GREEN PUMP INDEX

A METHODOLOGY TO BENCHMARK IN-SITU PUMP PERFORMANCE

WHITEPAPER

Deritend Industries
Focus on Energy Efficiency

RIVENTA

CONTENTS

2 INTRODUCTION

Why move beyond Pump testing?

This White Paper addresses the age old problem of how does a pump owner know how 'good' a pump is? Firstly all pumps are different; in terms of Head, Flow rate, Electrical Power, site hydraulic conditions and deviation from the Duty point.

In addition to these factors, often the motor is sized incorrectly, there may be a variable speed mechanism, demand requires pumping into different systems, or the systems can have low or high Static Head, low or high Frictional Coefficients, etc. Therefore defining 'Good' can be very difficult; simply measuring a pump's performance characteristic (i.e. the pump curve) is not adequate to fully evaluate the performance of a given pump. It is these real world circumstances that make the GPX Index invaluable.

A Benchmark for any Pump

The GPX Index stands for Green Pump IndeX. It takes into account all the parameters and factors described above and provides one number, the GPX Index, which quantifies the Energy Efficiency of any pump. The resulting GPX index "number" [which is between 0 and 100] can be used as an industry standard to compare any pumps.

Because the GPX Index takes account of all factors, it is a universal number that can compare the Energy Efficiency of any pump regarding of type, size, application, company or even country. The Index can be used to identify which pumps require improvement; furthermore the application of the GPX Index can provide a true and fair view of the relative condition of a given selection of pumps. Clearly, this commercially sound methodology could be used to assess the number of pumps which require improvement over the coming years.

Within this white paper, a "Pump" is defined by its function, as a converter of the primary energy input, electricity, to the functional output which is a desired Flow rate lifted through the Static Head of the system.

Evolution of the Concept

Traditionally, the initial starting point for any assessment of pump condition is to measure the pump curve and note how different it is from the pump curve of the unit when new. Two key points that can be considered are, firstly, the Best Efficiency Point (BEP) which is often aligned with the Duty Head. Secondly is the Hydraulic Efficiency at the operating Head which is often different to the Duty Head. However Hydraulic Efficiency (otherwise termed Pump Efficiency) is only one component of converting Electrical Power to useful Flow rate.

Typically, Station Managers have adopted the process of Normalising Electrical Power by Flow rate to compute Specific Power; this is an extremely important parameter for tracking changes in Energy Efficiency within a pumping station. However, it assumes that the system properties do not change and will not permit comparison with other pumping stations, as demonstrated by the following example;

Equation for Specific Power

$$\text{Specific Power} = \frac{\text{Electrical Power}}{\text{Flow Rate}}$$

It can be seen from Table 1 that the Specific Power of Station B is twice that of Station A -despite both system having the same frictional coefficient and the pumps and motors operating at the same efficiency. This is because the Static Head is much greater for Station B.

PARAMETER:	PUMP A	PUMP B
Electrical Power (kW)	1,000	2,000
Flow rate (m3/hr)	5,000	5,000
Frictional Coefficient (hr2/m5)	6.466E-07	6.466E-07
Static Head (m)	40	96.2
Total Differential Head (m)	56.2	112.3
Hydraulic Efficiency (%)	85	85
Motor Efficiency (%)	90	90
Specific Power (kWh/m3)	0.20	0.40

Table 1 | Specific Power Comparison

$$\text{GPX Index} = \frac{\text{Flow Rate x Static Head}}{\text{3.67 x Electrical Power}}$$

Where the units are as follows; Flow rate (m3/hr), Static Head (m) and Electrical Power (kW).

As the GPX Index is a true measure of Drive, Pump and System energy efficiency, it can be applied to any pump regardless of the operating parameters or the system it is pumping into; therefore applying it to the example in Table 1 produces a different outcome, as shown here;

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Total Differential Head (m)	56.2	112.3
Hydraulic Efficiency (%)	85	85
Motor Efficiency (%)	90	90
Specific Power (kWh/m3)	0.20	0.40
GPX Index	54	66

Table 2 | GPX Index Comparison

The GPX Index in Table 2 actually shows the opposite result to Table 1, that pump B is better than pump A; this is because it is a universal index and independent of system properties. In order to evaluate the GPX for a pump certain measurements have to be taken...

