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THE UNIVERSITY OF NEW SOUTH WALES

WATER RESEARCH LABORATORY

REPORT No. 5.

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by

H.R. Vallentine.

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The University of New South Wales

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REPORT ON

TESTS ON VENTURI METERS AND DIFFERENTIAL PRESSURE GAUGES

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TESTS ON VENTURI METERS AND DIFFERENTIAL PRESSURE GAUGES

INTRODUCTION:

The following tests and calibrations were undertaken by the Water Research Laboratory on behalf of the Cockatoo Docks and Engineering Co. Pty.Ltd. at the request of Mr. F.L.Harrison, Assistant Naval Architect of the Company.

(i) Calibration of two KDG Differential Pressure Gauges Serial Numbers 5810456/1 and5810456/3, herein referred to as Gauges Nos.1 and 3 respectively.

(ii) Testing of five Admiralty pattern venturi meters (two 1-1/4", two 2" and one 3") under British Standard Flow code conditions for conformity with the differential head-flow performance rating chart and formulae (Admiralty Drawings Nos.DNC 15/1064, 15/1065).

(iii) Testing of one 2" and one 3" Admiralty pattern venturi meter connected with associated pipework as in a proposed installation, for conformity with the differential head-flow characteristics of the same meters tested under British Standard Flow Code conditions.

SUMMARY OF RESULTS:

(i) Gauge No.1 had a positive error ranging from 0.3 inch at 10 inches to 1.0 inch at 45 inches. Gauge No.3 had a negative error of the order of -1.0 inch, with a maximum value of -1.6 inch in the range 16 to 30 inches.

(ii) The venturi meters tests showed that the discharges at any given differential head as read on a water manometer were consistently lower than the Admiralty chart figures by the following amounts:-

3" meter	28	percent approx.
2" meter	19	" "
1-1/4 meter	15	" "

There was no detectable difference in the performances of the two 2" meters, nor in that of the two 1-1/4" meters. The difference in percentages for the different meters is attributed to their lack of geometrical similarity, since all have the same throat length.

(iii) The differential head-flow relationship for the 2" and 3" meters tested in the "in-situ" position with the differential heads read on a water manometer and on Gauges Nos.1 and 2 yielded discharge values generally within 4 per cent of those obtained in the tests under standard conditions.

1. Differential Pressure Gauges

The differential pressure gauges were connected to a venturi meter by means of 3-way branch connections in such a manner that the pressure drop could be read on the two gauges and on a differential water manometer simultaneously. The errors in the gauge readings, referred to the water manometer readings were as shown in Fig.1. The pressure tapping was approximately 14 lb. per sq. inch gauge, at the upstream pressure tapping.

Gauge No.1 readings have a positive error ranging from about 0.3 inch at 10 inches to about 1.0 inch at 45 inches. The error generally is without 0-3 percent of the manometer values, being less with a rising gauge.

Gauge No.2 readings have a negative error of the order of -1.0 inch, with a maximum value of -1.6 inch in the range 16 to 30 inches. Little difference is detectable between rising and falling gauge readings.

For reliable gauge readings, care was necessary to ensure that the leads to the gauges were full of water and that the faces of the meters were tapped firmly with the finger prior to taking each reading.

2. Venturi Meters

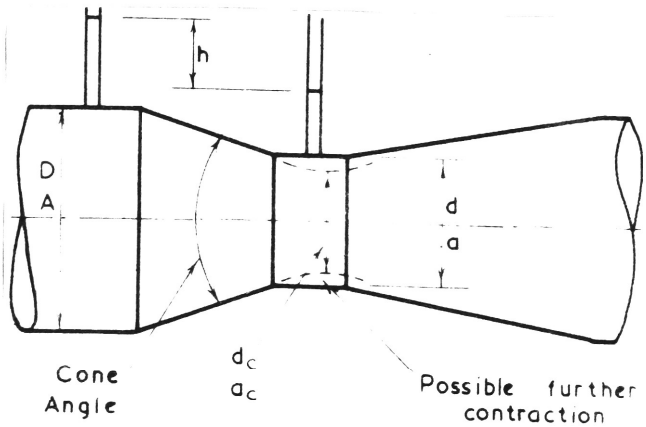
The venturi meters were tested individually with approach conditions in accordance with British Standard Code BS 1042:1943 "Flow Measurement". The flow rates were determined by orifice plates conforming to the above code and checked by calibration.

