NEW ZEALAND AGRICULTURAL ENGINEERING INSTITUTE

LIQUID MANURE PUMPS: PROCEDURE FOR CLEAN WATER HYDRAULIC TESTING

PROJECT REPORT P/12

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PROCEDURE FOR CLEAN WATER
HYDRAULIC TESTING

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1. INTRODUCTION

In designing a waste handling system with a pump as a component, information on the hydraulic performance characteristics of the pump is required. The objective of these tests is to determine these hydraulic characteristics, using clean water as the pumping medium.

For typical slurries from washed down yards, the hydraulic performance of a pump is sufficiently similar to clean water for design purposes (Dakers, 1975).

2. TEST PROCEDURE

The tests are carried out in accordance with British Standard 599:1966 "Methods for testing pumps" Class C, with the following exceptions:

(a) Flow rate is measured using a calibrated orifice meter.

(b) Inlet pressure is not measured but allowance is made for this, where applicable, in the analysis of the data.

2.1 MEASUREMENT

2.1.1 Outlet gauge pressure (P_g)

The outlet pressure is measured using a calibrated Bourdon type pressure gauge (0 - 700 kPa) fitted with a gauge saver. A single tapping was used. Tapping diameter and its location are as specified in B.S. 599: 1966.

2.1.2 Pump discharge (Q)

Pump discharge is measured using an orifice meter. Orifice diameter is selected according to the range of flows required. The orifice meter (complete) was calibrated at the Engineering School (Ilam) giving the following flow equations:

Orifice Diameter	Equation
25.4 mm (1 in.)	$Q = 0.573\ H^{.495}$ $r = 0.999$
38.1 mm (1½ in.)	$Q = 1.256\ H^{.500}$ $r = 0.999$
50.8 mm (2 in.)	$Q = 2.318\ H^{.496}$ $r = 0.999$

where Q is the pump discharge (m^3/hr)

H is the pressure difference across the orifice plate, manometer reading (mm Hg)

r is the correlation coefficient found by least squares fitting to the logarithm of the data

Pressure difference across the orifice plate is measured using a mercury manometer.

2.1.3 Electrical power and current input

Power input to the pump motor (P_i) is measured using the two wattmeter method. A Ferranti DPM 1999 Wattmeter is used. The total power input is given directly by this meter. Current is measured in the two phases and the average is taken. Voltage across each phase can also be measured.

The electrical measuring equipment was calibrated by the Municipal Electricity Department (Christchurch) and meets the specification requirements.

2.2 EQUIPMENT LAYOUT

The test equipment is set up as illustrated in Figures 1, 2 and 3. The water level is maintained at a constant level during tests.

2.3 ANALYSIS OF DATA

2.3.1 Pump Total Head (H_T)

British Standard 599:1966 defines pump total head as "the head imparted to the liquid by the pump". It is the difference between total outlet head (Ho) and total inlet head (H_i). Thus:

$$H_T = Ho - H_i \qquad \ldots (3.1)$$

$$H_T = \frac{P_g}{9.81} + \frac{Vo^2}{19.62} + Z + h_{Li} + h_e \qquad \ldots (3.2)$$

Where

H_T is pump total head

Pg is the measured outlet gauge pressure (kPa)

Vo is the outlet velocity (m/sec)

Z is the height of the outlet pressure gauge above average water level (m)

h_{Li} is the energy loss due to the pipe and fittings of the suction section (m)

h_e is the entrance loss at the suction inlet (m)

NOTE: For cellar type pumps, h_{Li} does not apply, and h_e can often be ignored.

