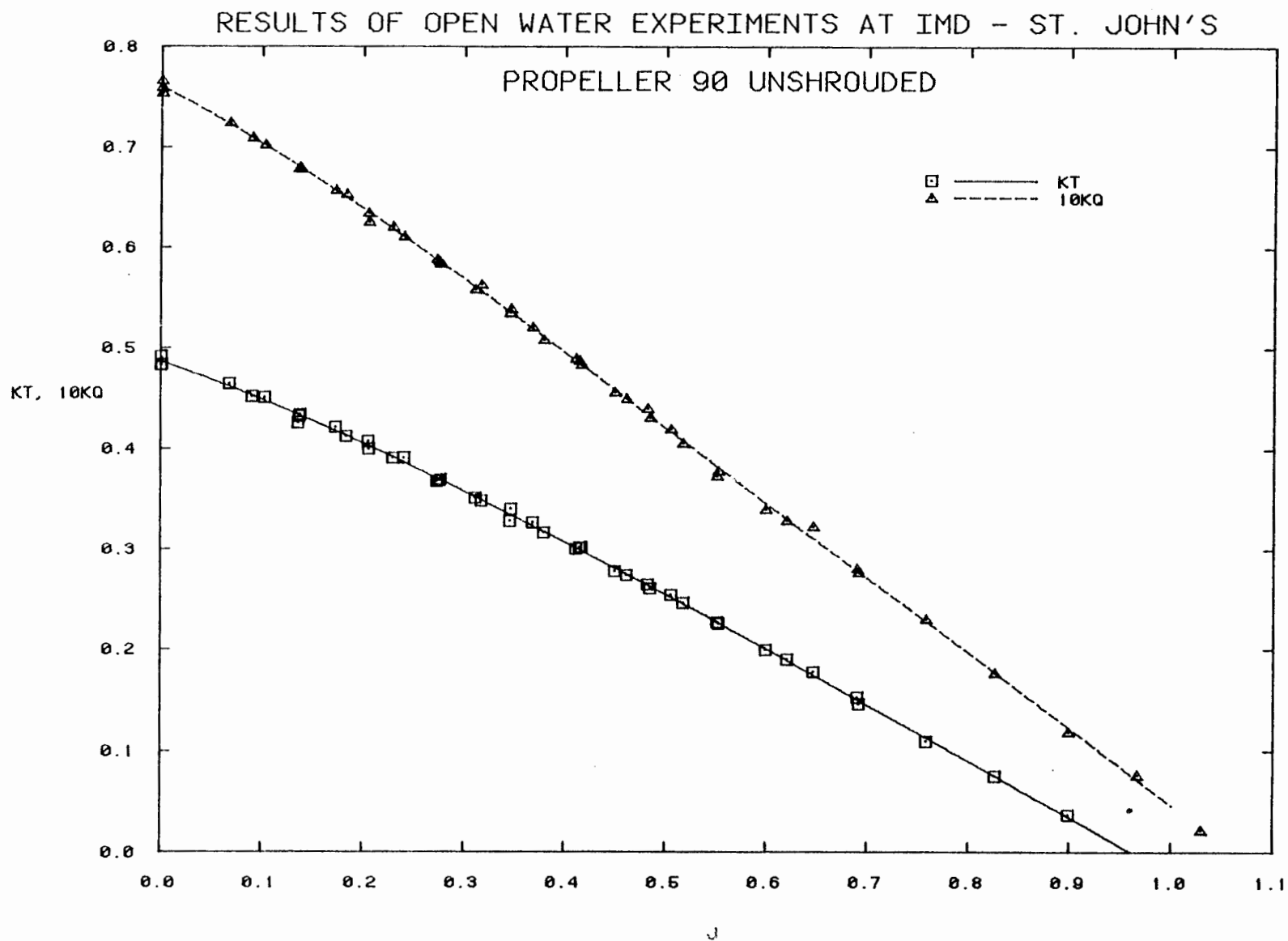
OTTAWA OPEN WATER
TEST APPARATUS

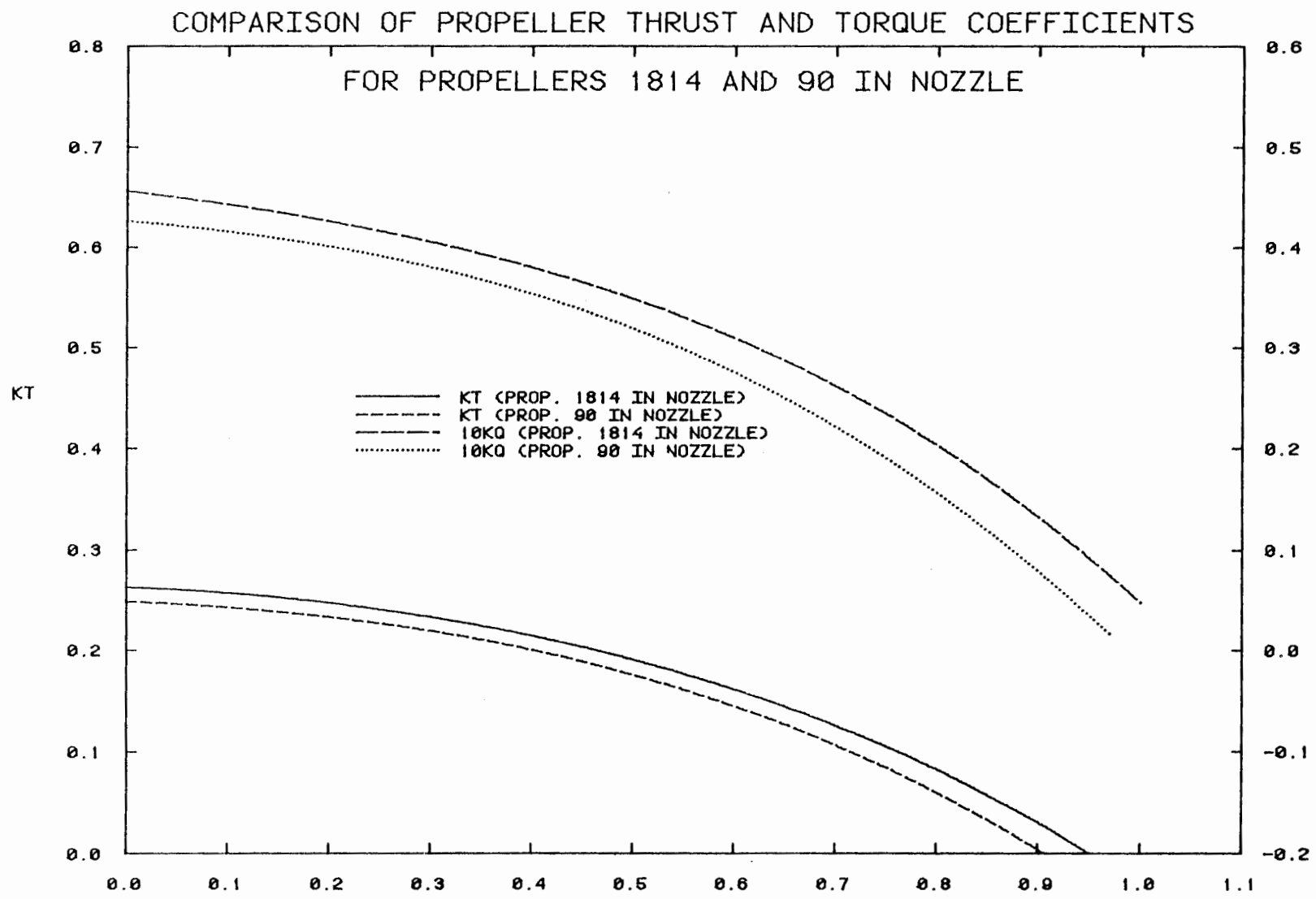