The differential head-discharge curves for the three sizes 3, 4 and 5 are plotted on the attached graph (Fig.2). The experimental curves are in all cases to the left of the corresponding Admiralty performance rating curves. The results for meters A and B of size 3 are in close agreement with each other, as are those for A and B of size 4.

In the Venturi meter equation

$$Q = C \frac{a}{\sqrt{1-\left(\frac{a}{A}\right)^2}} \sqrt{2gh}$$

where C = a discharge coefficient
a = throat area
A = approach pipe area
h = differential head
Q = rate of flow



VENTURI METER

The Admiralty Chart is based on a value C = 1.0. The experimental values are as follows:-

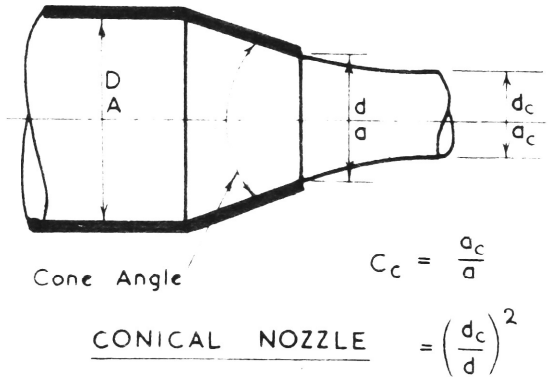
Size 3 meter	(pipe dia.	D = 1.25 in)	C = 0.85
" 4 "	" "	D = 2.00 ")	C = 0.81
" 5 "	" "	D = 3.00 ")	C = 0.72

The British Standard Flow Code Venturi meter has rounded corners at the entrance and exit to the conical section and a cone angle of 21°. Its C value is approximately C = 0.98. The Admiralty pattern has sharp corners and a cone angle of 82° so that one would expect its C value to be somewhere between that for an orifice plate (i.e. cone angle 180°), for which C = 0.62 (approx) and that for the British Standard meter's C = 0.98.

The contraction coefficient C_c for a free jet issuing from a conical nozzle at the end of a pipe can be estimated (see Table I, p.34 of "Engineering Hydraulics" edited by Rouse) and for an 82° cone angle, with $\frac{d}{D} = 0.577$, as in the Admiralty venturi,

$C_c = \frac{a_c}{a} = 0.77$, whence the theoretical discharge coefficient

$$C_d = \frac{C_c}{\sqrt{1 - C_c^2 \left(\frac{d}{D}\right)^4}} = 0.79$$



In the Venturi meter equation, if

$$\frac{C}{\sqrt{1 - \left(\frac{a}{A}\right)^2}} = 0.79,$$

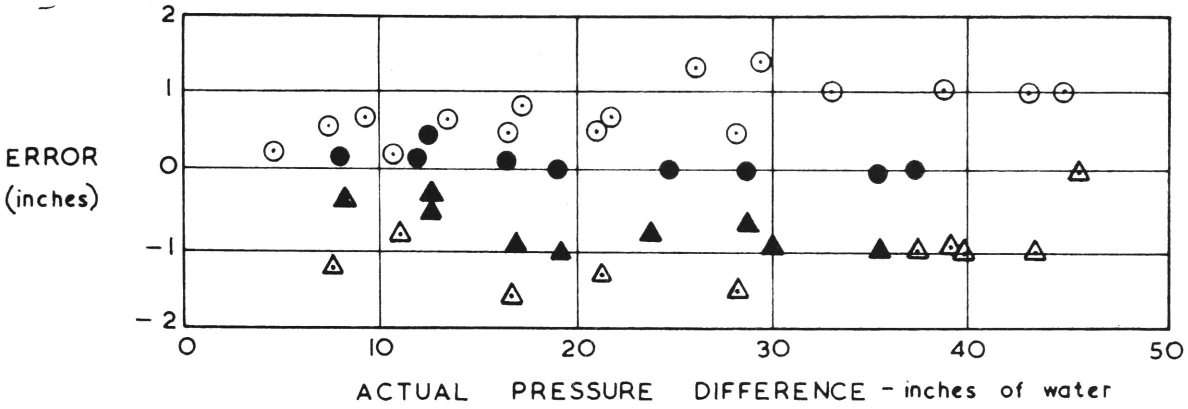
C = 0.75 for the Admiralty meters. This would be a rough approximation for these meters provided that the throat pressure were measured at the section of maximum jet contraction. However, the throat length of the Admiralty pattern is very short (3/8") and is constant for all sizes so that full contraction is not likely to be achieved in the throat. This lack of geometrical similarity (which is achieved in the British Standard pattern where the throat length and diameter are equal) accounts for the variation of C with size of the Admiralty meters.

