Field Testing of Pump Stations

As Presented to 2010 OWEA Annual Conference

Testing As Performed for

Columbus, Ohio in 2008-2009

BURGESS & NIPLE
Engineers ■ Architects ■ Planners

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The Columbus Pump Stations

- 70 pumps in 24 stations
- Storm water and wastewater
- 5 to 500 horsepower
- 4 inch to 48 inch discharge
- All physical styles
- All stations are telemetered to a central SCADA system, but instrumentation is generally sparse

Small Packaged Station

Dry Pit Submersible Station

Large Vertical Station

Large Axial Flow Submersible Station

Objectives

- Which pumps are wasting energy?
- Which pumps are a priority for repair/replacement?
- What is appropriate budget to sustain the pumps?
- What information is needed?
- What is the best way to obtain that info?

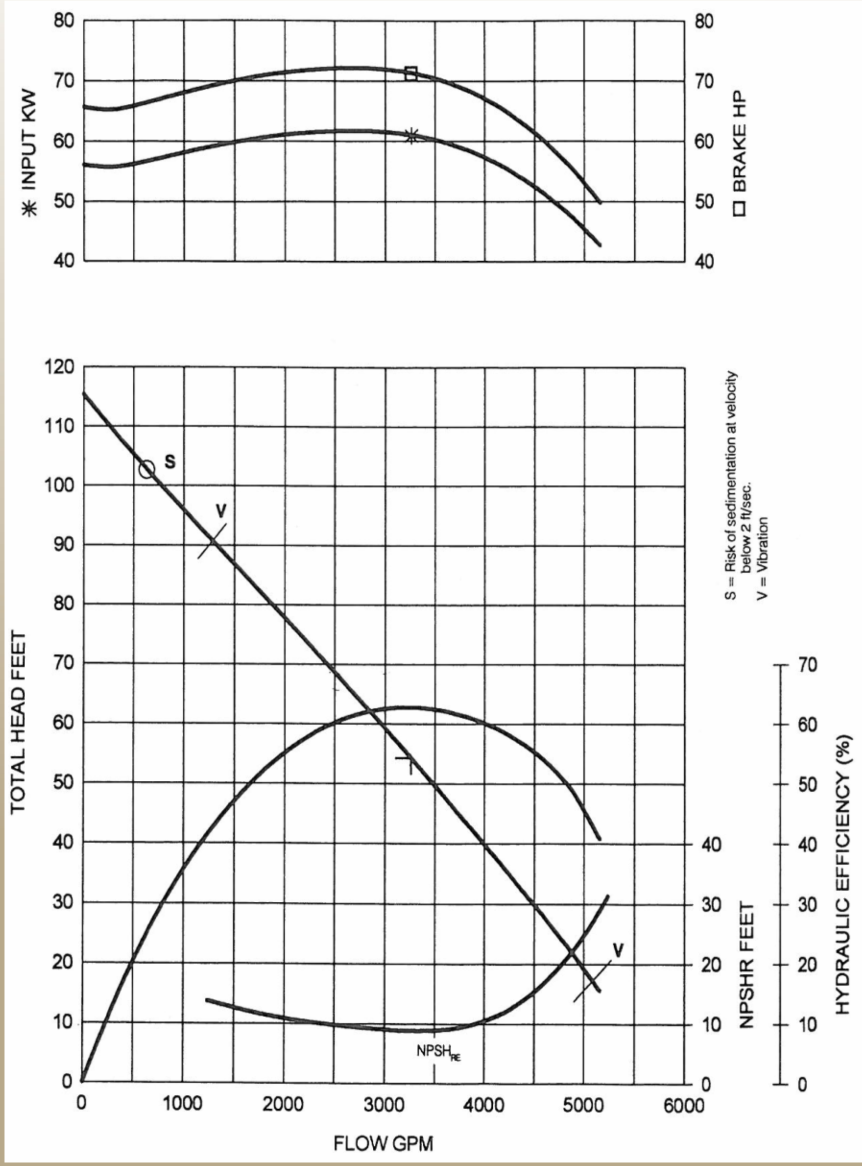
The nature of the problem…

- Some old, some new,
  some borrowed, some blue!
- Some pumps are used hourly
- Some pumps are not used every year
- All stations are unmanned and remote
- Observable performance opportunity is very limited
- Pumps valued at $5,000 to $360,000 each

What causes loss of performance?