PROPELLER OPEN WATER
DYNAMOMETER

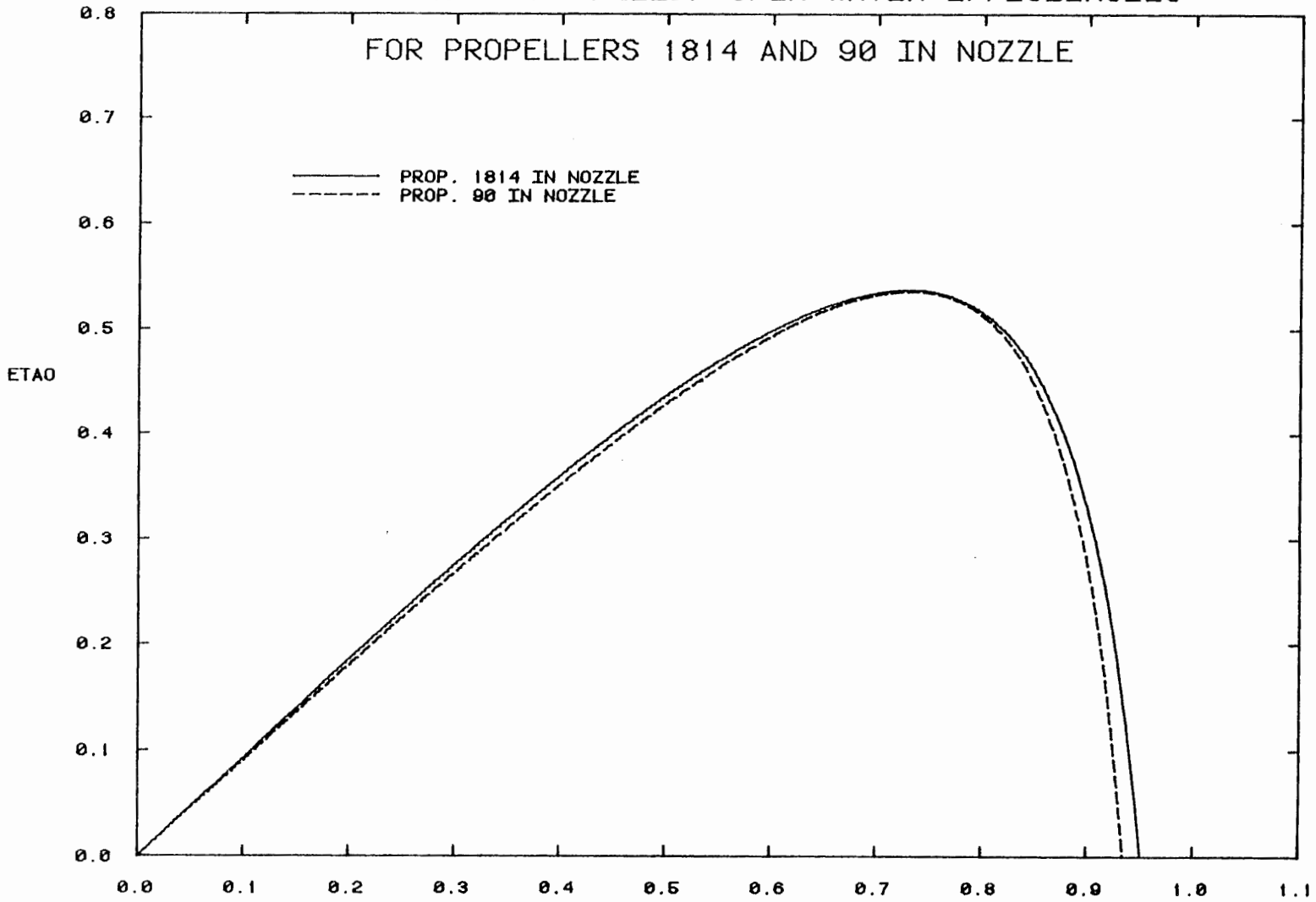