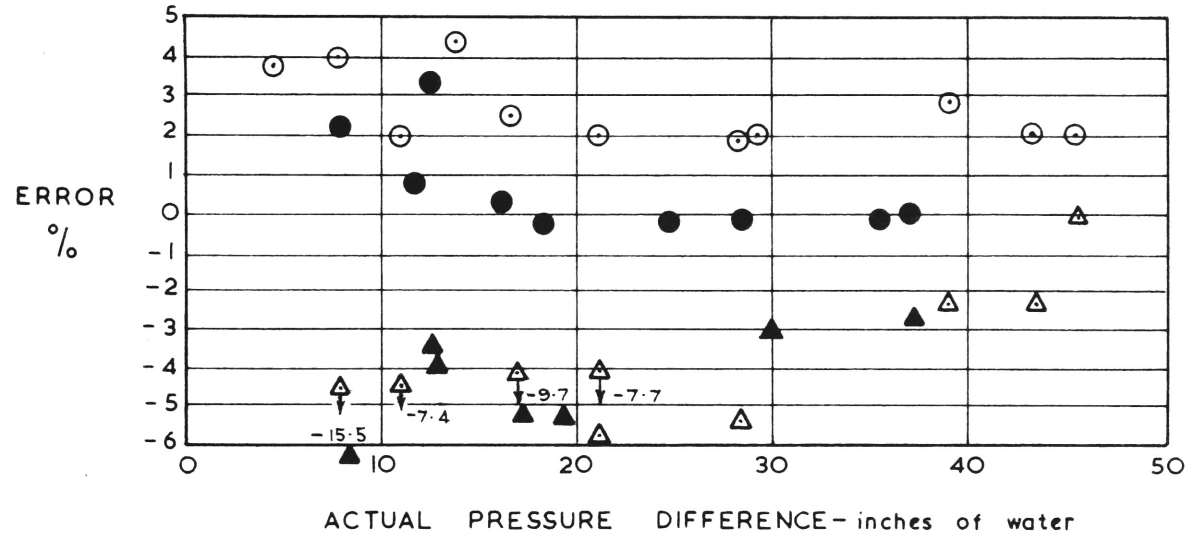
It is evident that the Admiralty rating chart (Drawing DNC 15/1065) is in error, as are the formulae upon which it is based, shown in the last column of the first table on Drawing DNC15/1064.

3. Venturi Meters "in situ".

The 2" and 3" venturi meters were tested with the curved upstream piping attached as supplied. The experimental points with the differential head measured by means of a water manometer are plotted in Fig. 3a, which also shows the Admiralty curve and the curve obtained by test under British Standard Flow Code conditions. It is evident that the "in situ" discharge figures agree with the British Standard Conditions curves within ± 4 per cent over the range of tests.

The curves obtained by the use of Differential Gauges Nos. 1 and 3 with the 2" venturi "in situ" arrangement are shown in Fig. 3b. These tests were made with a pressure at the upstream tapping of approximately 14 lb. per sq. in. gauge. The gauge readings conformed with the British Standard Conditions curves within ± 4 per cent over the range of tests.





GAUGE No.	RISING	FALLING
1	●	⊙
3	▲	△

Errors plotted against true pressure differences.

FIGURE No. 1.