- Age, years
- Run time, hours
- Rotational speed, rpm
- Wear due to abrasives, grit
- Corrosion due to electrolysis, salts
- Operating point off of best efficiency point

Performance Curve Example



Why is pump performance so important?

- “Off” performance causes premature seal and bearing failure thru increase vibration
- Pump repair/replacement requires equipment downtime, labor, and capital
- Pump performance affects power consumption
- Power consumption directly affects operating costs

Typical telemetered signals

- On/off
- Accumulated run time
- Wet well level
- Pump amps
- Station entry
- Loss of power

Instrumentation & SCADA limitations

- Reliability of primary sensors for flow, pressure, level, or power
- Data transients and anomalies
- Loss of calibration, both sudden and decay
- Loss of transmission signal
- Limitations in data storage and accessibility

Telemetering is a great tool, but in most cases the SCADA WORLD is not enough to determine <u>individual pump performance</u> in a reliable way.

The case for field testing …

If you want to know how your pumps are performing (overall efficiency), hands-on field testing is the best way to find out.

Field testing – what is involved?

1. Collect & review existing records
2. Visit sites & gather more input information
3. Analyze station hydraulics
4. Develop test procedure; know expected values
5. Install test instruments
6. Perform field test
7. Analyze results
8. Draw conclusions