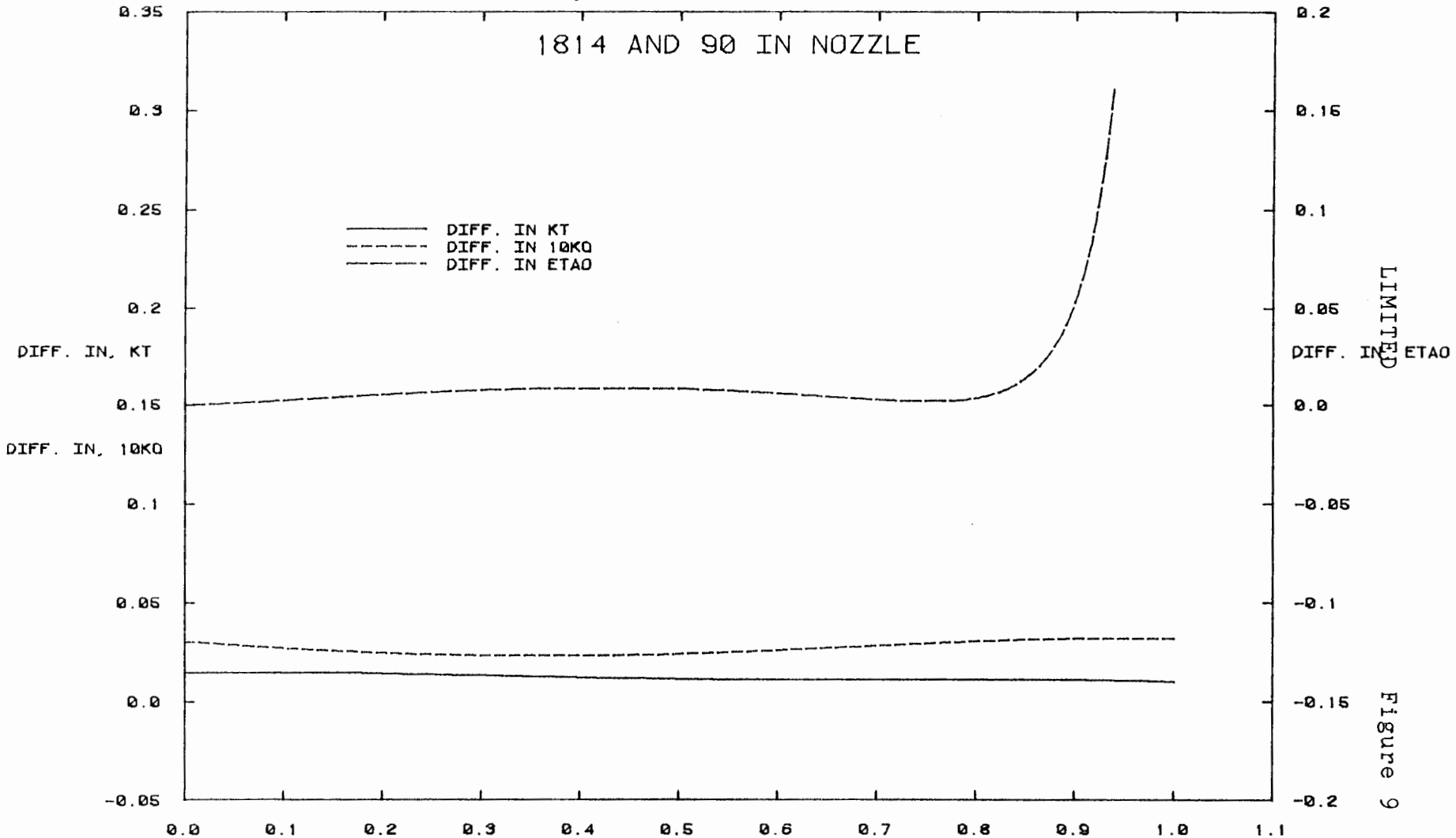


COMPARISON OF PROPELLER OPEN WATER EFFICIENCIES
FOR PROPELLERS 1814 AND 90 IN NOZZLE