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DIFFERENTIAL GAUGE TESTS

Scale:	Date: 22·4·59
Drawn: H.R.Vallentine	CE-E-2519
Traced: P.A.	
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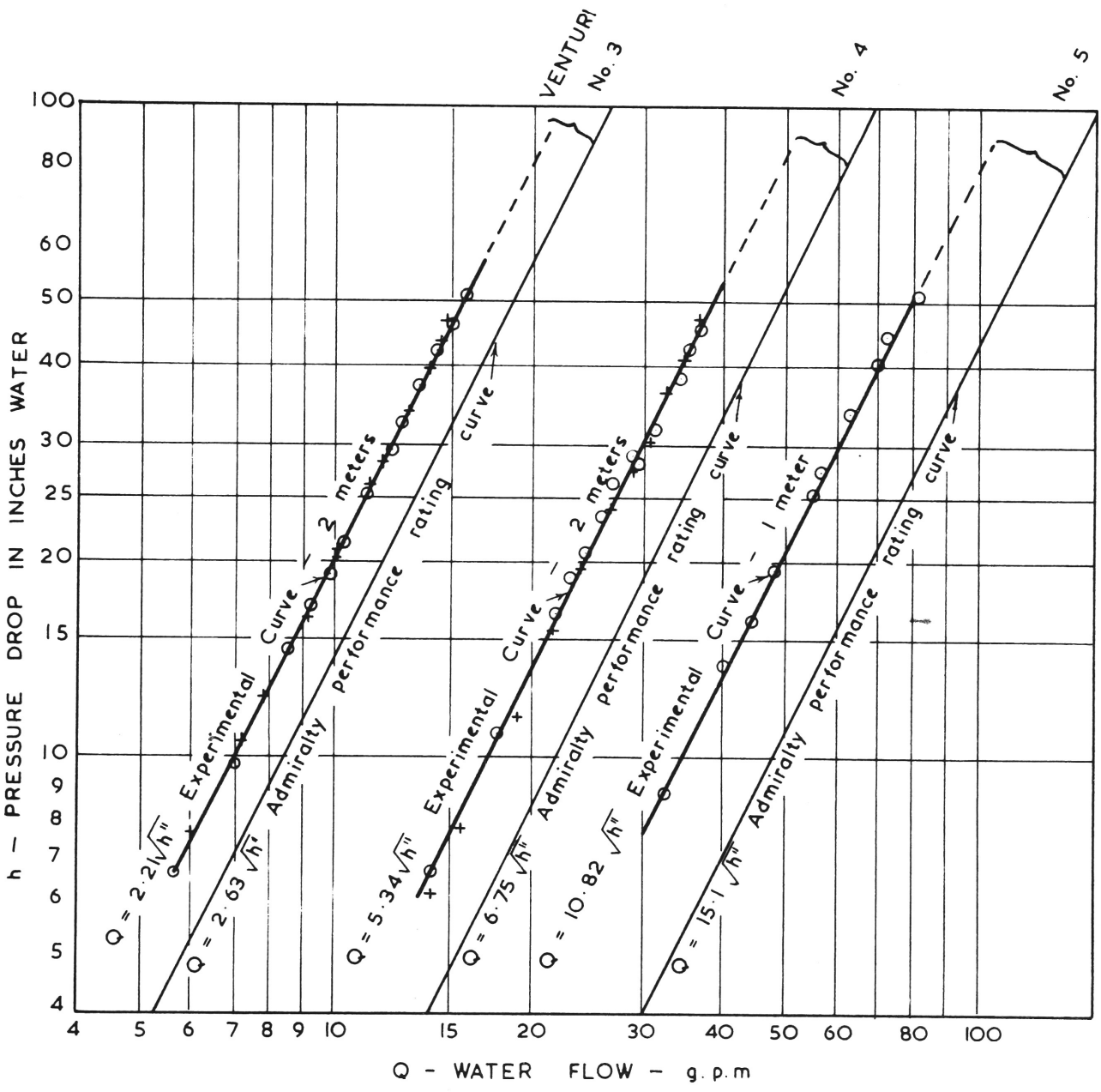
COMPARISON OF EXPERIMENTAL CURVES WITH ADMIRALTY PERFORMANCE RATING CURVES



Based on Admiralty Drawing No. D.N.C 15/1065

FIGURE No. 2.

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VENTURI METER TESTS	Scale:	Date: 22 4 59
	Drawn: H.R.Vallentine	CE-E-2520
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