CONFERENCE 16TH EDITION EXHIBITION

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INTERNATIONAL OPERATIONS & MAINTENANCE CONFERENCE
IN THE ARAB COUNTRIES

UNDER THE THEME
"MANAGING MAINTENANCE WITHIN INDUSTRY 4.0"
CONICIDE WITH **THE 16TH ARAB MAINTENANCE EXHIBITION**

ASSESSING PUMPING SYSTEM OPERATION FOR UPGRADING WORKS IN BUKIT KUDA WATER TREATMENT PLANT, LABUAN, MALAYSIA

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- METHODOLOGY
- RESULTS AND FINDINGS
- DISCUSSION
- CONCLUSION

INTRODUCTION

- Designing/selecting pump for an upgrading system and new system has differences
- New systems - most information on friction losses, internal pipe diameters, minor loss of the system in the **water supply systems to be put into operation is** rather easier to determine in order to design the duty point, hence select the pump.
- Designing **upgrading work of an operating system** can be erroneous if the assumptions were wrong and not representative of the actual site condition.
- Design of duty point of an upgraded system needed information of the relationship between pressure as the flow in the existing system is increased.
- Hence the existing system curve is constructed by observing the incremental change in pressure as the flow in the system is varied by valve throttling.
- Integrating the Bernoulli’s principles of the geodetic, static and dynamic energy and input power data will enable the analysis of energy input and output and hence arriving to pump efficiency values.

INTRODUCTION

- This method helps in determining **operation conditions for refurbishment systems** (upgrading) accurately
- The on-site measurements will allow the determination of the averaged actual friction coefficient which includes the effect of system deterioration and fitting conditions. This information will be used to determine the expected duty point of an upgrading system more precisely. The study will also highlight the **actual pump operating efficiencies** for an old pumping installation.
- In an old system, pigging works should be carried out before designing a new system to obtain a power saving system rather than designing big pump to operate in an inefficient system.
- This procedure **resulted in improvement of operation parameter** and can be immediately utilised for the upgrading design.
- The methods offers the accurate way to determine pumping system duty point for **upgrading condition of system in operation** instead on depending on assumptions provided in normal design tasks.