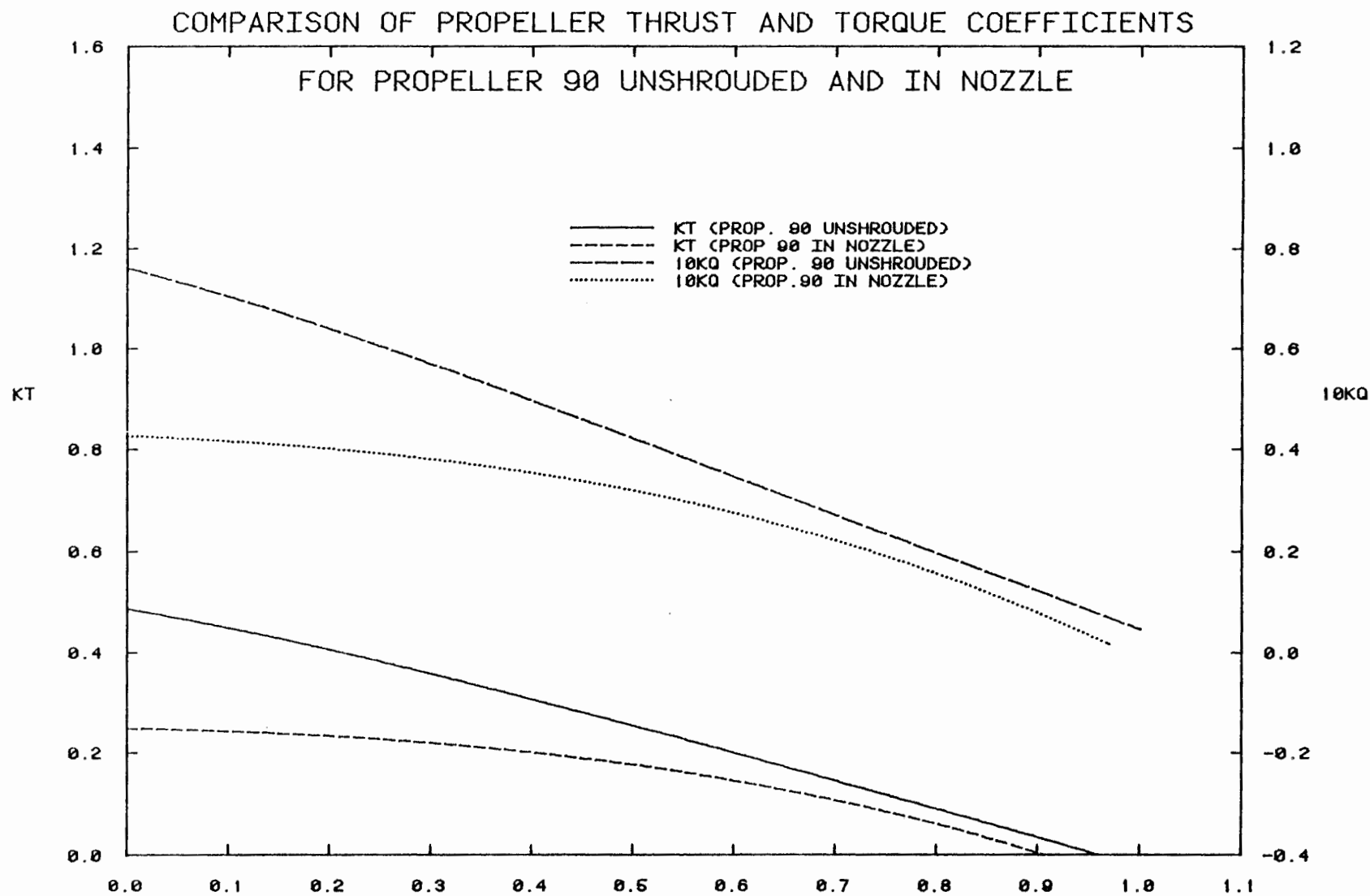
DIFFERENCES IN KT, 10KQ AND ETAO BETWEEN PROPELLERS