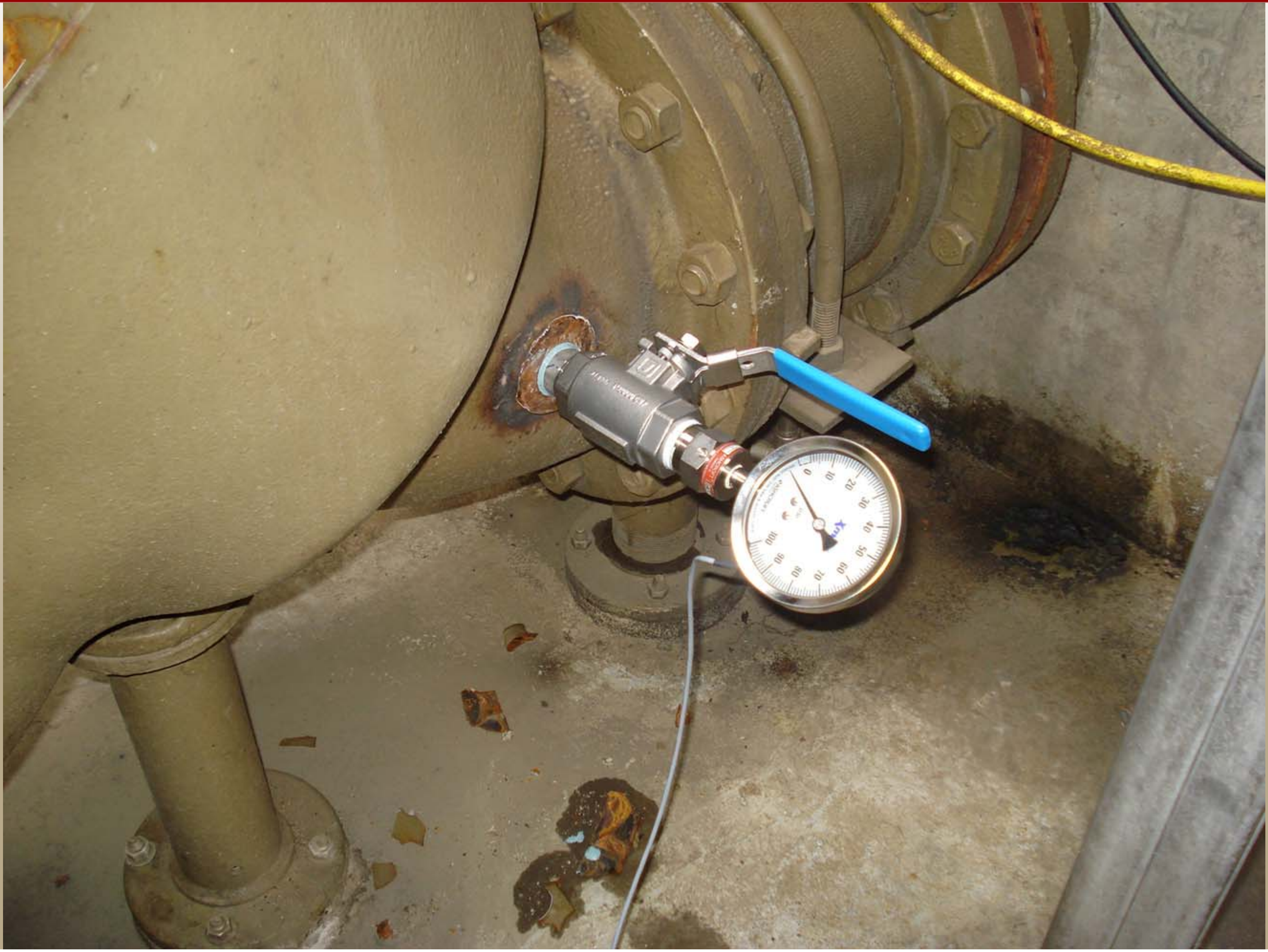
Test parameters

- Flow or volume and time
- Level
- Pressure / head
- Power

Portable Ultrasonic Flowmeter

Portable Ultrasonic Level Sensor

Transmitting Pressure Gauge



Polyphase Wattmeter

Data Logger

The Columbus experience

- Flow metering versus draw test
- Pressure gauges vs pressure transducers
- Level sensing vs stick measurement
- Ammeter vs polyphase watt metering
- Measuring power vs use of power bills
- Electronic data logging vs manual

Points to consider in field testing

- Ultrasonic flow meters – may be affected by throttling valve
- Force mains are dynamic – water surge pressure waves may be experienced
- Pressures may be positive or negative – sensors must be selected accordingly
- Voltages over 600 – requires special power metering equipment

Further points to consider

- Field testing is not as accurate or as repeatable as factory testing
- High usage stations may justify permanent power monitoring
- Station voltages above 1000 volts, may justify permanent power monitoring