METHODOLOGY

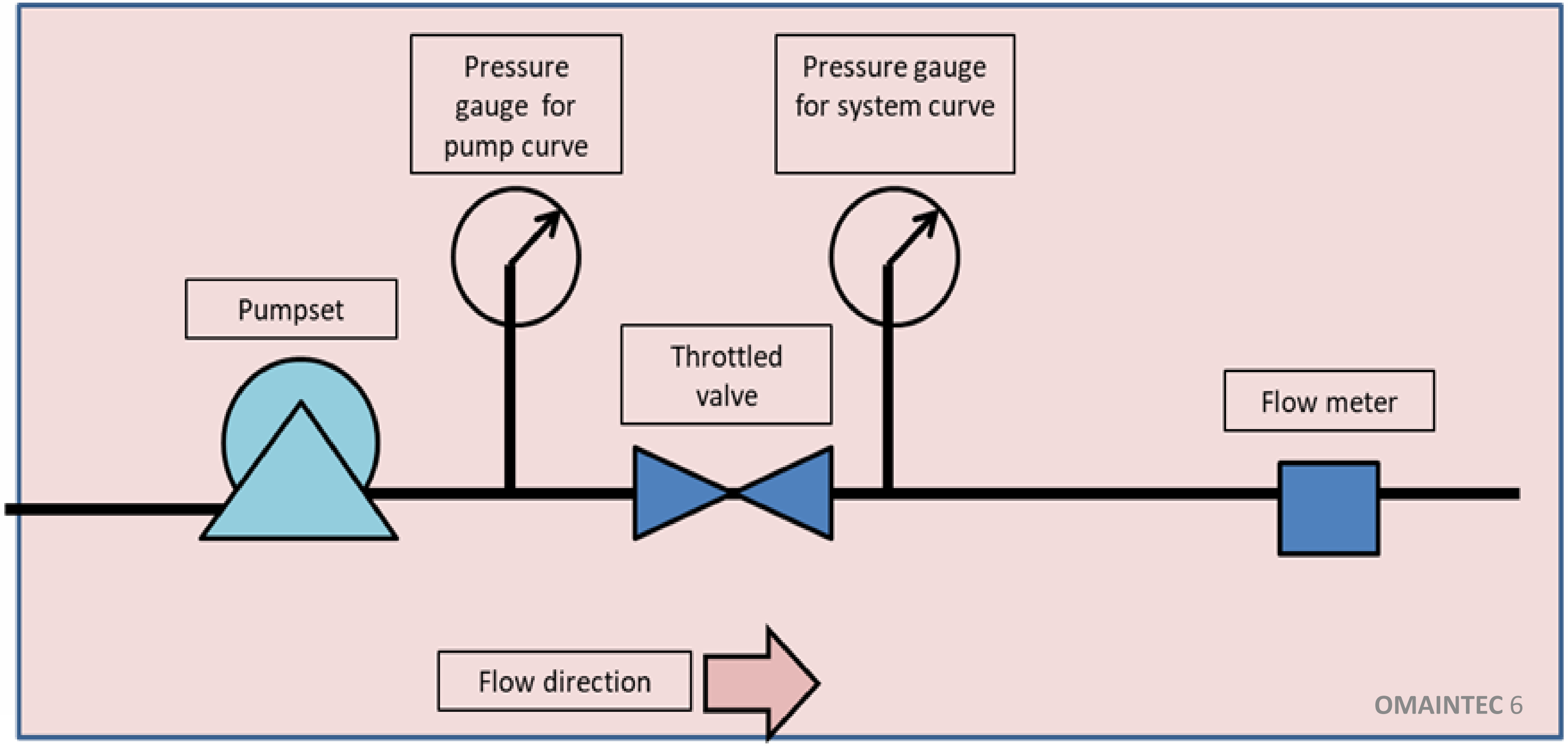
ARRANGEMENT OF INSTRUMENTS

- The most important and difficult task in performing this study is to find a suitable location for the measurement of flow and pressure.
- Flowmeter location must comply the requirement of manufacturers in terms of providing the adequate straight length (straight running pipe).
- Panametric Model PT878 which was used requires 10 x pipe diameter for the upstream and 5 x pipe diameter for downstream. (GE Measurement and Control, 2011; p5).
- For collecting data for pump curve, the pressure sensor must be positioned between the pump unit and the throttled delivery valve (as shown in next slide).
- For collecting for system curve, the pressure sensor must be located after the throttled valve (as shown in next slide).

METHODOLOGY

ARRANGEMENT OF INSTRUMENTS (cont.)

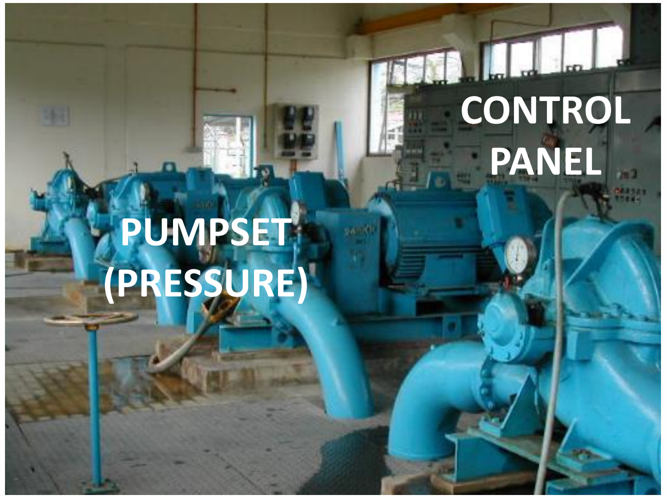
Valve throttling must be done slowly since the pressure change will take time and flow stabilization will also consume time. Caution must be taken to avoid pump damage or stoppage due to excessive vibration.

