Water for Profit

PUMPING UNIT EFFICIENCY: BORE PUMP SYSTEMS

WATERFORPROFIT

Pumping efficiency tests completed as part of system auditing within the Rural Water Use Efficiency Initiative found that many systems are operating inefficiently.

Introduction

There are a number of reasons for inefficient operating:

- Worn pumps
- Incorrect wiring of motors
- Poor pump selection
- Improper motor size
- Changes in application systems
- Big gun – drip tape
- Insufficient water supply

This Water for Profit sheet provides information enabling you to determine how efficient your pumping unit is and the costs involved.

What is pump efficiency?

Pump efficiency is a measurement of how well a pump converts power input into water delivery (represented as a percentage).

Pump Efficiency = water power output ÷ power input

When the irrigation system was originally designed, a pump would have been chosen to provide sufficient head pressure, including all friction losses, so that the sprinkler located at the highest point in the irrigation block operated efficiently.

Pump curves

To obtain a pump curve from an irrigation supplier or the manufacturer, so that comparisons can be made against pump specifications, you will need the following information.

Considering that you are unable to see the pump due to the fact that it is in the ground some of these details will need to be sourced from farm records: make, size and type of pump; and motor specifications (Hp / kW, RPM).

For a bore test you will also need to know the following information and as an example let us assume these measurements:

- bore depth (31 metres)
- pump inlet depth (29 metres)
- current standing water level (21.6 metres)
- six stage pump (0.55 metres in length)
- air line (28.5 metres).

Water Power Output

Total Dynamic Head (TDH)

TDH refers to the amount of work the pump is required to do in providing adequate pressure at the discharge end and is the sum of:

- lift below
- pump operating pressure (head above)
- column friction (Fc) – friction incurred due to column diameter and shaft diameter
- discharge friction (Fd) – refers to fiction losses in delivery mainlines
- water discharge

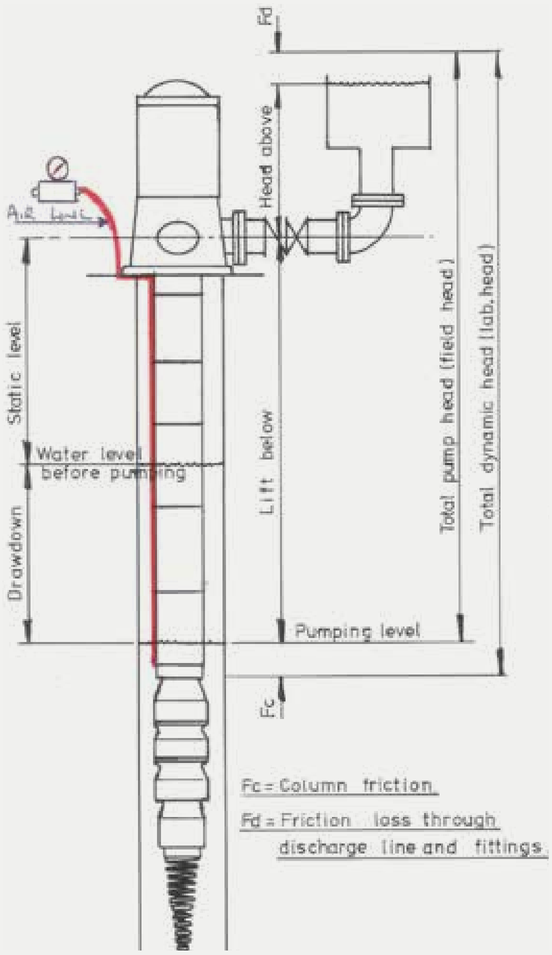

Figure 1: Total Dynamic Head Diagram

Lift below

For bore pumps with a working air line an accurate measurement of water level can be taken. Air lines are a very useful tool but unfortunately not many bore pumps have them fitted. Generally the end of the air line will be at the top of the stages.

There are three measurements that can be taken:

- when the pump is off you can determine static water level
- when the pump is operating you can determine drawdown
- when the irrigation has finished you are able to progressively measure recharge.

Monitoring an air line will help to maintain:

- pump performance
- bore performance
- aquifer sustainability.

To determine water levels apply air pressure to the airline using a bike pump, until the needle on the gauge begins to bounce. (The bounce effect is due to a higher air pressure than water pressure at the end of the air line).

Release the pressure allowing the needle to descend back towards zero. The needle should stop on its decent at a given pressure and it is this pressure reading that is required to determine the amount of water above the end of the tube.

Example:

Static level

- Apply pressure using a pump
- Gauge bounces between 200 – 250 kPa
- Release the pressure and the gauge falls, stopping at 68 kPa.

68 kPa x 0.102 = 6.9 metres of water above the end of the air line.