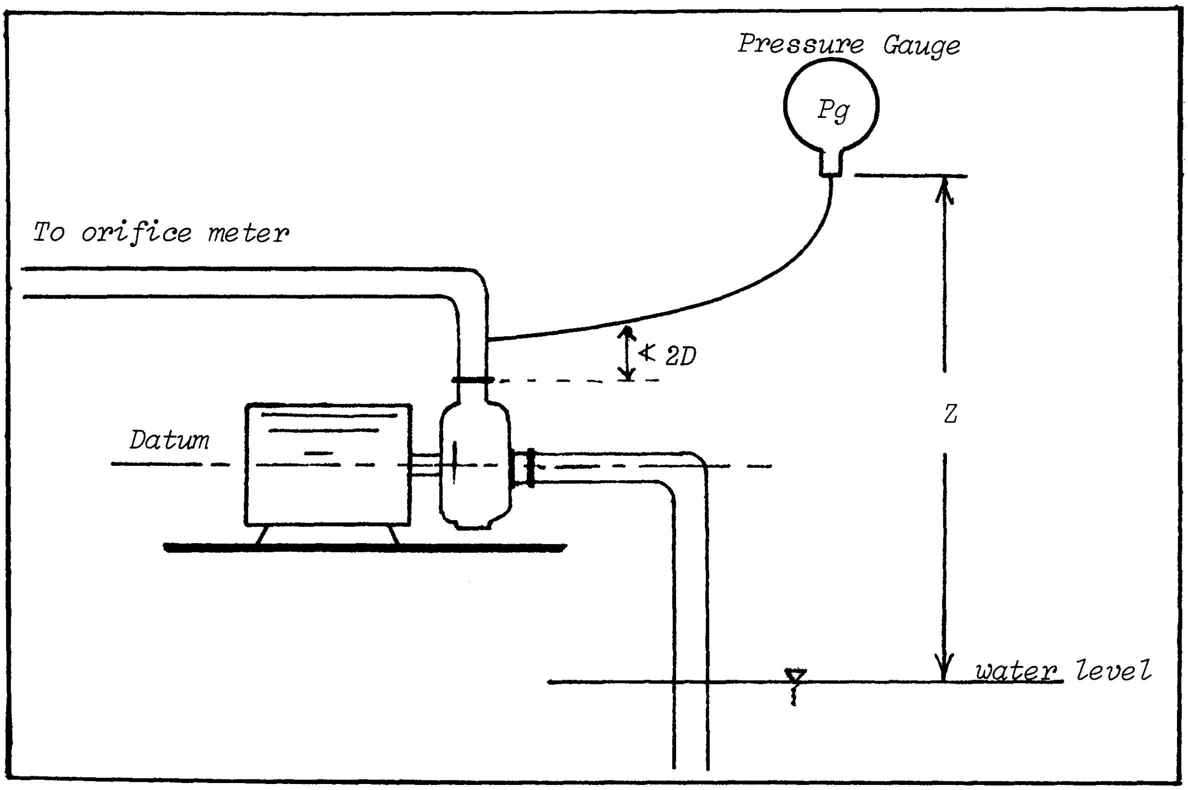

Figure 1. Surface mounted pump.

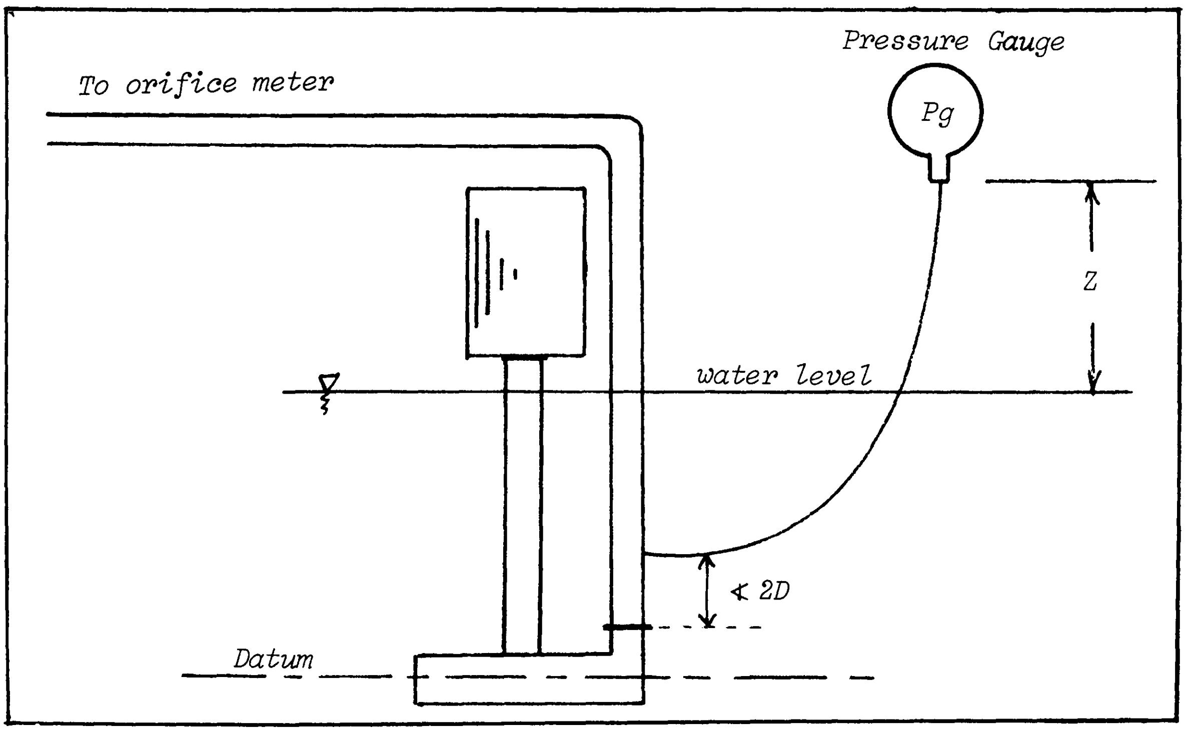

Figure 2. Cellar-type pump.