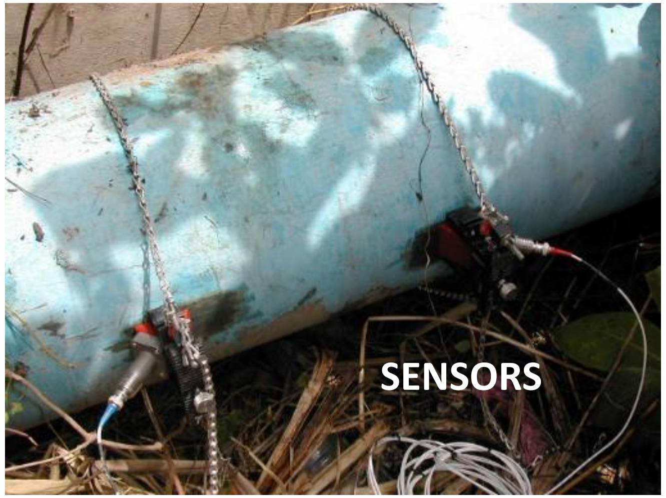


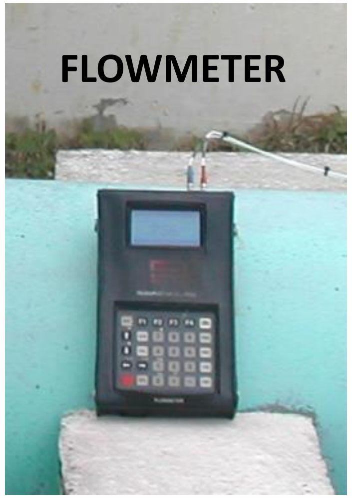
METHODOLOGY

RECORDING THE DATA

- The measurement of pressure is done using **calibrated pressure gauges** whereas measurements of flows are done using **calibrated ultrasonic flowmeter.**
- Ultrasonic flowmeter must have adequate straight length both upstream and downstream to maintain accuracy of the flowmeter.
- The measurement of Voltage (V), Current (A), Power Factor (PF) are done at site using **multi tester equipment** to read the input voltage, current and PF at every point.







METHODOLOGY

FORMULA TO USE

- Results were tabulated and total head of the operating pump is calculated using Bernoulli's formula as follows:

$$H_t = (P_d - P_s) + (Z_d - Z_s) + ((V^2/2g)_d - (V^2/2g)_s),$$

where;

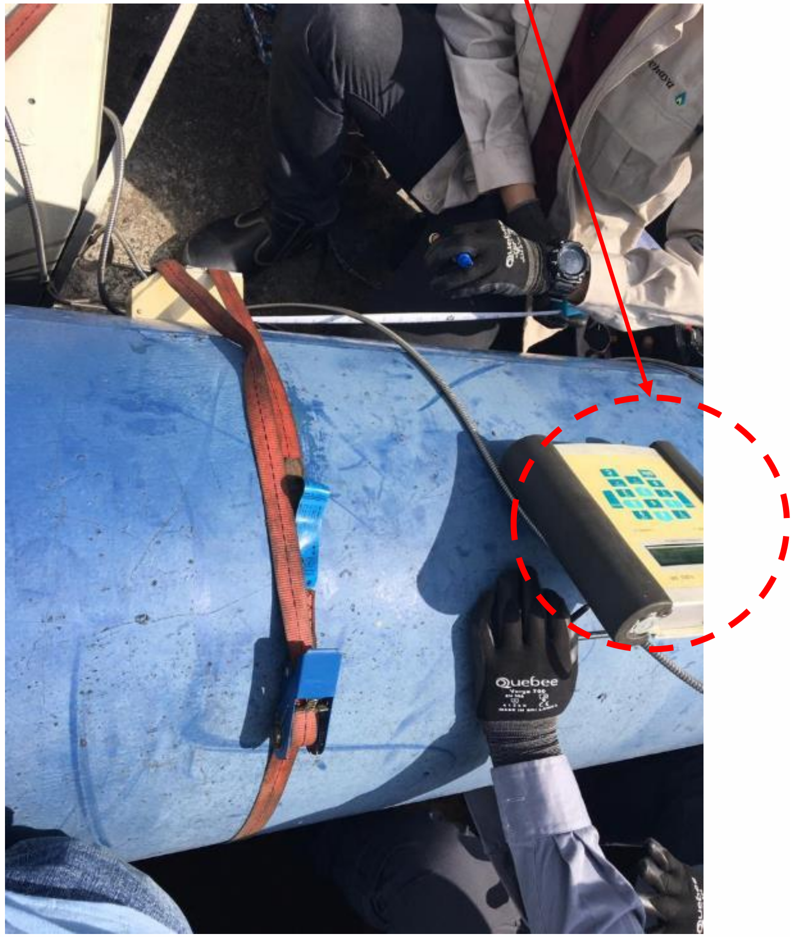
V_s = velocity (m/s) at suction
V_d = velocity (m/s) at discharge
$Z_d - Z_s$ is the difference in pressure gauge level at suction and discharge
$P_d - P_s$ is the difference in pressure at suction and discharge