In their simplest forms, the measurements required are just:-

- STATIC HEAD
- FLOW RATE
- ELECTRICAL POWER

2 Introduction Continued

For a text book example, the Static Head can be obtained from heights (drawings) and sump levels, from installed power meters and flow meters. The likely problems faced include complex systems with multiple and varying Static Heads, and dynamic frictional coefficients resulting in continuously changing Flow rate and Power.

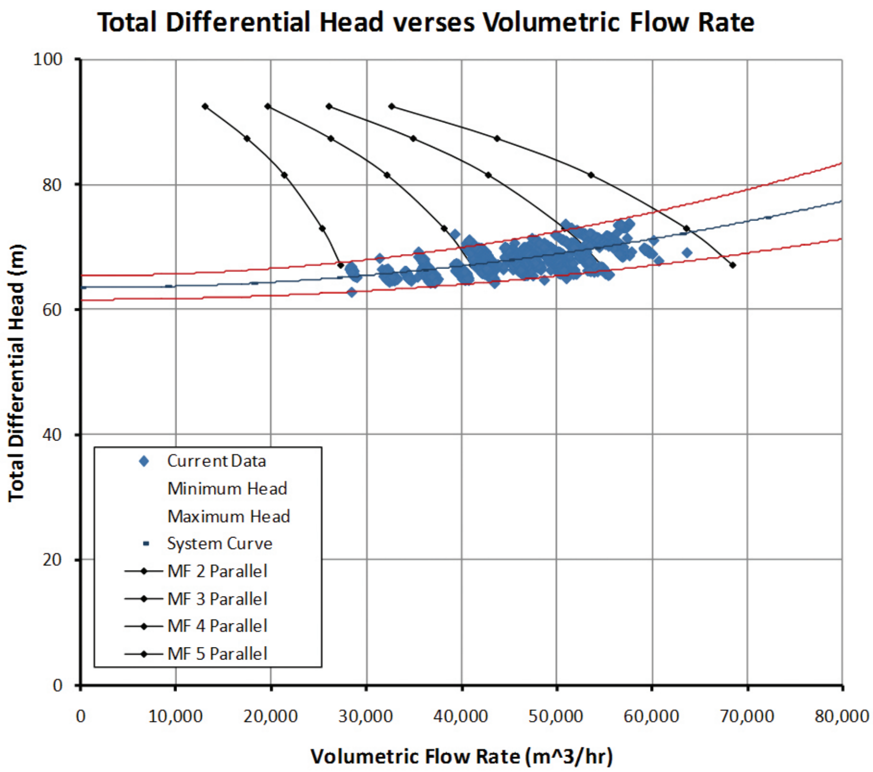


Figure 1 | Variations in Flow rate due to Dynamic System Characteristics

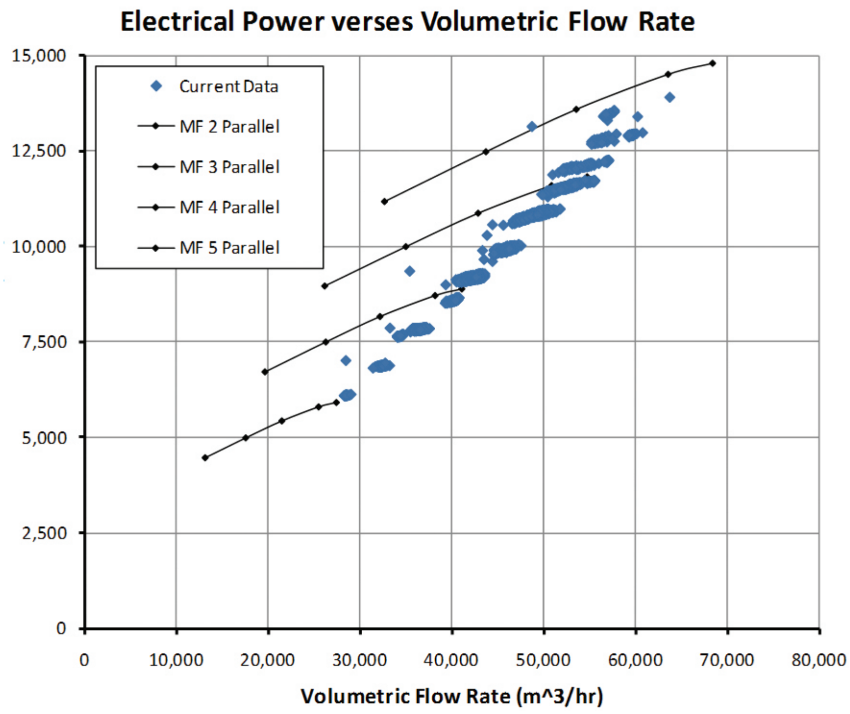


Figure 2 | Variations in Electrical Power due to Dynamic System Characteristics

The most reliable way to ascertain the parameters required for the GPX Index is by Thermodynamic Monitoring which can provide individual monitoring on each pump and through analysis the Static Head can be calculated and the average Electrical Power and Flow rate.

3 INTERPRETING THE RESULTS

As the GPX Index provides a measure of the energy efficiency then the magnitude of the number indicates the whether the pump unit requires investigation or remedial work. If there were no losses then the GPX Index would be 100 although, in practice best performance cannot exceed 92.

GPX INDEX		C	P
<50	G8		
50 - 54	G7	53	
55 - 59	G6		
60 - 64	G5		
65 - 69	G4		
70 - 74	G3		71
75 - 79	G2		
80+	G1		

ACTION
BELOW RECOMMENDED EFFICIENCY Immediate Action recommended to improve Energy Efficiency
AVERAGE PERFORMANCE Future planning should include Energy Reduction measures
EXCELLENT PERFORMANCE

Figure 3 | Green Pump Index

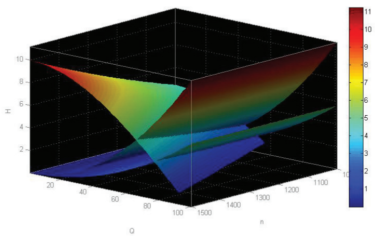