Typical output from field testing

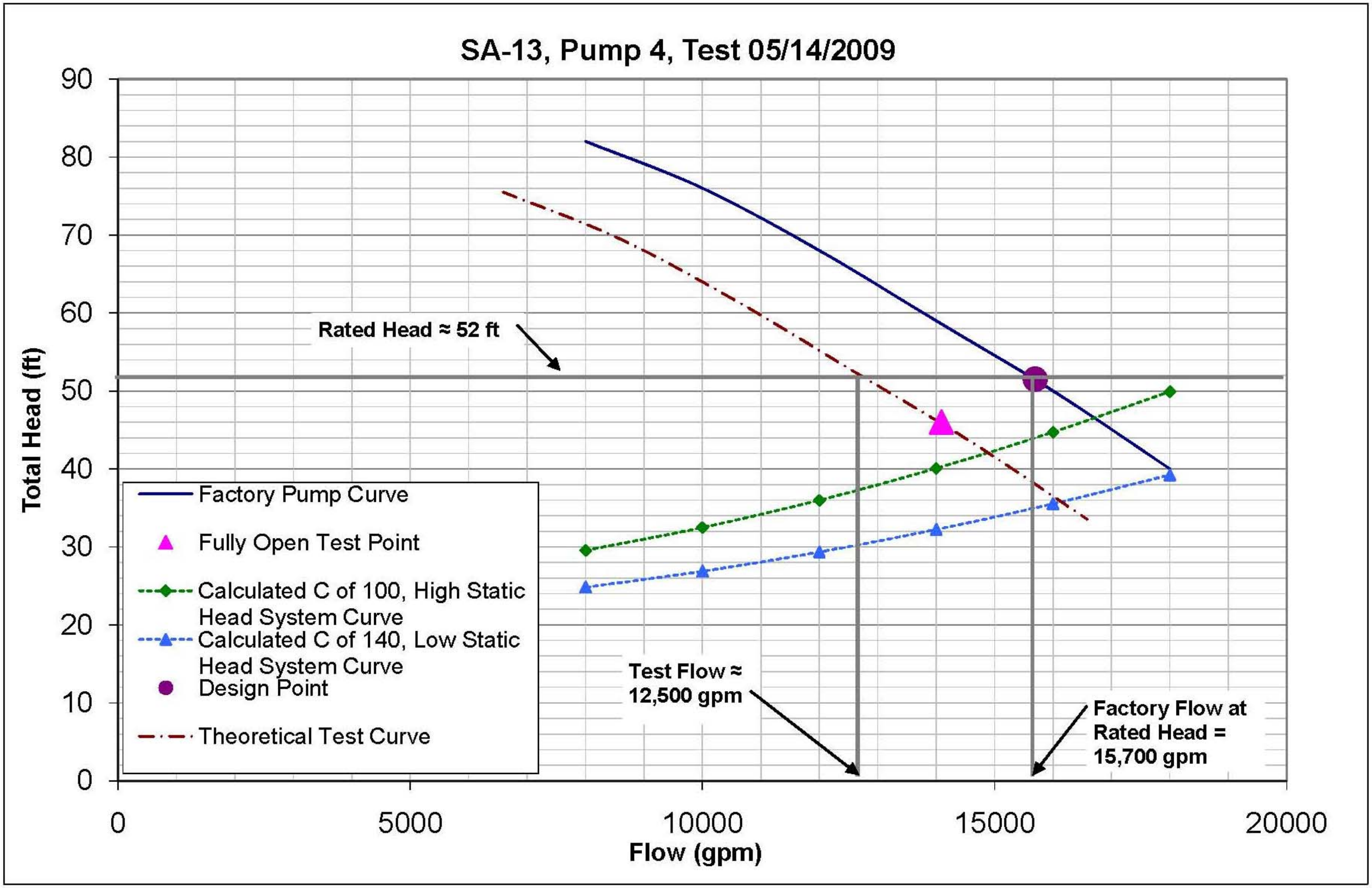
PUMP TEST DATA FORM

STATION NO:	SA-13	PWR FACT:		DATE:	5/14/09
LOCATION:	585 Sullivant Ave	VOLTAGE:		CREW:	AL, ML, JR
PUMP NO:	#4, Runs 1+2	SPEED:		WEATHER:	Partly Cloudy, ~75°

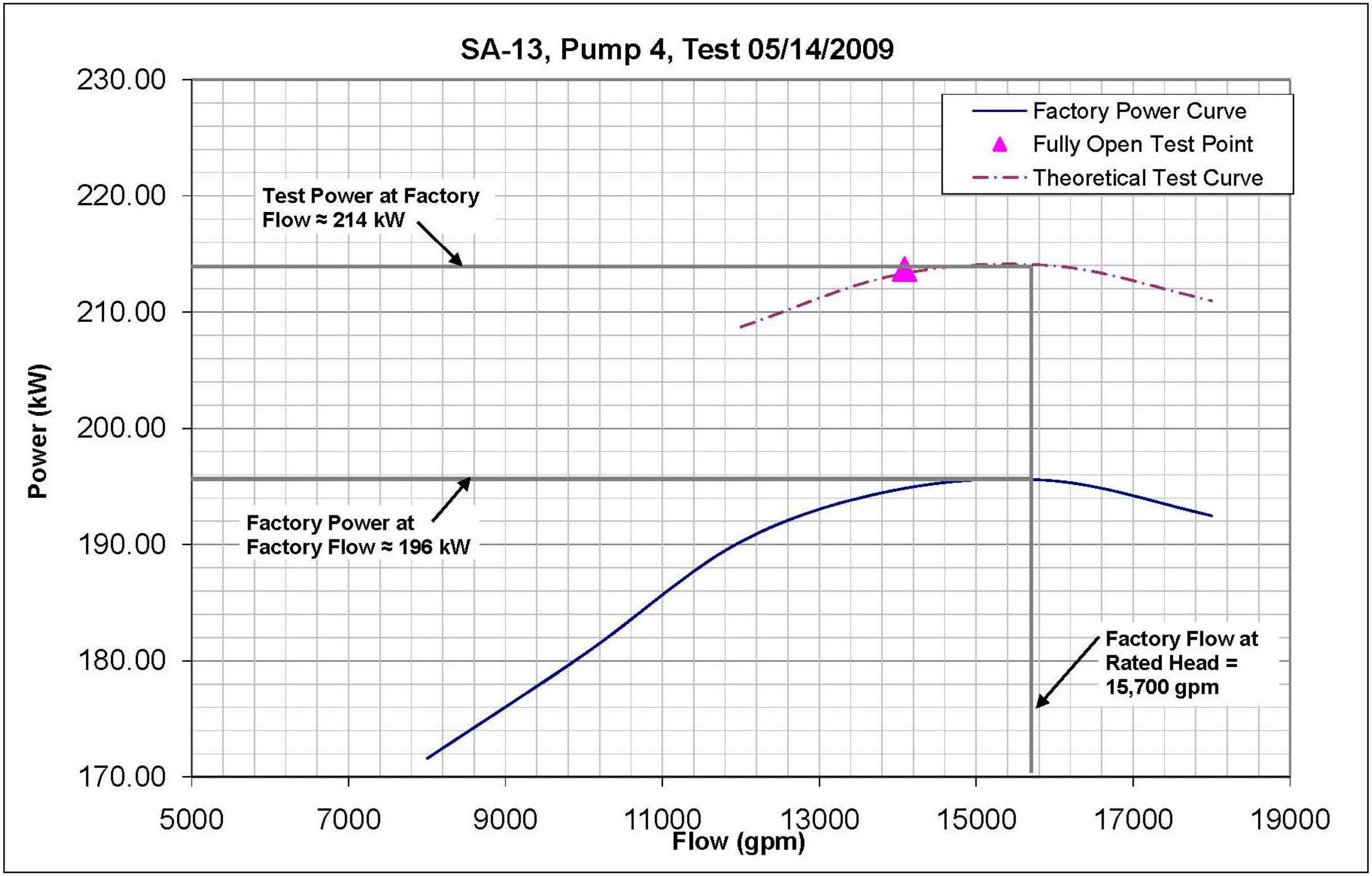
	(A) Time, hh:mm:ss	(B) Wet Well Level, ~~ft~~ in	(C) Displace Flow, gpm	(D) Metered Flow, gpm	(E) Discharge Pressure, psig	(F) Electrical Power, kwatts	(G) Electrical Current, amps	(H) Remark
(1)	10:24:12	240.51		–	20.44	216.8	–	
(2)	+:20	243.69	13,579	–	19.95	209.5	–	
(3)	+:40	247.10	14,752	–	20.53	218.3	–	
(4)	+:60	250.39	14,233	–	20.78	215.4	–	
(5)	+:80	253.57	13,805	–	20.63	209.5	–	
(6)	+:100	256.63	13,284	–	22.18	211.0	–	
(7)	+:120	259.24	13,717	–	22.46	216.8	–	
(8)								
(9)	10:55:24	239.49		–	19.02	212.5	–	
(10)	+:20	243.01	15,031	–	19.84	212.5	–	
(11)	+:40	246.19	13,757	–	20.03	216.8	–	
(12)	+:60	249.71	15,228	–	19.32	212.5	–	
(13)	+:80	252.77	13,284	–	21.08	215.4	–	
(14)	+:100	255.95	13,805	–	21.76	211.0	–	
(15)	+:120	258.11	14,560	–	21.94	213.9	–	