METHODOLOGY

NOT ENOUGH STRAIGHT LENGTH

METHODOLOGY

FLOW MEASUREMENT



METHODOLOGY

PRESSURE POINTS

DELIVERY PRESSURE AFTER THROTTLING VALVE

THROTTLING VALVE

RESULTS AND ANALYSIS

HYDRAULIC DATA COLLECTED

No. of Point	Capacity Flow rate	Pressure Reading				Gauge height from pump c/line		Velocity head ($V^2/2g$)				Level Difference in Suction Tank	
		Delivery (D)		Suction (S)		D	S	Suction	Delivery	Difference	Total Head	Start	Stop
	m^3/h	(bar)	(m)	(bar)	m	mm	mm	m	m	m	metres	mm	mm
F.O	480.00	2.20	22.46	0.10	1.02	0	-230	0.376	0.918	0.542	22.21	0	0
2	320.00	2.40	24.50	0.10	1.02	0	-230	0.167	0.408	0.241	23.95	0	0
3	120.00	2.50	25.53	0.10	1.02	0	-230	0.024	0.057	0.034	24.77	0	0
F.C	0.00	3.1	31.65	0.10	1.02	0	-230	0.000	0.000	0.000	30.86	0	0

Note:

F.O Fully open **.C** Fully closed **2, 3** Position of valve with flow between 1/3 to 2/3 of F.O flows

RESULTS AND ANALYSIS

POWER CONSUMPTION DATA COLLECTED

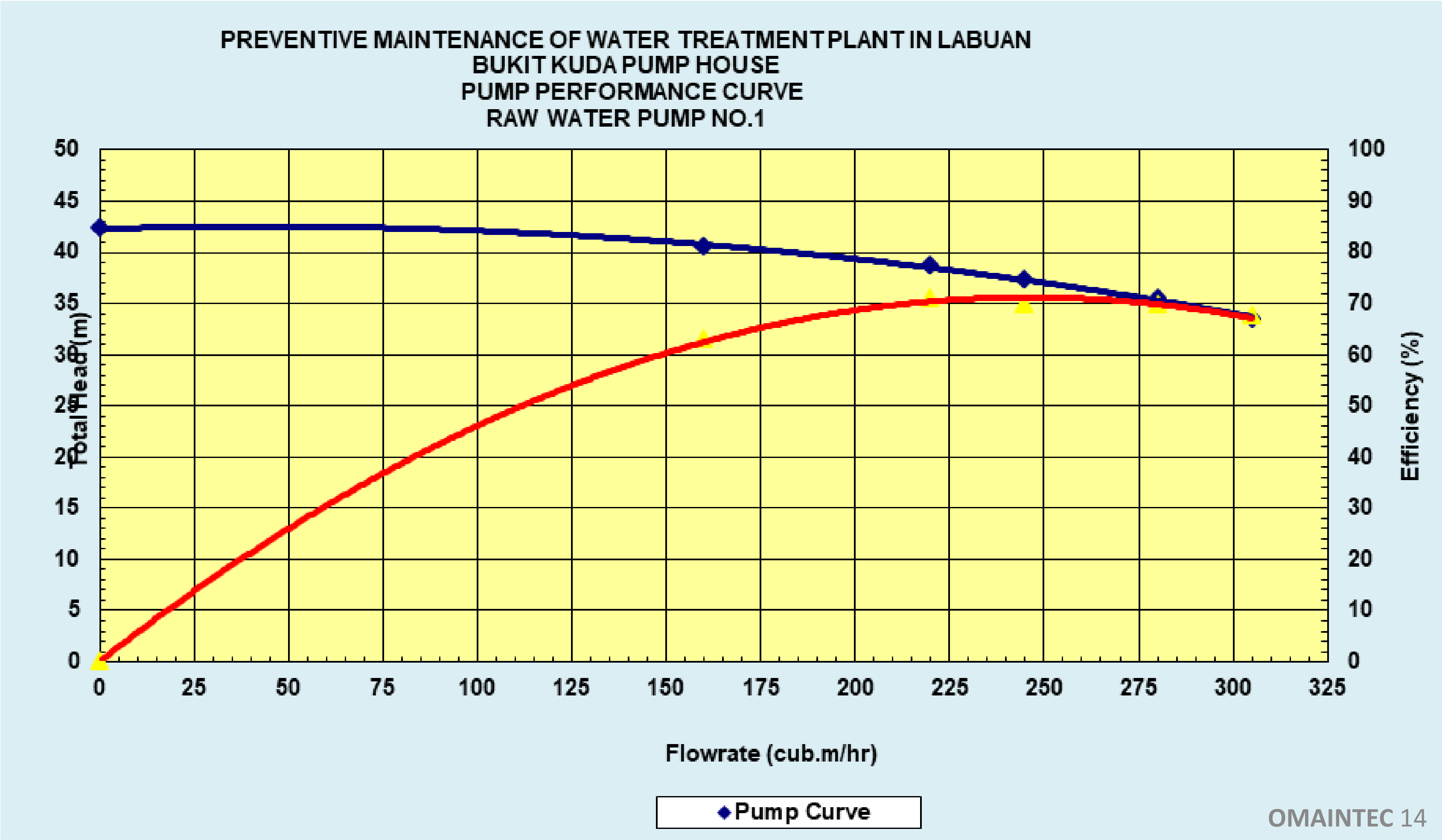
No. of Points	Capacity Flow rate	Electric Motor (50 Hz)			Time	WHP	BHP (Use η motor = 90%)	Input	Pumpset η (calculated)
		Current	Power factor	Voltage					
	m^3/h	Amp	PF	Volt	min.	kW	kW	kW	%
F.O	480.00	102.20	0.89	425.00	0	29.05	32.28	66.95	**48**
2	320.00	100.60	0.89	424.80	0	20.89	23.21	65.87	**35**
3	120.00	99.79	0.89	425.20	0	8.10	9.00	65.41	**14**
F.C	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	**0**