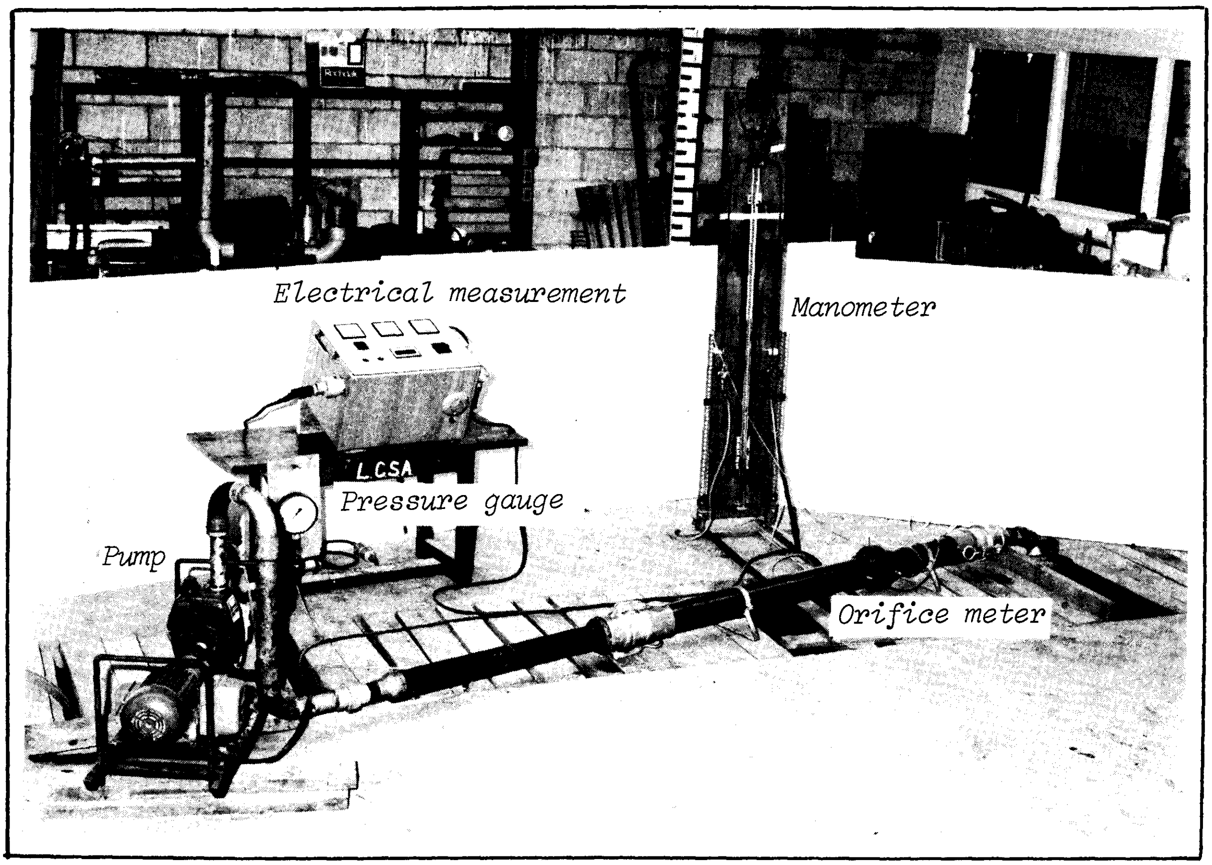

Figure 3. Pump under test

2.3.2 Efficiency (η)

The efficiency term in these tests relates to the overall efficiency of the pump-motor unit. It is the ratio (expressed as a percentage) of the water power output (Pw in kW) to the electrical power input (P_i in kW)

where

$$Pw = 2{\cdot}72 . QH_T . 10^{-3} \quad \ldots (3.3)$$

$$\text{Efficiency (\%)} = Pw/P_i . 100$$

2.3.3 Power factor (Cos Ø)

$$\text{Cos } Ø = \left[1/ \quad 1+3\left(\frac{1-y}{1+y}\right)^2 \right]^{\frac{1}{2}}$$

where $y = W_1 / W_2$

and W_1 and W_2 are the wattmeter readings (kW).

3. PRESENTATION OF RESULTS

The following relationships are expressed graphically:

(a) Pump total head, H_T (m), versus pump discharge, Q (m^3/hr).

(b) Overall efficiency (η), as a percentage, versus pump discharge, Q (m^3/hr).

(c) Electric power consumption, P_i (kW), versus pump discharge, Q (m^3/hr).

(d) Where applicable the point of current overload as related to the specified motor current rating is noted.

REFERENCES

B. S. 599: 1966 Methods of testing pumps.

Dakers, A. J. (1975) Pumping Farm Waste
Proc. M. A. F. Agricultural Engineering Conference 1975.

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