In the Fig 3, the GPX index has been divided into grades of energy efficiency. The figure also shows the Current (C) and also the Potential (P) GPX rating. The potential rating can be calculated based on all possible ways that energy performance could be improved, including coating, refurbishment, replacement, pipework upgrades or the use of variable speed.

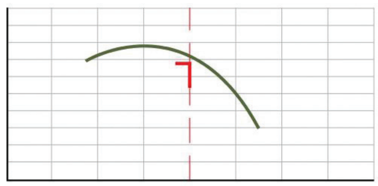
Of course, in order to realise improvement in energy efficiency, the potential benefits of any investment should be evaluated in the traditional ways, such as payback period, IRR etc.

Fig 3 also offers a means of separating short-term from longer-term investment. Where the GPX index is at the lower end of the scale, it is probable the improvements may be achieved with relatively low-cost improvements, such as a pump refurbishment. Whereas, long-term considerations such as upgrading pipework, may be a practical investment in the medium to short term.

MOTOR EFFICIENCY
is governed by the construction of the motor and the operating point relative to rated power

VARIABLE SPEED EFFICIENCY
is a function of the type of drive and the ratio of operating speed to maximum speed





PUMP EFFICIENCY
is predominantly determined by the condition/wear of the pump, operating point relative to BEP and technology employed

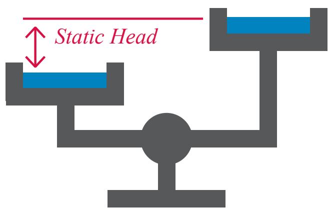
STATION LOSSES
is a function of the Shock Losses like bends, diameter changes, branches etc and their spacial relationship

$$H_L = K\frac{V^2}{2g}$$

$$H_L = \frac{flV^2}{2gd}$$

PIPEWORK LOSSES
is the Head Loss due to friction in the distribution system and is a function of roughness, diameters, lengths etc and the dynamic response of the active users

USEFUL WORK
in order to supply the work on inevitable amount of energy is required. In its simplest form this is the flow rate through a change in height



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