Calculation water power and efficiency

PUMP INFORMATION	*Pump type*	*Motor Type*	*Speed*	*Pipe delivery dia.*	*Pipe suction dia.*
	Vertical, Weir	Slip Ring	1450 RPM	150mm	200mm

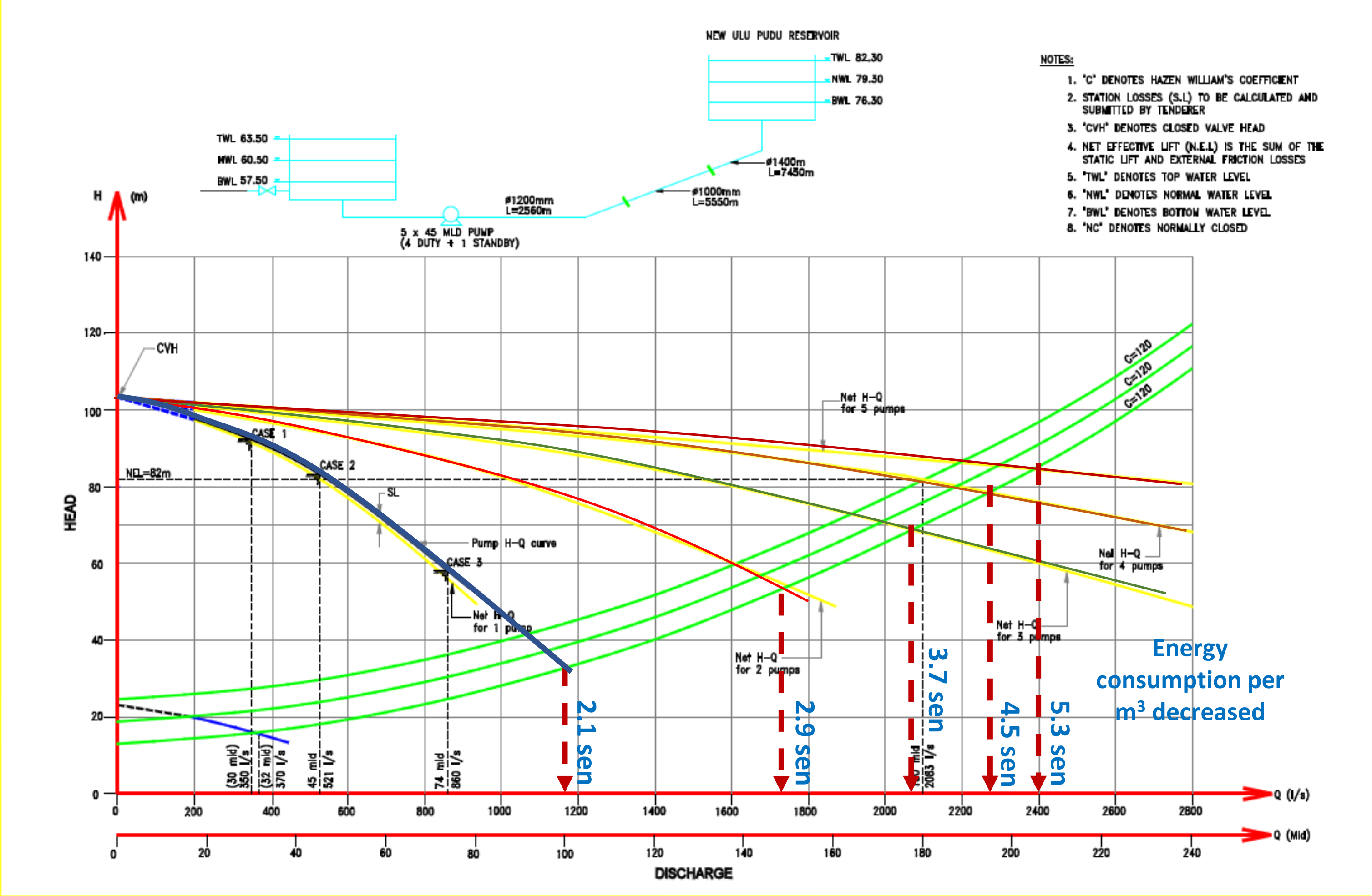
RESULTS AND ANALYSIS

PUMPING AND EFFICIENCY CURVES



RESULTS AND ANALYSIS

PARALLEL PUMPING



DISCUSSION

CALCULATING PUMP EFFICIENCY

Pump efficiency = BHP / input power

Where BHP = brake horse power

For three phase installation

Input power (kW) = V x I x 1.732/1000

where:
V = RMS voltage (V)
I = RMS current (A)

(RMS is root mean square is the mean used since the current have positive and negative values)

BHP (kW) = WHP (kW)/ η;

where:

η = motor efficiency (assumed at 90% for all loading)

To calculate water horse power (WHP):

WHP (kW) = Q x H_t /367

where:
Q = flow (m^3/s)
H_t = total head (m)

H_t is derived using Bernoulli's principle;

$$H_t = (P_d - P_s) + (Z_d - Z_s) + (V^2/2g)_d - (V^2/2g)_s;$$

where:
V_s = velocity (m/s) at suction
V_d = velocity (m/s) at discharge
$Z_d - Z_s$ is the difference in pressure gauge level at suction and discharge
$P_d - P_s$ is the difference in pressure at suction and discharge

