Energy Tips – Pumping Systems

Pumping Systems Tip Sheet #4 • September 2005

Industrial Technologies Program

Suggested Actions

- Survey the priority pumps in your plant and conduct efficiency tests on them.
- Identify misapplied, oversized, or throttled pumps, or those that have bypass lines.
- Identify pumps with operating points below the manufacturer's pump curve (if available); estimate energy savings of restoring the system to its original efficiency.
- Identify pumps with flow rates of 30% or more from the BEP flow rates, or with system imbalances greater than 20%.
- Determine the cost effectiveness of each improvement.

Resources

DOE and Hydraulic Institute, *Improving Pumping System Performance: A Sourcebook for Industry.*

Hydraulic Institute—HI is a non-profit industry association for pump and pump system manufacturers; it provides product standards and a forum for the exchange of industry information for management decision-making. In addition to the ANSI/HI pump standards, HI has a variety of energy-related resources for pump users and specifiers, including training, guidebooks, and more. For more information, visit www.pumps.org, www.pumplearning.org, and www.pumpsystemsmatter.org.

U.S. Department of Energy—DOE's Pumping System Assessment Tool (PSAT) can help you assess pumping system efficiency and estimate energy and cost savings. PSAT uses pump performance data from Hydraulic Institute standards and motor performance data from the MotorMaster+ database.

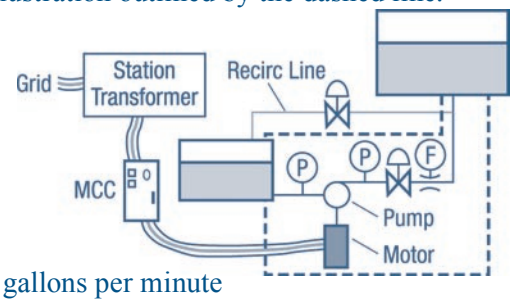
Visit the BestPractices Web site at www.eere.energy.gov/bestpractices for more information on PSAT and for upcoming training in improving pumping system performance and in becoming a qualified pumping system specialist.

Test for Pumping System Efficiency

A pump's efficiency can degrade as much as 10% to 25% before it is replaced, according to a study of industrial facilities commissioned by the U.S. Department of Energy (DOE), and efficiencies of 50% to 60% or lower are quite common. However, because these inefficiencies are not readily apparent, opportunities to save energy by repairing or replacing components and optimizing systems are often overlooked.

Define Pumping System Efficiency

System efficiency incorporates the efficiencies of the pump, motor, and other system components, as shown in the area of the illustration outlined by the dashed line.



Pumping system efficiency (η_{sys}) is defined as follows:

$$\eta_{sys} = \frac{Q_{req} \times H_{req} \times SG}{5308 \times P_e},$$

where

Q_{req} = required fluid flow rate, in gallons per minute
H_{req} = required pump head, in feet
SG = specific gravity
P_e = electrical power input.

Only the required head and flow rates are considered in calculating system efficiency. Unnecessary head losses are deducted from the pump head, and unnecessary bypass or recirculation flow is deducted from the pump flow rate.

Conduct Efficiency Tests

Efficiency tests help facilities staff identify inefficient systems, determine energy efficiency improvement measures, and estimate potential energy savings. These tests are usually conducted on larger pumps and on those that operate for long periods of time. For details, see Hydraulic Institute standards ANSI/HI 1.6-2000, Centrifugal Pump Tests, and ANSI/HI 2.6-2000, Vertical Pump Tests.

Flow rates can be obtained with reliable instruments installed in the system or preferably with stand-alone tools such as a sonic (Doppler-type) or "transit time" flow meter or a Pitot tube and manometer. Turbulence can be avoided by measuring the flow rate on a pipe section without fittings at a point where there is still a straight run of pipe ahead.

Improve System Efficiency

Internal leaks caused by excessive impeller clearances or by worn or misadjusted parts can reduce the efficiency of pumps. Corrective actions include restoring internal clearances and replacing or refurbishing worn or damaged throat bushings, wear rings, impellers, or pump bowls. Changes in process requirements and control strategies, deteriorating piping, and valve losses all affect pumping system efficiency.

Potential energy savings can be determined by using the difference between actual system operating efficiency (η_a) and the design (or optimal) operating efficiency (η_o), or by consulting published pump curves, as available, for design efficiency ratings.

Software tools like DOE's Pumping System Assessment Tool (PSAT) also provide estimates of optimal efficiency. When the required head and flow rate, as well as actual electrical data, are input into the software, PSAT will account for artificial head and flow losses.

The equation for calculating potential energy savings is as follows:

$$\text{Savings} = kW_{in} \times t \times (1 - \eta_a/\eta_o) ,$$

where

savings = energy savings, in kilowatt-hours (kWh) per year
kW_{in} = input electrical energy, in kilowatts (kW)
t = annual operating hours
η_a = actual system efficiency, calculated from field measurements
η_o = optimal system efficiency.

Example

Efficiency testing and analysis indicate that a 300-horsepower centrifugal pump has an operating efficiency of 55%. However, the manufacturer's pump curve indicates that it should operate at 78% efficiency. The pump draws 235 kW and operates 6,000 hours per year. Assuming that the pump can be restored to its original or design performance conditions, estimated energy savings are as follows:

$$\text{Savings} = 235 \text{ kW} \times 6{,}000 \text{ hours/year} \times [1 - (0.55/0.78)] = 415{,}769 \text{ kWh/year.}$$

At an energy cost of 5 cents per kWh, the estimated savings would be $20,786 per year.

References

Centrifugal Tests (ANSI/HI 1.6-2000), Hydraulic Institute, 2000.

Conduct an In-Plant Pumping System Survey, DOE Pumping Systems Tip Sheet, 2005.

Match Pumps to System Requirements, DOE Pumping Systems Tip Sheet, 2005.

Trim or Replace Impellers on Oversized Pumps, DOE Pumping Systems Tip Sheet, 2005.

About DOE's Industrial Technologies Program

The Industrial Technologies Program, through partnerships with industry, government, and non-governmental organizations, develops and delivers advanced energy efficiency, renewable energy, and pollution prevention technologies for industrial applications. The Industrial Technologies Program is part of the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

The Industrial Technologies Program encourages industry-wide efforts to boost resource productivity through a strategy called Industries of the Future (IOF). IOF focuses on the following eight energy and resource intensive industries:

- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Petroleum
- Steel

The Industrial Technologies Program and its BestPractices activities offer a wide variety of resources to industrial partners that cover motor, steam, compressed air, and process heating systems. For example, BestPractices software can help you decide whether to replace or rewind motors (MotorMaster+), assess the efficiency of pumping systems (PSAT), compressed air systems (AirMaster+), steam systems (Steam Scoping Tool), or determine optimal insulation thickness for pipes and pressure vessels (3E Plus). Training is available to help you or your staff learn how to use these software programs and learn more about industrial systems. Workshops are held around the country on topics such as "Capturing the Value of Steam Efficiency," "Fundamentals and Advanced Management of Compressed Air Systems," and "Motor System Management." Available technical publications range from case studies and tip sheets to sourcebooks and market assessments. The Energy Matters newsletter, for example, provides timely articles and information on comprehensive energy systems for industry. You can access these resources and more by visiting the BestPractices Web site at **www.eere.energy.gov/ industry/bestpractices** or by contacting the EERE Information Center at **877-337-3463** or via email at **www.eere.energy.gov/informationcenter/.**

BestPractices is part of the Industrial Technologies Program Industries of the Future strategy, which helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and best energy-management practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

BestPractices emphasizes plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-size manufacturers.

FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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