NAVY DEPARTMENT
DAVID TAYLOR MODEL BASIN
WASHINGTON, D.C.

THE CALCULATED PRESSURE DISTRIBUTION ABOUT THE MARK 19 TORPEDO

by

M.A. Garstens, Sc.D.

~~CONFIDENTIAL~~

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PERSONNEL

The calculations were made and the report was written by Dr. M.A. Garstens of the Hydrodynamics Section, under the direction of Comdr. E.A. Wright, USN, and Mr. L. Landweber.

Miss Duncan
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1. Taylor Model Basin Report R-245 entitled, "The Calculated Pressure Distribution About the Mark 19 Torpedo," by M. A. Garstens, was downgraded from Confidential to Unclassified by reference (a).

2. It is requested that the addressees of this letter change the classification marks on all copies of the report in their possession.

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THE CALCULATED PRESSURE DISTRIBUTION ABOUT THE MARK 19 TORPEDO

ABSTRACT

Von Kármán's method for obtaining the pressure distribution about a surface of revolution is briefly outlined and applied to the Mark 19 torpedo. The calculated results are compared with some experimental pressure data available for this torpedo form.

INTRODUCTION

In connection with several projects for the Bureau of Ordnance, information on the pressure distribution around the Mark 19 torpedo form has been requested by various agencies. It is the intention of the David Taylor Model Basin to conduct pressure measurements on this torpedo form either in one of the model basins or in the circulating water channel when this latter facility has been calibrated and is in operation.* In the meantime, the pressure distribution at zero angle of yaw has been calculated.

If potential flow is assumed, the pressure distribution about an arbitrary surface of revolution can be calculated. Since in actual flow, a boundary layer forms and the flow separates at the after end of the body, the actual pressure will deviate from the computed distribution.

In the present instance it was required to compute the pressure distribution about the surface of the Mark 19 torpedo. The method chosen for obtaining this approximation was developed by von Kármán (1).**

METHOD OF CALCULATION

The basis of the von Kármán method is the distribution of source and sink segments along the axis of the torpedo in a manner to produce streamline motion corresponding to that about the torpedo itself. The zero streamline is made to coincide with the surface of the body and the strengths of the source and sink segments are determined by the condition that the zero streamline is the bounding surface of the body. This assumes, of course, no cavitation and no separation of flow.

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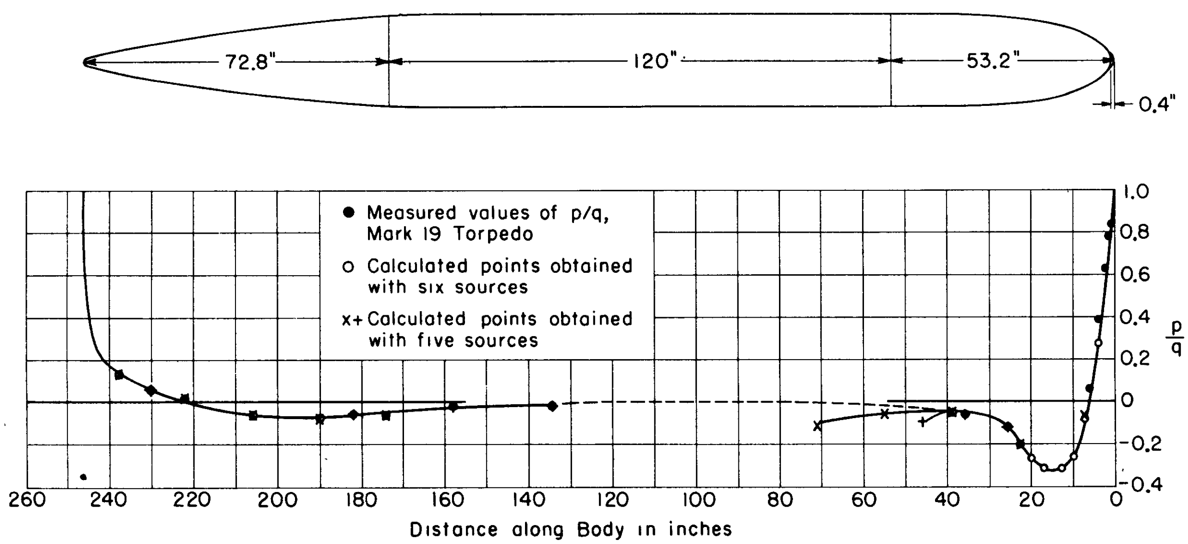
* The present report was first issued in preliminary form in February 1944.

