RURAL WATERSUPPLY : PUMP AND ENGINE SELECTION

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Synopsis

The data required for selection of a water pump in a rural water supply has been given. Current figures for calculating the demand are used. From the discharge required, topography of the area and supply pipe characteristics the power required, feasible pump and engine are proposed.

1. Introduction

As in many engineering fields, a variety of designs and equipment standards have been introduced into Tanzania especially in rural water supply schemes. The designs are as many as the countries they are imported from. It is common to see quite a number of designs, of storage tanks, domestic points, pumphouse designs, water consumption data etc. been used in many installations. The Ministry of Water Energy and Minerals (MAJI) has tried to standardize, to simplify procurement of pipe fittings, pumps and engines. This is advantageous in that;

a) it reduces the time for design of a scheme,
b) simplifies procurement of materials and spareparts
c) simplifies operation and maintenance of machines.

Nevertheless, the Water Supply Engineers in the region and districts have to assess every project on its own merit and make proposals for the materials required. This in itself is a tough task as one must know the type and ratings of pumps and engines available on the market, and their performance efficiency to be as high and economical as possible. Cases have been reported where engines ordered do not match the accompanying pumps, thus rendering the whole villagers efforts and enthusiasm fruitless.

Following is a simple method of determining the pump size and engine capacity required, given the demands of a village to be supplied. The pump and pipeline characteristics used are obtained and reproduced by the courtesy of Jos Hansen & Soehne (T) Limited, P.O. Box 9521, Dar es Salaam, Tel. 21645, dealers of KSB pumps.

2. Design Procedure

2.1 Guidelines to present MAJI practice

The per capita design water consumption from a domestic point supply in rural Tanzanian village is taken as 30 1/d

Population growth figures: 10 years increase by 50%
20 years increase by 100%.

The multiplification factors for the population growth can be alarming compared to the national growth of about 2.7%. It is greatly influenced by probable migration of village population as the presence of reliable water source might enhance migration.

2.2 Determination of Water Demand - Peak Hours

Peak hours demand is to be considered in the design. Normally, it can be taken as 3 hours in the early mornings and late afternoons.

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Therefore the design value of peakflow in the distribution system would be

$$\frac{\text{Daily Demand } (m^3)}{6 \text{ hrs. peak hours}}$$

Cattle demand has to be dtermined if the village has a trough. In case the village has a school, hospital/dispensary or a market place, the demands of these places have to be taken into consideration. Minimum pressure required at domestic points: 5–7 m water head. Maximum pressure in distribution system 60 m if possible, to enable the use of class B pipes. Pumping hours at source: 10–12 hrs per day.

3. Determination of Required Centrifugal Pump

3.1 Problem details

For the purposes of the design, the assumption is that the total demand required as calculated by the above estimations is 140 m^3/h. The source is 520 m away from storage tank, at elevation 1945 masl., Air temperature: 40°C, Humidity: 90%. To maintain the required head at domestic point, the storage tank will be concrete, erected at the village at elevation 1972 m.a.s. From the water analysis carried out, results are that it is potabble, non-aggrassive and free from abrasive particles which might destroy our pump impeller or the supply pipeline. Since no electricity is supplied to the village, we have to power the pump by a diesel engine. Supply pipeline will be galvanized steel.

3.2 Determination of required pumping head

From the chart in fig.1, below the velocity in the pipe should not exceed 2.4 m/s.

