Irrigating Smart

Conserves Water
Saves Money
Reduces Energy

Irrigation Pumping Plant Efficiency Testing

LSU AgCenter
Research & Extension

AgriLIFE EXTENSION
Texas A&M System

UA
DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

NM STATE UNIVERSITY

Basics of On-site Pumping Plant Evaluations

Nicholas Kenny, P.E. – Extension Irrigation Specialist, Texas A&M University

An irrigation pumping plant is made up of two primary components – the motor and the pump.

In simplistic terms, a motor converts input energy from a fuel source (electricity, natural gas, diesel, etc.) into rotational power that turns a pump, which, subsequently lifts and/or pressurizes water. Following this process, it is not difficult to see that a pumping plant that can deliver water with the least amount of input energy provides economic and operational benefits.

A pumping plant evaluation is a testing method that allows for individual pumping plant components to be evaluated for efficiency to help in determining component sizing, replacement, compatibility and the associated economics.

GM 7.4L V8 during testing. On-site evaluations are effective primarily due to simultaneous measurement of fuel flow, water pressure and flow, depth to water and horsepower.

Testing Process

To perform a pumping plant evaluation the pumping plant must be completely shut down to allow the testing apparatus to be installed in the fuel line or control panel, driveline, pipeline and well. The pumping plant is then operated under representative conditions, and measurements are taken. Intermediate results usually are available immediately following testing, typically followed by formal results upon further review. No permanent alterations are made to the pumping plant during testing.

Internal Combustion Engine

To evaluate the efficiency of an internal combustion engine (natural gas, diesel, gasoline, etc.) the incoming fuel flow and the output horsepower are measured. The potential energy of the consumed fuel is calculated to provide a baseline for the amount of energy provided to the engine. During a formal test, natural gas or diesel meters may be used to record the fuel consumption over a brief period of time. Long-term consumption can be determined from fuel bills, delivery records and the total hours of operation covered during a given period.

The output power of an engine is a bit more complicated to evaluate since it requires a torque cell to be installed in the driveline. A torque cell is a rotational dynamometer that can measure the twisting force applied by the motor to turn the pump. Most torque cells have an rpm ring installed that also allows for the measurement of horsepower during operation. The thermal efficiency of the

Lebow 1243-20K torque cell in operation. The lines from the torque cell transmit torque and rpm signals to a Daytronics 4K/HP monitor that displays continuous torque, rpm and horsepower readings.

engine is calculated by comparing the potential energy of the consumed fuel with the actual power produced by the engine during typical operation.

	Btu/Unit	Engine Efficiency	Replacement
Natural Gas (MCF)	1,000,000	23%	20%
Gasoline (gal.)	125,000	23%	20%
Diesel (gal.)	139,000	35%	33%
Propane (gal.)	91,000	23%	20%
Ethanol (gal.)	76,000	23%	20%
Electricity (KWh)1	3,412	80-95%	Failure

Electric Motor

The same principle of input energy applies to evaluating electric motors, although nameplate efficiencies generally are used in determining the output power. This is because it is very difficult to measure output power of an electric motor during on-site testing and because electric motors generally retain efficiency until failure. The most reliable method for testing electrical consumption is to measure voltage and current of the incoming power using a True-RMS clamp meter. On-site electrical meters can be used if electrical multipliers are known, if the meter is readable and if the motor being tested is the only appliance on the meter.
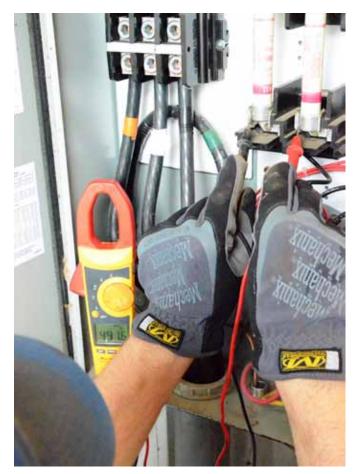
The input power measured can then be multiplied by the nameplate motor efficiency to provide the power produced by the motor. In cases where nameplates are missing or are not accessible, standard efficiencies are suitable.

Pump and Well

The output horsepower from the engine or motor also serves as the input horsepower to the pump and is used to evaluate the combined pump and well efficiency. The required horsepower for a pump during any given pumping condition is calculated using the water horsepower equation based on water flow, pumping depth, water pressure and well column friction. These parameters are measured using water flow meters, well depth measurement tools, pressure gauges and calculations, respectively.

Typical digital electrical meter.

Testing voltage with Fluke 336 True-RMS clamp meter.

$$HP = \frac{Q * TDH}{3960 * Eff.}$$

Where: *HP* = required pumping horsepower
       Q = water flow in gallons per minute
       TDH = Total Dynamic Head in feet
       3960 = constant unit conversion factor
       Eff. = pump and gear head efficiency

The combined pump and well efficiency can be calculated by comparing the output horsepower of the engine or motor with the theoretical water horsepower. About 75 percent efficiency is considered the standard expected efficiency for a properly fitted pump in actual field pumping locations. Depending on fuel costs, 55-60 percent efficiency is the economic replacement threshold.

Overall Efficiency

The overall efficiency of a pumping plant is the ratio of the water horsepower to the potential energy. This can be calculated by multiplying the engine efficiency and the pump/well efficiency or it can be figured directly. The overall efficiency typically is calculated in cases where a torque cell is not available or not able to be installed. Expected overall efficiencies for pumping plants are 16 percent, 25 percent and 67 percent for new, properl- sized natural gas, diesel and electric pumping plants, respectively.

Benefits of Pumping Plant Evaluations

The energy cost associated with pumping irrigation water generally is a significant expense and occasionally is the single largest budget line item. Thus, the most valuable information that comes from an evaluation of an irrigation pumping plant is the economic improvement that can be associated with equipment upgrades or replacements, properly sized components and changes in operational parameters. Basic pumping plant improvements that have been the direct results of recent pumping plant evaluations include:

- An increase in pumped water and reductions in pumping costs with a pump replacement.
- Proper sizing of electrical pumping plant in diesel conversions.
- Identify when engines should be replaced or rebuilt.
- Proper mixture ratio of natural gas and diesel in dual fuel applications.
- Adjustment of engine rpm to match maximized efficiency.
- Replacement of gear head to match engine speed with pump rpm.
- Resizing of engine to match pump and generator load (center pivot powered by genset).
- Evaluation of economic feasibility of on-site natural gas electrical generation.
- Evaluation of alternative fuels such as hydrogen, biodiesel, etc.

www.LSUAgCenter.com