1814 AND 90 IN NOZZLE



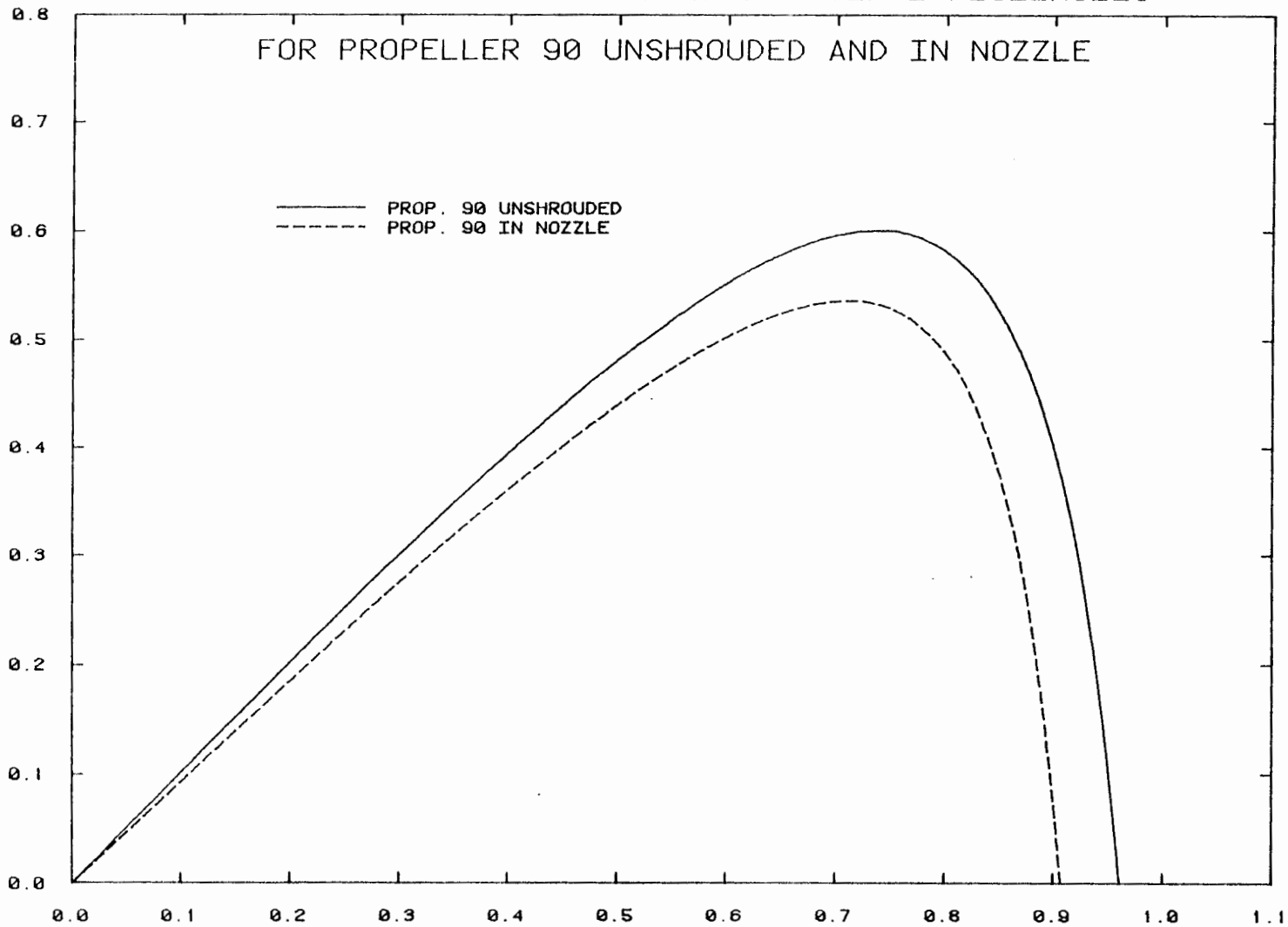
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Figure 9