DISCUSSION

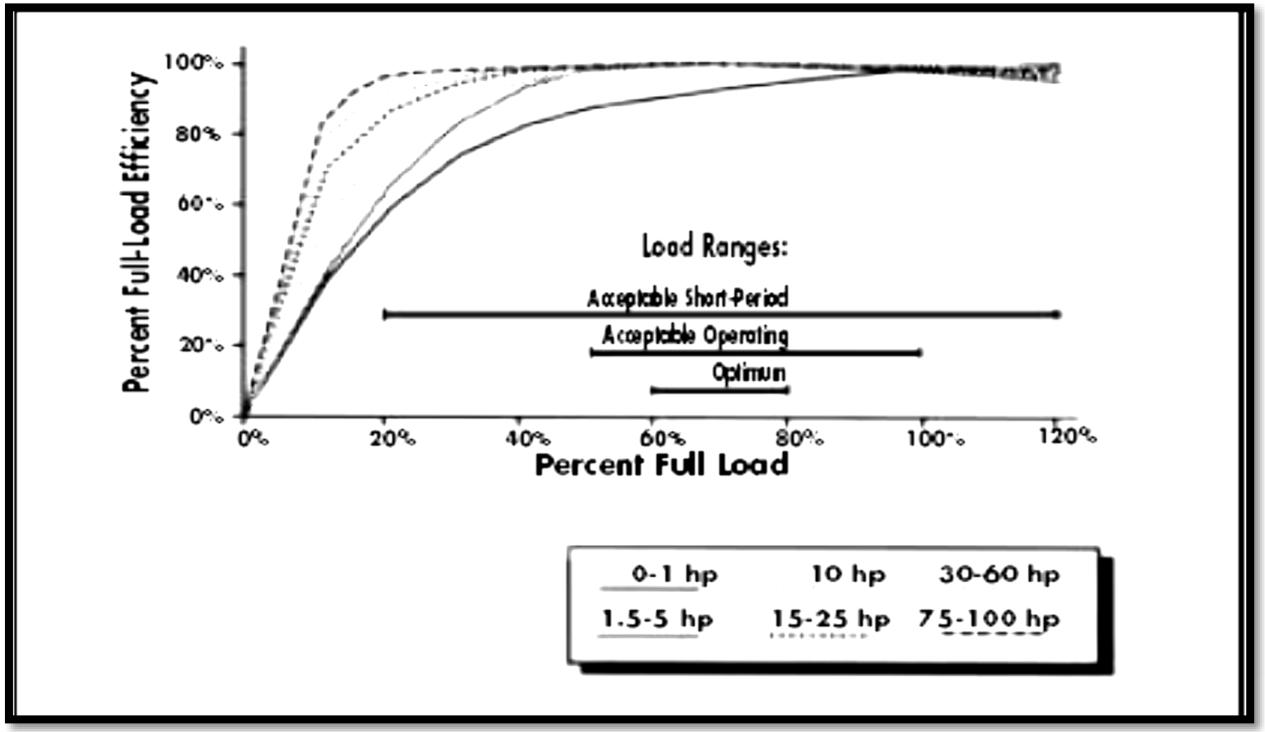
LOW EFFICIENCY OF PUMPSET – WHY?

- Impeller conditions
- Packing or mechanical seal
- Wear rings and impeller clearances improper
- Bypass line installed from the discharge side of the pump to the suction piping or valve not drop tight
- Running the pump with a throttled valve
- Eroded or corroded internal pump passages will cause fluid turbulence
- Any restrictions in the pump or piping passages such as product build up, a foreign object, or a stuck check valve
- Over lubricated or over loaded bearings
- Misalignment - pump and motor
- Pipe strain
- Protruding gasket rubbing against the mechanical seal
- Impeller imbalance
- Bent shaft
- Loose hardware.
- Cavitation
- Harmonic vibration
- Improper assembly of the bearings, seal, wear rings, packing, lip seals etc.
- Operating too far off of the best efficiency point of the pump
- Water hammer and pressure surges
- Dynamic, non ‘O’-ring elastomers that cannot flex and roll, but must slide
- Build up of product on the inside of the stuffing box rubbing against the mech seal
- Grease or lip seals rubbing the shaft next to the bearings
- Over tightening packing or improper seal installation

DISCUSSION

MOTOR EFFICIENCY

Efficiency of motors changes as loading changes. However from the graph, 73 – 100 HP motor has stable high efficiency until it is less that 20% full load and for 15.25 HP it is up to 40% full load. Hence, it is quite safe to assume efficiency of 90% for motors in the analysis for motors used in water treatment plants of motors in such range of horse power. Hence the pump efficiency can be derive once the combined efficiency is known.



DISCUSSION

REPAIR OR CHANGE?

- Proper maintenance is one way to overcome pump operating at low efficiency.
- Maintenance of water treatment plant may involve hundreds of items and pumpset is one of the main equipment which need to be maintained.
- To avoid oversight or delayed service and maintenance, proper preventive or scheduled maintenance need to be implemented.
- For big pump, it is viable to evaluate cost benefit analysis on changing parts such as impellers as it saves money as well as avoids water treatment plant disruption. For smaller pump, it is sometimes better to change the entire pump.