For pipes with bores 5/8 to 10 in. = 15 to 250 mm and a flow Q of 0.5 to 500 m³/h

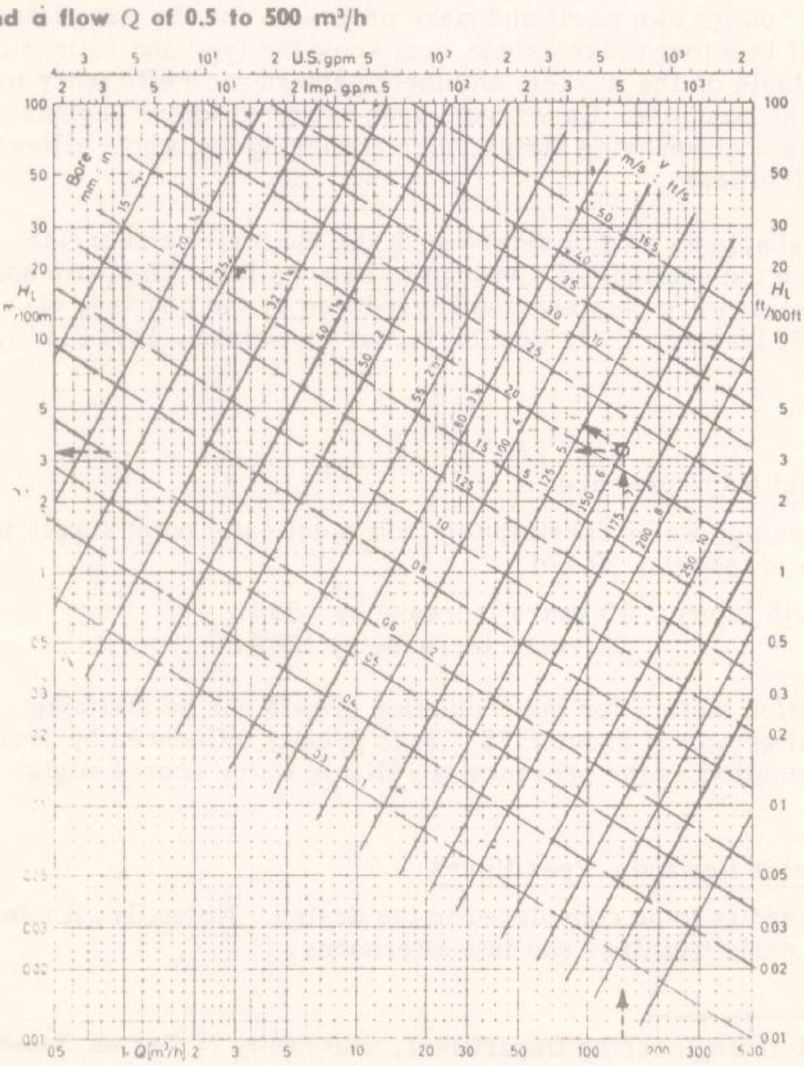

Fig. 1

The velocity of flow should be based on the reduced area resulting from internal deposits.
Example: Discharge Q = 140 m³/h, new cast-iron pipe, bore diameter = 6 in. = 150 mm
From the chart, loss of head H_l = 3.25 m w.g. per 100 m run, flow velocity v = 2.2 m/s

Therefore the pipe diameter selected is 150 mm. This pipe selected should give a velocity discharge of 2.2 m/s. Frictional losses: 3.25 m length of pipe for every 100 length. Local losses in pipeline occur at bends and valves. An average value of loss for each bend or valve equal 5 m of straight pipe. Assuming that we use 1 non-return valve and there are 4 bends, the total calculated equivalent pipelength is 520 + 5 x 5 = 545 m. Friction loss will be calculated on 545 m length,

3.3 Suction pipe and head

Length of suction pipe: 12 m; Suction head should not exceed 5.2 m. The total pumping head will therefore be static head + suction head + Friction losses.

$$1972 - 1945 + 502 + \frac{545 \times 3.25}{100} = 49.9 \text{ m say } 50 \text{ m.}$$

The suction pide diameter 200 mm is used. From chart in figure 1, velocity in pipe = 1.25 m/s ; say 1.3 m/s. Frictional losses: 0.8 m per 100 m length of pipe. Let also, 1 footvalve, 1 gatevalve, and 1 bend used as shown in figure 3; adding up the calculation length of suction pipe to 12 + 3 x 5 = 27 m.