COMPARISON OF PROPELLER OPEN WATER EFFICIENCIES

FOR PROPELLER 90 UNSHROUDED AND IN NOZZLE



APPENDIX A

RESULTS OF PROPELLER OPEN WATER EXPERIMENTS:
PROPELLER 68

RESULTS OF OPEN WATER TESTS

PROPELLER 68: UNSHROUDED

P/D = 0.911

J	KT	10KQ	ETA0
0.000	0.492	0.687	0.000
0.025	0.480	0.672	0.028
0.050	0.468	0.656	0.057
0.075	0.456	0.640	0.085
0.100	0.445	0.625	0.113
0.125	0.432	0.609	0.141
0.150	0.420	0.593	0.169
0.175	0.408	0.578	0.197
0.200	0.396	0.562	0.224
0.225	0.383	0.546	0.251
0.250	0.370	0.530	0.278
0.275	0.358	0.514	0.305
0.300	0.345	0.498	0.331
0.325	0.332	0.482	0.356
0.350	0.319	0.466	0.381
0.375	0.306	0.450	0.406
0.400	0.293	0.434	0.430
0.425	0.279	0.417	0.453
0.450	0.266	0.401	0.475
0.475	0.252	0.384	0.496
0.500	0.239	0.368	0.517
0.525	0.225	0.351	0.536
0.550	0.211	0.334	0.553
0.575	0.197	0.317	0.569
0.600	0.183	0.301	0.582
0.625	0.169	0.284	0.594
0.650	0.155	0.266	0.602
0.675	0.141	0.249	0.606
0.700	0.126	0.232	0.606
0.725	0.112	0.215	0.601
0.750	0.097	0.197	0.588
0.775	0.082	0.180	0.566
0.800	0.068	0.162	0.531
0.825	0.053	0.144	0.480
0.850	0.038	0.127	0.403
0.875	0.023	0.109	0.289
0.900	0.007	0.091	0.116