Pumping level

- Apply pressure using a pump
- Gauge bounces between 100 – 150 kPa
- Release the pressure and the gauge falls, stopping at 10 kPa.

10 kPa x 0.102 = 1.02 metres of water above the end of the air line.

The difference between the static level and pumping level is called drawdown (6.9 – 1.02 = 5.88 metres).

If the inlet is 29 m deep and the distance between the end of the air line and the pump inlet is 0.55 m and there is 1.02 m above the end of the air line then:

Lift below during pumping: 29 – 0.55 – 1.02 = 27.43 m

If no air line is present then knowledge of current water levels is required.

For example:

- Distance between centreline of discharge main and current standing water level is 22 metres below ground level.
- If the pump is drawing air during its operation then you may be able to determine that drawdown levels are close to the pump inlet and then knowledge of inlet depth will help to determine a lift below figure.
- If this can not be determined, use the standing water level reading.

Pump operating pressure

Measure using a suitably sized gauge installed as close as possible to the pump on the discharge side.

- To convert psi to metres of head multiply by 0.70284
- To convert kPa to metres of head multiply by 0.10194.

Column friction (Fc)

Expressed in metres and is dependant upon the length and size of the column and shaft and also flow rate.

Example to determine Total Dynamic Head

- Lift below: 27.43 m
- Pump operating pressure (head above): 35 m (344 kPa @ pump)
- Column Friction (Fc): 100 x 20 column and shaft size @ 22.7 l/sec flow rate = 17 m/100m of column = 0.17 x 29.5 = 10 m
- TDH = 27.43 + 35 + 10 = 72.43 m.

Water discharge – litres/second (Q)

Measuring flow rate using a water meter

To obtain good readings the water meter needs to be positioned on the discharge side according to design specifications. If the closest that you are able to locate the meter is in the paddock at a hydrant point then check all hydrants for leakage.

The majority of meters are rotating number units, similar to an odometer in your vehicle, with black and red coloured numbers. The black numbers are whole megalitres and the red are part there of.

To obtain a value, measure time taken, in seconds, for 1000 litres (1m3) to travel through the water meter.

E.g. 1000 litres ÷ 100 seconds = 10 litre/sec.

Measuring flow rate without a water meter

If no water meter is available then measure discharge per sprinkler using a hose, bucket and stopwatch.

By timing the period it takes to fill a bucket you can determine discharge rate from individual sprinklers. The more sprinklers that you record the more accurate the discharge rate measurement will be.

E.g. Bucket is 20 litres, takes 100 seconds to fill the bucket and there are 50 sprinklers: 20 litres ÷ 100 seconds x 50 = 10 litre/sec.

Power input

Electricity consumption (kW)

Systems reading large amounts of electrical usage are geared to rotate slower and will have a multiplier number marked as 'M' on the face.

Multiple disc meters

Pumps operate on thee-phase power supply accounting for the three individual meters.

The kilowatt load or demand of a pumping unit can be measured reasonably accurately by observing the time taken for the kWh meter discs to rotate a specific number of revolutions.

Using a stopwatch, record the time taken for you to count a predetermined number of disc revolutions per disc.

kW = (R ÷ t) x (3600 ÷ c)

R – Number of revs counted

t – Time taken in seconds

c – Meter constant

E.g. meter constant is 266.6 kWh, count 50 revs/disc taking 111 second. kW = (150 ÷ 111) x (3600 ÷266.6) = 18.2.

Note: Counting across the discs will even out any difference in the meters.

Digital meter

Digital meters are becoming more common as systems are upgraded or newly installed.

The meter scrolls continuously, displaying each screen for 9 seconds. Record an initial reading from either the total value or Rates A/B and then after a predetermined amount of time record the new value.

Example: Initial Total kWh reading (001) 12345.5 and after 20 minutes the next reading is 12351.6

This equates to 6.1 kW used in 20 mins =18.3 kW/hr.

Screen information		
888	Check all display segments are okay	
002	Time	
003	Date	
001	Total kWh used	
005	Total kWh used	Rate A
010	Total kWh used	Rate B
060	Program ID	

Motor Efficiency (Me)

Depending on the size of the motor determine which decimal factor to use. Refer to motor specifications.

10 – 22 kW	0.88
22 – 55 kW	0.90
55 – 75 kW	0.92

Drive factor (Df)

How the motor drives the pump determines drive loss. Select the appropriate decimal factor:

Drive Type	Loss Factor
Flat belt	0.88
V-Belt	0.93
Gear Drive	0.95
Direct	1.0

Pumping efficiency calculation

Once the relevant data has been collected a calculation can be completed to determine pumping efficiency.