Since then, a few pressure distributions on model torpedo forms have been measured in the high speed water tunnel at the California Institute of Technology and in the new variable pressure water tunnel at the Iowa Institute of Hydraulic Research.

** Numbers in parentheses indicate references on page 5 of this report.

This condition results in n linear equations expressed in terms of the n unknown strengths Z_i $(i = 1, \ldots n)$ of sinks and sources and the known coordinates of the surface. After solving these equations for the unknown strengths Z_i, the stream function can be set up, from which the velocity and pressure distributions are obtained.

To obtain reasonable accuracy, it is necessary to have a sufficiently dense distribution of sources in the regions of large curvature, for example at the head and the tail. However, if we limit ourselves to five or six sources, then the denser the distribution in the curved portions, the



Offsets of Mark 19 Torpedo			
Distance from Nose inches	Offset inches	Distance from Nose inches	Offset inches
1.80	4.46	192.01	19.66
3.68	9.10	196.01	19.00
6.80	13.70	200.01	18.18
9.93	16.56	204.01	17.28
13.05	19.04	205.87	16.78
16.17	19.88	207.99	16.16
19.30	20.66	211.99	15.04
20.67	20.72	215.99	13.82
47.19	21.00	219.99	12.44
53.19	21.04	223.99	11.00
173.19	21.04	227.99	9.54
176.01	20.96	231.99	8.00
180.01	20.84	235.99	6.46
184.01	20.60	239.61	5.25
188.01	20.18		

v is the velocity of the body

ρ is the mass density of the fluid

$q = \frac{\rho}{2} v^2$

p is the pressure along the body

The measured values of p/q are for the Mark 17 torpedo. However the Mark 19 torpedo has the same nose shape as the Mark 17 torpedo except for a 0.4-inch projection at the nose of the Mark 19 torpedo.

Figure 1 - Calculated Pressure Distribution on the Mark 19 Torpedo at Zero Yaw

smaller is the portion of the body covered by the computation. Increasing the number of sources beyond six increases to unwieldy proportions both the number of equations to be solved and the associated computational work. Therefore, to form some idea of the pressure distribution along the parallel middlebody of the torpedo, the same number of sources, overlapping at the origin, were spread over varying lengths of the torpedo axis. The envelope of the curves thus obtained indicated the pressure trend toward the mid-length, as indicated by the broken line on Figure 1.

CALCULATED RESULTS

At the forward end of the torpedo, where three sets of sources and sinks were used, the resultant pressure-distribution curves coincided closely up to a point 40 inches from the nose and then diverged. At the after end, where two overlapping sets were used, coincidence was complete over the region covered in common by both, that is, up to a point 72 inches from the end of the tail. The pressure distributions for each set of sources and sinks are indicated in Tables 1 and 2, and in Figure 1.

TABLE 1

Values of $\frac{p}{(\rho/2)v^2}$* at the Forward End of the Mark 19 Torpedo

Distance from Nose inches	Six Sources and Sinks	Five Sources and Sinks	Five Sources and Sinks
4.0	+0.28		
7.2	-0.09	-0.08	-0.06
10.4	-0.26		
13.6	-0.31		
16.8	-0.31	-0.30	
20.0	-0.26		
23.2			-0.20
26.4		-0.13	
36.0		-0.06	
39.2			-0.04
45.6		-0.10	
55.2			-0.05
71.2			-0.10

* For a definition of these symbols, see Figure 1.