NOTES:

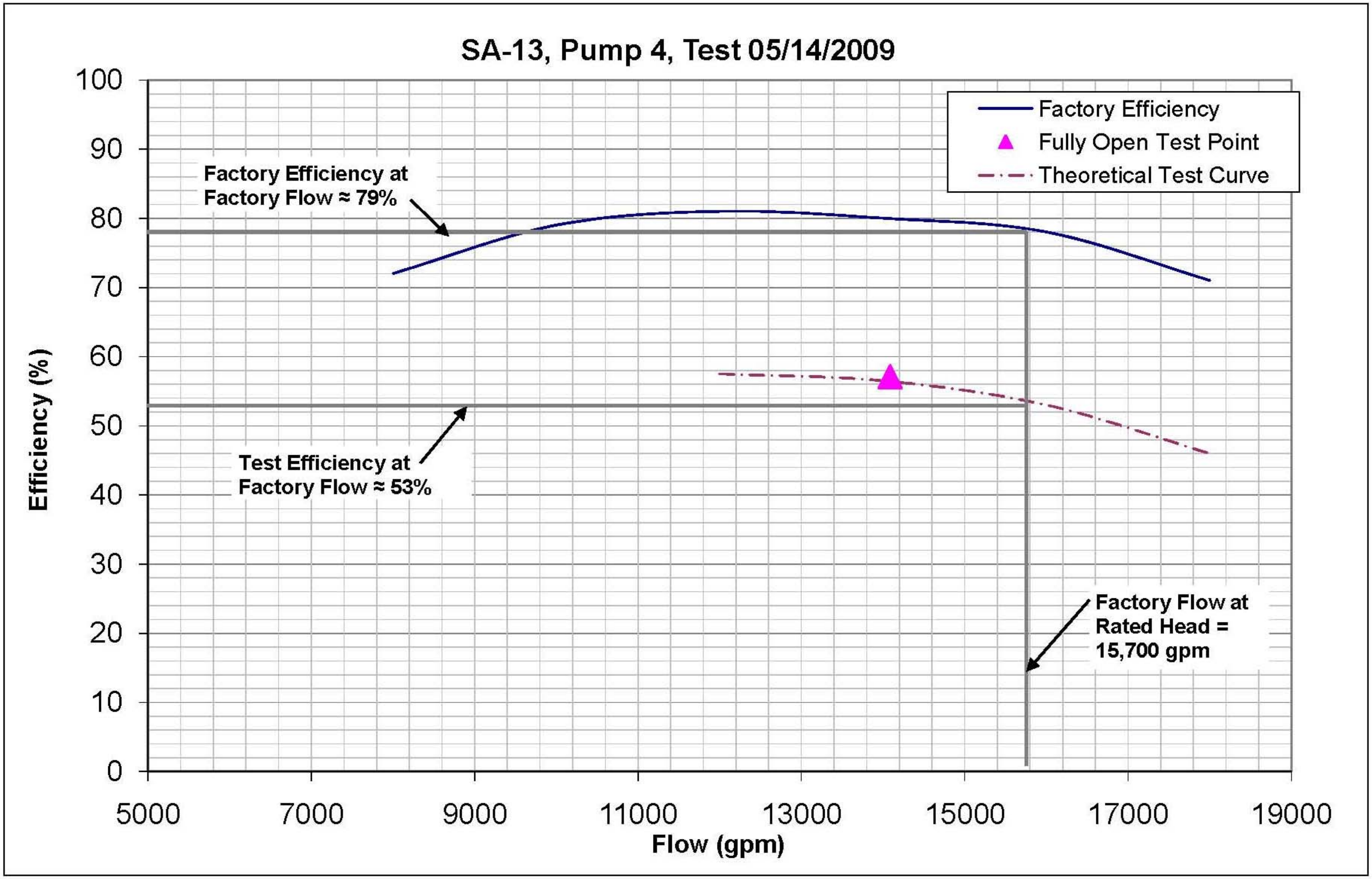
Head performance curve



Power performance curve



Overall efficiency performance curve



Annual Pumping Cost

For a given pump, must know …

- Rate of flow, Q
- Head at Q
- Annual run time
- Overall efficiency at Q
- Unit cost of power

Concept of efficiency deficiency

- Efficiency of perfect machine
  - Versus
- Overall efficiency as field measured
  - Efficiency of variable frequency drive
  - Efficiency of motor
  - Efficiency of transmission shaft & couplings
  - Efficiency of pump

Prioritization among multiple pumps

- Highest water horsepower (flow X head)
- Most annual run time
- Greatest overall efficiency deficiency
  - Perfect machine – field measured efficiency
- Highest unit power cost

Together this allows calculation of highest Present Value of "wasted" power – a priority rating tool

Priority Table

TABLE PRO-2b - PRIORITIZATION FOR UPGRADES									
Sorted by Current Priority									
Station No. (1)	Pump No. (2)	Test Flow gpm (3)	Test Head feet (4)	Water Horse-power whp (5)	Annual Run Time hours (6)	Overall Efficiency % (7)	Unit Cost of Power $/kwh (8)	Present Value of Lost Power $	Current Priority % (10)
SA-02	1	3,900	106	104	1,213	44	0.042	38,992	15.7
SA-02	3	4,100	115	119	490	58	0.105	25,553	10.3
SA-02	2	3,900	102	100	878	50	0.042	21,339	8.6
SA-13	1	660	72	12	3,034	47	0.074	17,501	7.0
SA-13	2	730	80	15	2,619	55	0.074	13,471	5.4
SA-05	2	2,650	24	16	2,988	48	0.042	12,578	5.1
SA-01	2	6,050	52	79	959	62	0.042	11,297	4.5
SA-05	3	2,500	18	11	2,273	38	0.042	10,196	4.1
	68							248,365	
NOTES:									
1	Lost Power is the difference between operating the actual pump and a perfect machine.								
2	Present Value is based on interest rate (%) of:					5	and period (years):		10

Summary

- Loss of pump performance and increased power consumption frequently goes undetected
- Loss of pump performance wastes energy and literally sends money down the drain
- In general, permanent metering systems do not measure pump performance reliably
- Pump performance can be measured in the field with calibrated portable instruments
- Field-measured pump performance is a useful tool to prioritize repair/replacement projects