Therefore frictionloss on suction pipe: $\frac{27 \times 0.8}{100} = 0.2$ m.

The whole system sums up the losses 49.9 + 0.2 = 50.1

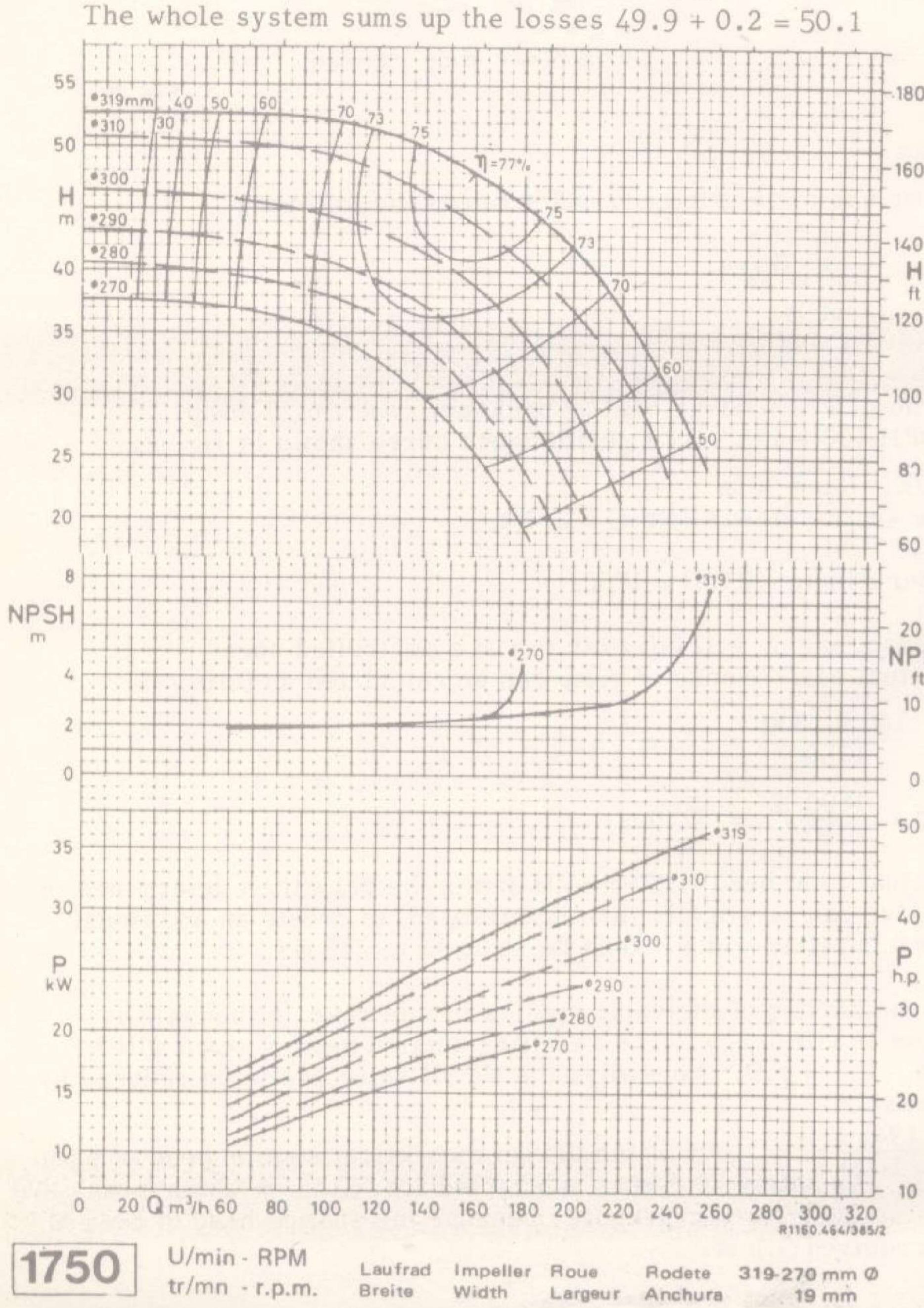

Fig. 2

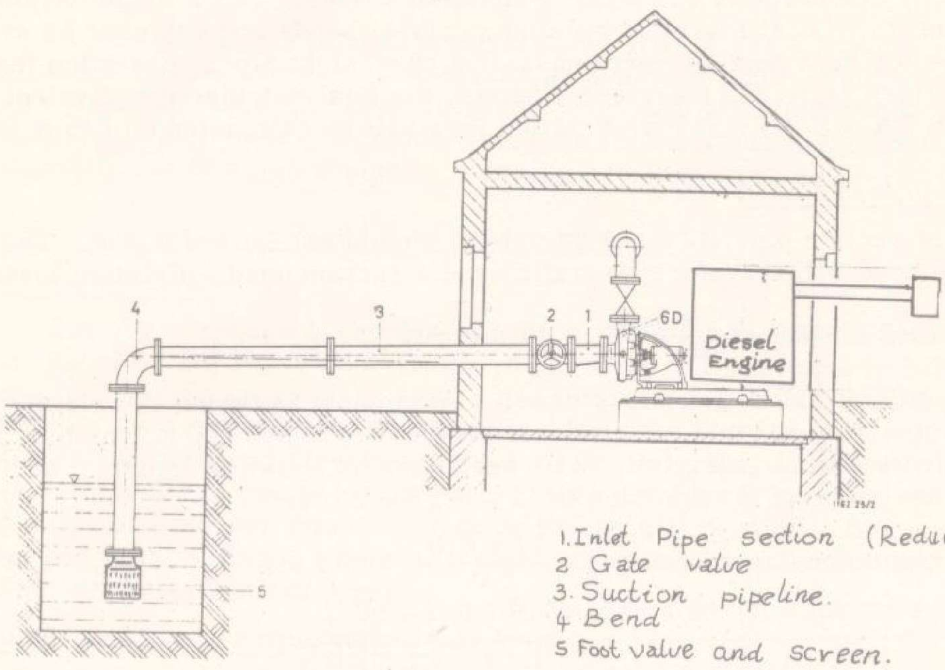

Fig. 3

4. Selection of pump

Now the pump has to be selected, which fulfils the following requirements:

Discharge Q = 140 m^3/h
Total head 50 m
Suction head 5.4 m

A possible pump would be a KSB low pressure contrifugal pump. Pump type: ETANORM 100 - 135 with a performance curve shown in fig. 2.

Q = 140 m^3/h. Head 50 m
Net positive suction Head (NPSH) = 2.1 m
Efficiency = 75%
Rotations per minute: (RPM) = 1750

Since the diesel engine will however run at a controlled speed of 1800 RPM, the actual performance of pump can be calculated as follows:

Discharge: $\frac{140 \times 1800}{1750} = 144\ m^3/h.$

Head: $50 \times (\frac{1800}{1750})^2 = 52.9\ m.$

Since the actual total head is 50 m to maintain the velocities determined in the pipe, the gatevalve can be slightly throttled (closed) to create an additional loss of 2.9 m or pump impeller width should be reduced to 215 mm.

Therefore, the closing of the valve applies in this case, although it is associated with a loss in efficiency. The resulting suction head of pump will be 10 m - NPSH = 10 m - 2.1 = 7.9. Normally, the NPSH value has to be reduced by 1m for every 1000 masl.

Therefore, $\frac{1945 \times 1}{1000} = 1.945$ which brings theoretical suction head of pump to 7.9 - 1.95 = 5.95. As safety, 0.5 m is subtracted i.e. 5.45 m which means that the pump selected is suitable for our purpose, because the suction head of 5.45 m is greater than the required 5.2 m.