DISCUSSION

BENEFIT OF THE STUDY

The assessment as done in this study is applicable to achieve other intention such as:

- Determining the condition pump just after installation
- Producing system curve for the pumping system
- Determining duty point of the pump; i.e. the point where the pump's curve crosses the system curve with different discharge conditions -valve fully close, throttled and with the discharge valve fully open
- Assessing the match between "full flow" (flow delivered by the pump with the discharge valve fully open) and the actual design flow requirement
- Assessing the implications of throttled discharge valves and opportunities to open discharge valves and modify pump performance via trimming the existing impeller or expanding the impeller's diameter, changing the motor to achieve an incremental motor/pump speed change

Fine tuning of pumping protocol to benefit from reduced operating costs

- Assess the flow variations produced in the system as different active elements are repositioned by their control processes.
- Detect and diagnose other control or performance problems

DISCUSSION

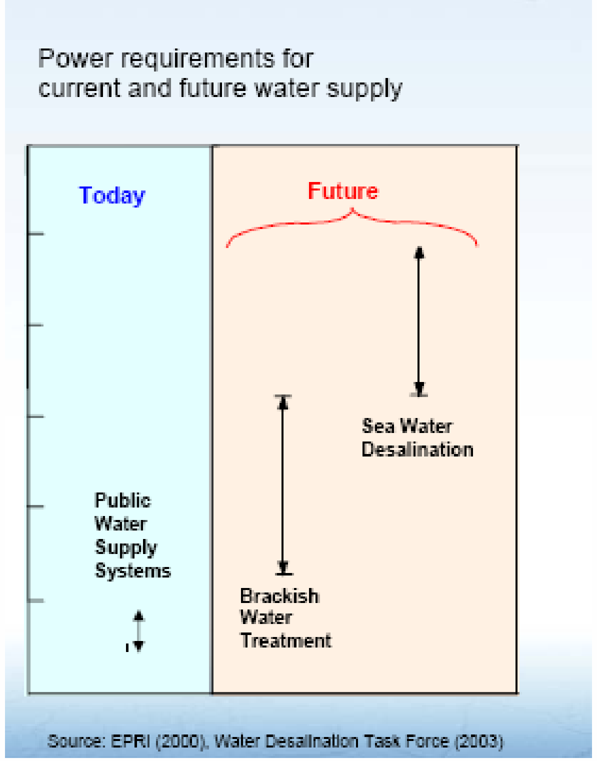
DETERMINING FINANCIAL BENEFIT

- It is possible to determine the financial saving and viability of changing pumpset
- Assuming the pump running at fully open valves having pumpset combined efficiency of 98% x 48% = 43% using 67kW
- Assume we change to a new pump set with a combined efficiency of about 75% (power required approximately 39kW).
- A new 40kW pumps cost RM40,000 for (USD9,570) pump renewal.
- Power saving = 37kW. In one day saving is 888kWh
- Assume power rate of 25 sen/kWh, daily saving is RM222.00 (USD53)
- Hence the payback period is 180 days (about 6 months). Additional benefit is better service from a new pumpset.
- These exercises were able to proof the viability of pump change for the water treatment plant.

CONCLUSION

- It was established that aging pumps are performing at very low efficiencies and the efficiencies dropped further whenever throttling is applied.
- For refurbishment works, inverter is recommended to be used as it ensures pump duty points can be maintained at optimum efficiency. This is due to the limitation in determining precisely the actual duty point of a refurbished system.
- The availability of inverters gives the option to operate at optimum even though there may encounter changes during installation period such as discovery of hidden valves. *(There could a long list of possible problems that might affect the duty point after more information gathered during investigations)*
- Cost-benefit analysis can be easily carried out to justify changing of pumpsets. Example shows that at fully open valves a pumpset with combined efficiency of 43% using 67kW can give a payback period of 6 months when changed to a 75% efficiency pumpset.
- Alternatively, this procedure may also be useful to conduct routine assessment efficiency of pumpset which is recommended by Hydratek & Associates Inc (USA) to be conducted as frequent as annually according to the size of pumpsets.

CONCLUSION



- This method was proven to be more satisfactory to our clients than other methods
- Thermodynamic method can also be used, determined on change in temperature (small change)
- Future power require (per unit volume) is expected to increase and the impact of inefficient pumps will be much higher

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Thank You

Heartiest Gratitude

- The Organiser
- Prof Ir Megat Johari Megat Mohd Noor
- Dato' Seri Dr Ir Zaini Ujang
- Ir Sulaiman Kamisan Director JBA Labuan
- Ir Syed Mahmor Syed Abu Bakar
- Engr Mansor Abdul Ghani