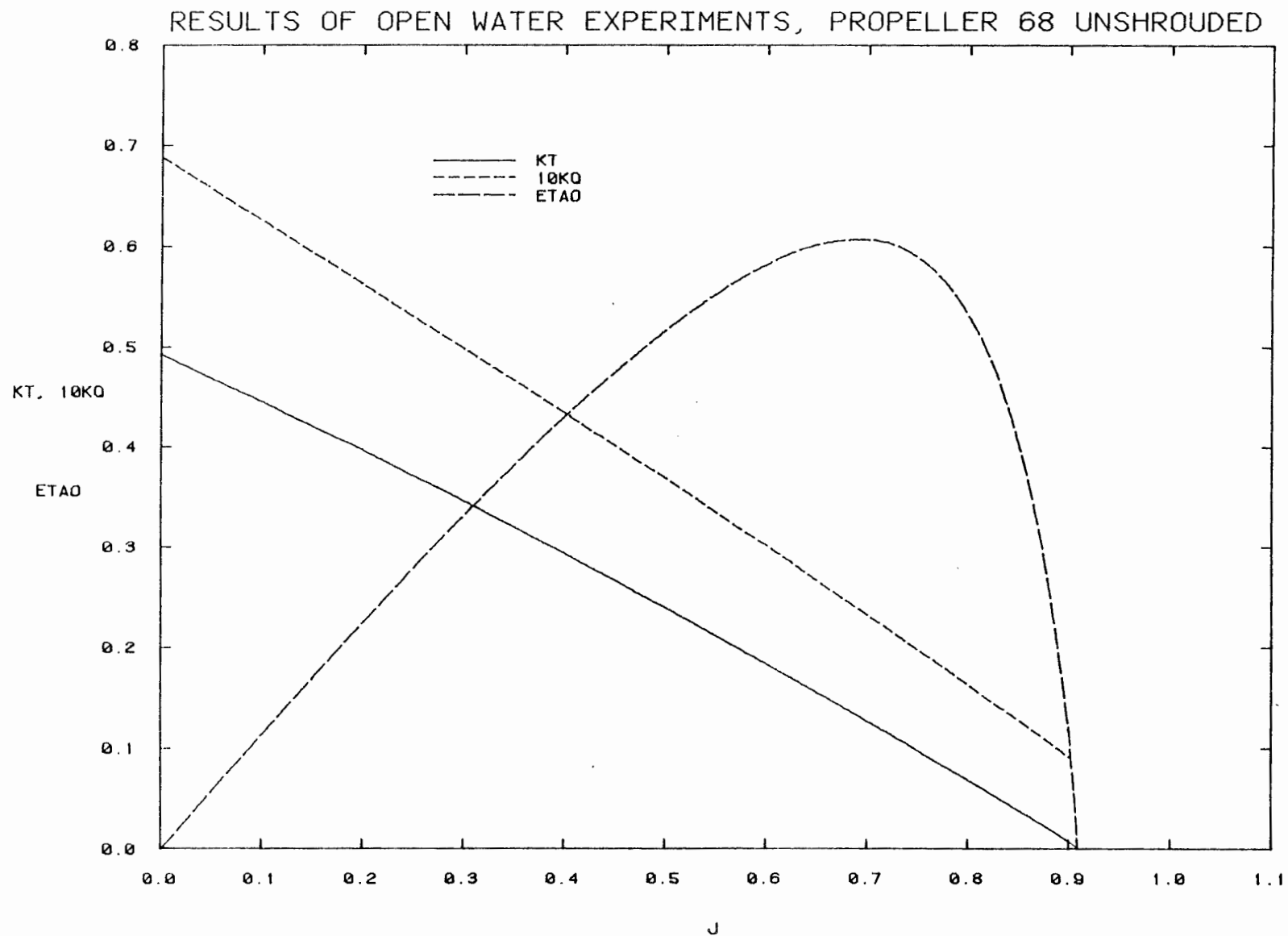
RESULTS OF OPEN WATER TESTS

PROPELLER 68: IN NOZZLE

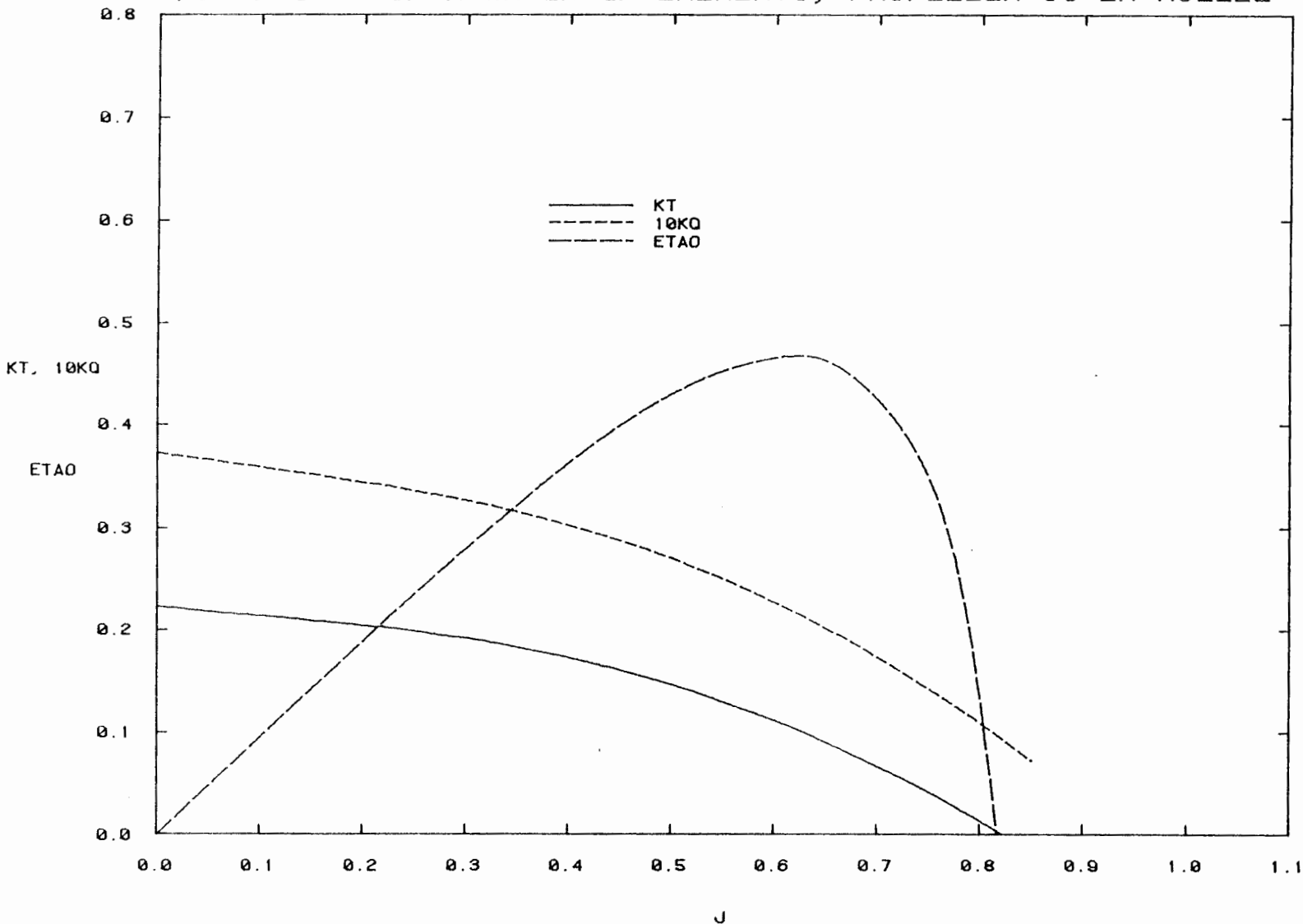
(NO DUCT THRUST MEASURED)