Pump Efficiency = water power output ÷ power input

Water power output: 0.98 x Q x TDH

Power input: kW x Me x Df

Example: The motor is rated at 18 kW and is direct drive so use Me of 0.88 and Df of 1.0.

0.98 x 10 x 72.43 ÷ 18.2 x 0.88 x 1.0 = 709.814 ÷ 16 = 44.36%.

To determine how efficient the pump is operating refer to a manufacturer's pump performance curve which will help determine maximum efficiency available. 0.98 is a constant.

After following this process the pump efficiency is only 44.36% but according to the manufacturer's pump curve its maximum attainable efficiency is 70% meaning the pump is below operating efficiency.

- Benchmark pump efficiency – 70%
- Majority of pumps should achieve – 75%.

Note: The test that you have completed is for a specific point in time and particular irrigation block. Pumping efficiency will change as a result of water level fluctuation and the topography of individual irrigation blocks being tested.

Diagram referenced from Thompson Kelly Lewis KL – GG Turbine Pump Technical Data Booklet. Assistance from National Centre for Engineering in Agriculture / University of Southern Queensland staff is gratefully acknowledged in compiling this information.

For more details contact Growcom on 07 3620 3844.

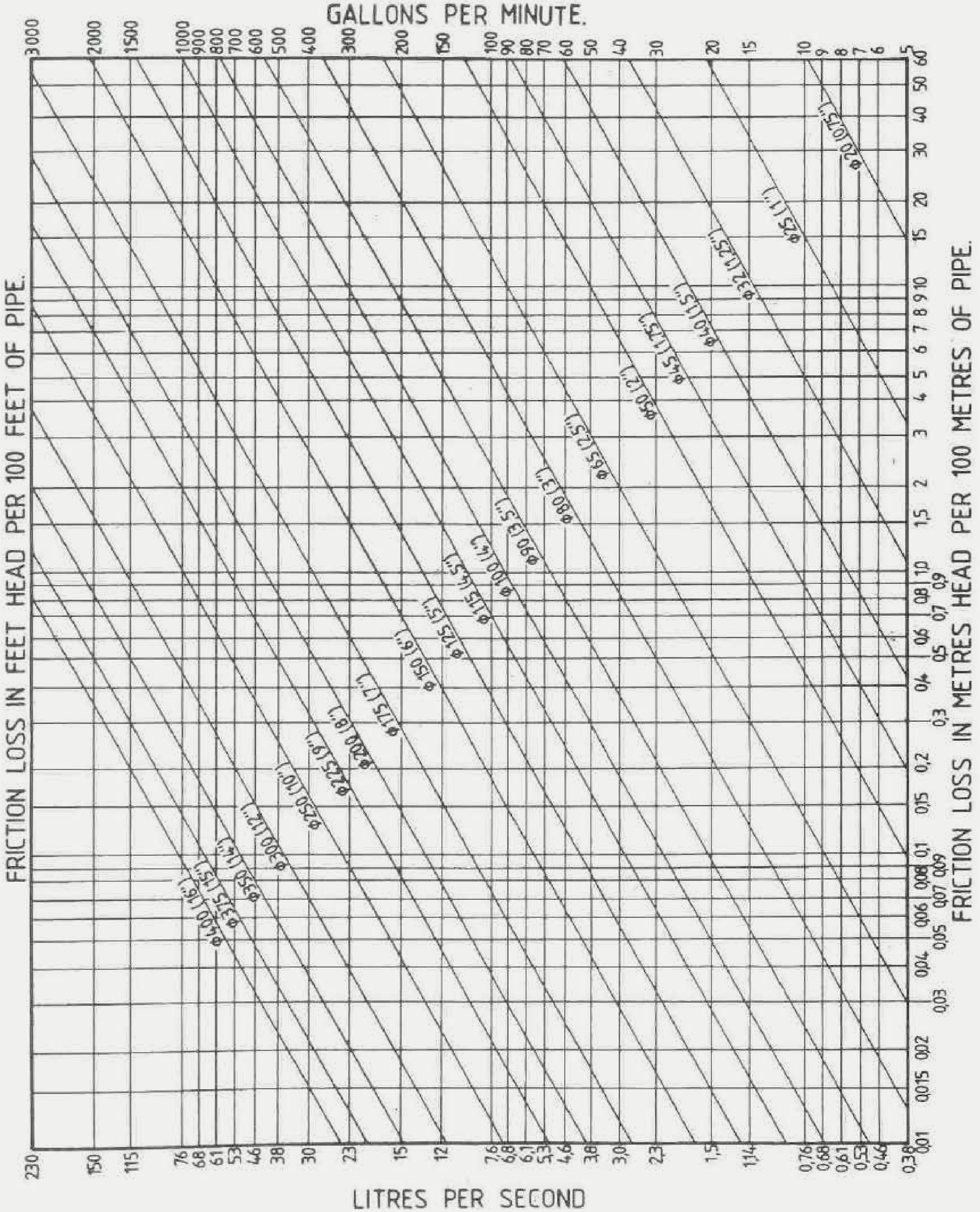

Figure 2: Discharge pipeline friction

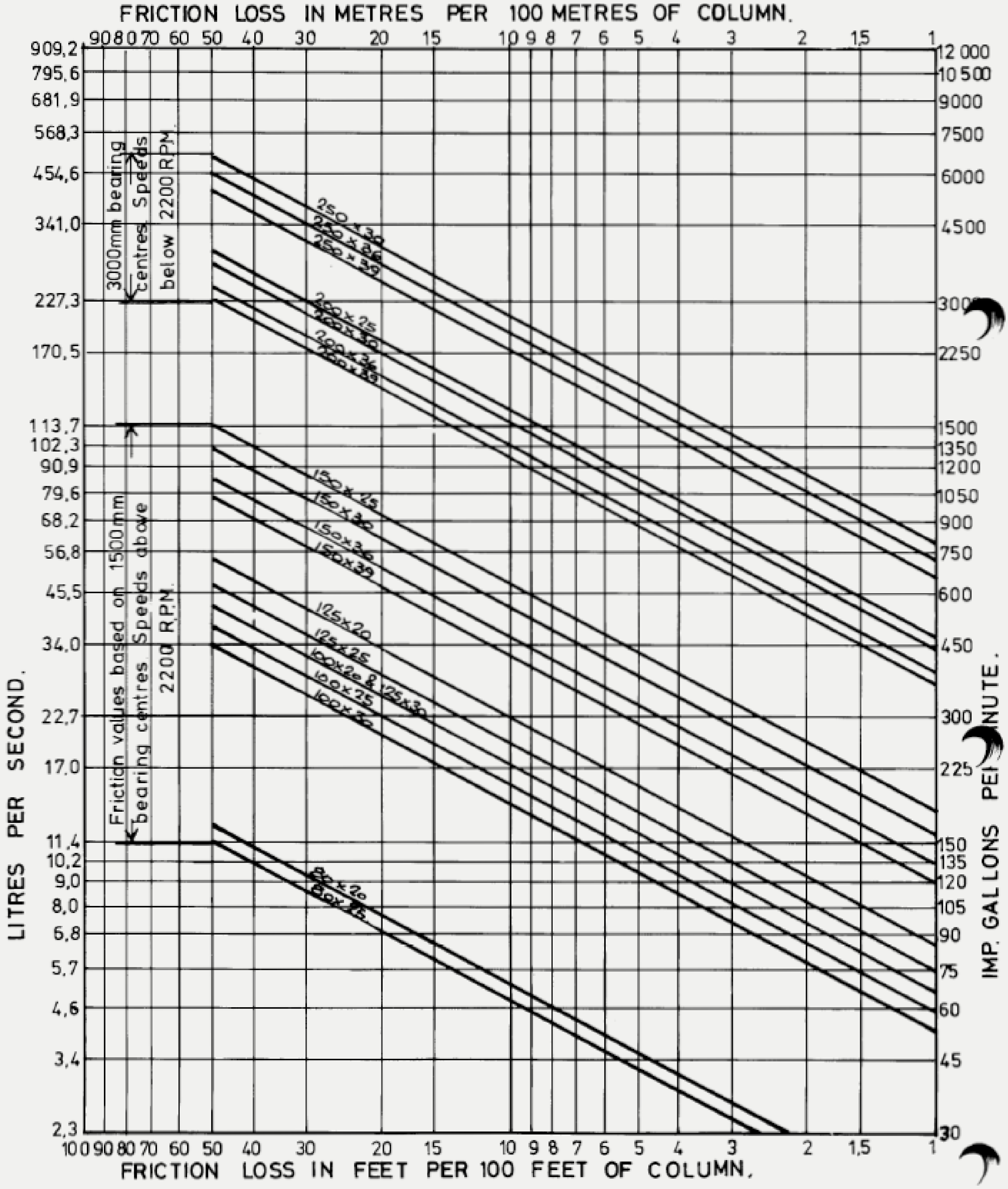

Figure 3: Water Lubrication: Column Capacity Chart – Standard Col-Shaft Dimensions

Disclaimer: This information is provided as a reference tool only. Seek professional advice for irrigation specifics.

A Growcom project conducted in collaboration with the Queensland Department of Agriculture, Fisheries and Forestry and the National Centre for Engineering in Agriculture with funding provided by the Queensland Government's Rural Water Use Efficiency Initiative.

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