TABLE 2

Values of $\frac{p}{(\rho/2)v^2}$ at the After End of the Mark 19 Torpedo

Distance from Nose inches	Five Sources and Sinks	Five Sources and Sinks
134	-0.01	
158	-0.02	
174		-0.05
182	-0.06	
190		-0.08
206	-0.05	-0.05
222		+0.01
230	+0.05	
238		+0.12

EXPERIMENTAL RESULTS

At the nose of the Mark 19 torpedo, the button-shaped nose piece projects 0.4 inch. The first computed point, however, is 4 inches aft of the tip of the nose piece. In the region extending from this first computed point to the tip of the projection where p/q is equal to 1, the pressure distribution was obtained by fairing in a curve.

With the projection removed, the Mark 19 torpedo has the same nose shape as the Mark 17 torpedo. Experimental values of $\frac{p}{(\rho/2)v^2}$ along the Mark 17 torpedo, obtained at the Taylor Model Basin in connection with another project, are shown in Figure 1 and in Table 3.

TABLE 3

Experimental Values of $\frac{p}{(\rho/2)v^2}$ on the Nose of the Mark 19 Torpedo

Distance from Nose,* inches	0.63	1.18	2.13	3.97	6.21
$\frac{p}{(\rho/2)v^2}$	0.85	0.78	0.63	0.39	0.07

* The distances from the nose indicated in Table 3 are 0.4 inch greater than actually measured on the Mark 17 torpedo to give the proper correspondence of points with the Mark 19 torpedo.

DISCUSSION

It is important to keep in mind that the pressure distribution was computed on the assumption of potential flow around the body. Since a boundary layer forms and the flow separates at the after end of the body, the actual pressure will deviate from the computed distribution.

Some idea of this divergence of pressure due to non-potential flow can be obtained from Figure 2, which is reproduced from an article by G. Fuhrmann (2). This figure shows the computed and the measured pressure distribution along the surface of an airship hull. The correspondence is good toward the forward end of the airship. At the after end, however, the actual pressure does not attain the computed maximum but rises to a value of about 15 per cent of the computed maximum.

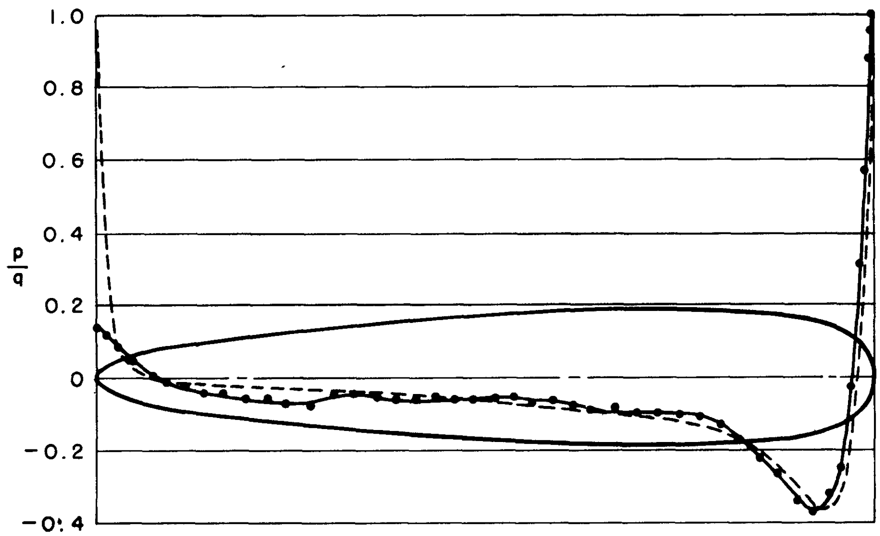


Figure 2 - Distribution of Pressure about a Streamlined Body (After Fuhrmann)

The broken lines represent computed values; the points measured values.

REFERENCES

(1) "Berechnung der Druckverteilung an Luftschiffkörpern" (Calculation of Pressure Distribution on Airship Hulls) by Theodor von Kármán, Abhandlungen aus dem Aerodynamischen Institut an der Technischen Hochschule Aachen, 1927, No. 6. Translation in NACA Technical Memorandum 574, July 1930.

(2) "Theoretische und experimentelle Untersuchungen an Ballonmodellen" (Theoretical and Experimental Investigations on Balloon Models) by Georg Fuhrmann, Diss., Göttingen, 1912. Published in Jahrbuch der Motorluftschiff-Studien-Gesellschaft, 1911-12.