P/D = 0.911

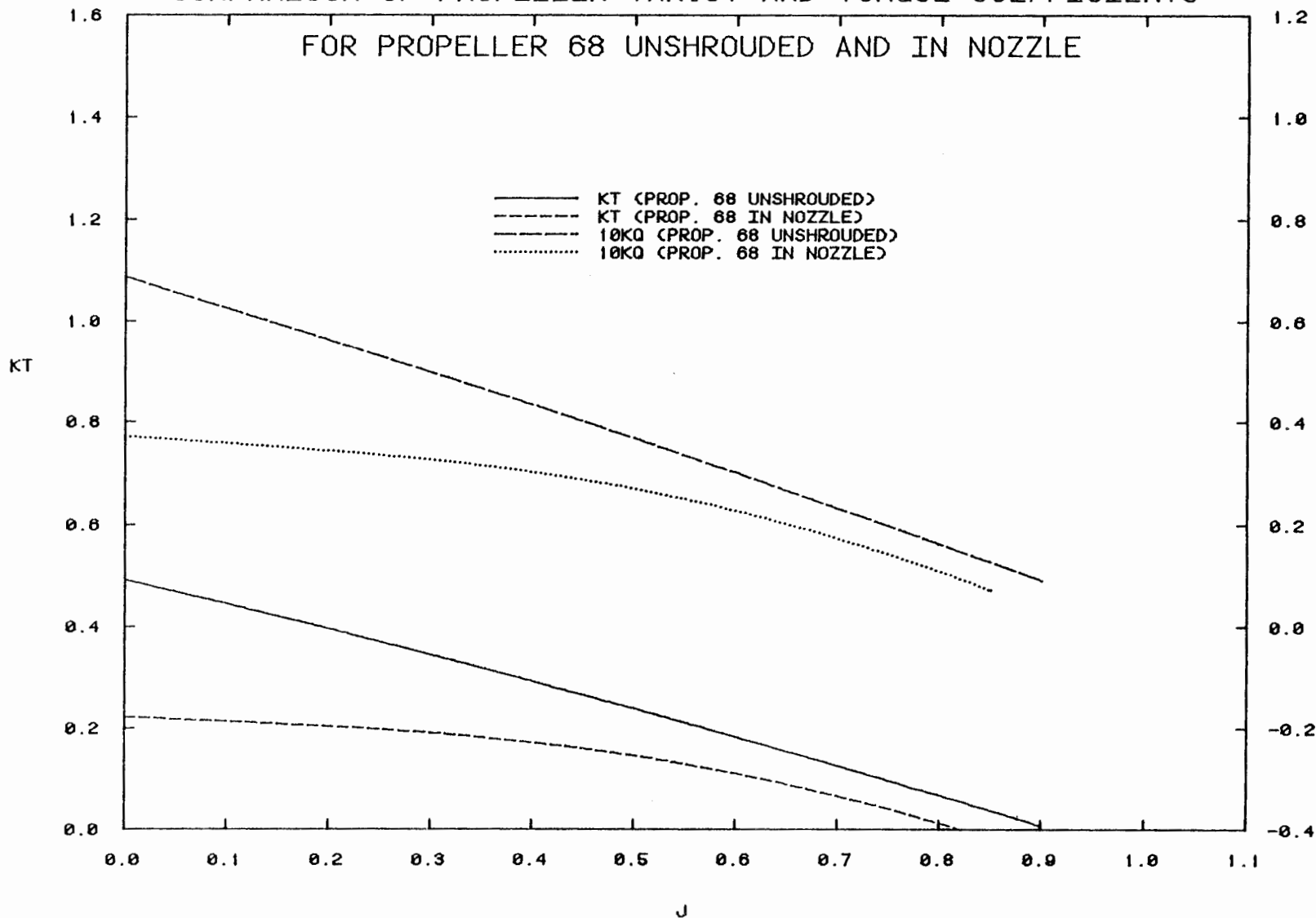
J	KT	10KQ	ETA0
0.000	0.222	0.372	0.000
0.025	0.220	0.368	0.024
0.050	0.217	0.365	0.047
0.075	0.215	0.361	0.071
0.100	0.213	0.358	0.095
0.125	0.211	0.354	0.119
0.150	0.208	0.351	0.141
0.175	0.206	0.347	0.165
0.200	0.203	0.343	0.188
0.225	0.201	0.340	0.212
0.250	0.198	0.335	0.235
0.275	0.194	0.331	0.257
0.300	0.191	0.326	0.280
0.325	0.187	0.321	0.301
0.350	0.182	0.315	0.322
0.375	0.177	0.309	0.342
0.400	0.172	0.302	0.363
0.425	0.166	0.295	0.381
0.450	0.160	0.287	0.399
0.475	0.153	0.279	0.415
0.500	0.146	0.270	0.430
0.525	0.138	0.260	0.443
0.550	0.129	0.250	0.452
0.575	0.120	0.239	0.459
0.600	0.111	0.227	0.466
0.625	0.101	0.215	0.467
0.650	0.090	0.201	0.463
0.675	0.078	0.188	0.446
0.700	0.066	0.173	0.425
0.725	0.054	0.158	0.394
0.750	0.041	0.142	0.345
0.775	0.027	0.126	0.264
0.800	0.013	0.109	0.152
0.825	-0.002	0.091	-0.029
0.850	-0.017	0.072	-0.319



RESULTS OF OPEN WATER EXPERIMENTS, PROPELLER 68 IN NOZZLE



COMPARISON OF PROPELLER THRUST AND TORQUE COEFFICIENTS
FOR PROPELLER 68 UNSHROUDED AND IN NOZZLE



LIMITED
10KQ

Figure A-3

COMPARISON OF PROPELLER OPEN WATER EFFICIENCIES
FOR PROPELLER 68 UNSHROUDED AND IN NOZZLE

