"TURNING INFORMATION INTO ENERGY SOLUTIONS FOR INDUSTRY"

ENERGY MATTERS

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A California refinery's plant-wide assessment identifies $52.5 million in energy savings. See page 6.

Compressed Air's Role in Productivity

By Frank Moskowitz, DRAW Professional Services, Cave Creek, AZ

Compressed air is one of the most important utility requirements of the typical industrial manufacturer. Compressed air is used throughout many applications and processes such as pneumatic tools, pneumatic controls, compressed air-operated cylinders for machine actuation, product cleansing, and blow-offs. Without a consistent supply of quality compressed air, a manufacturing process can stop functioning.

Compressed air is the third most important utility to industry (behind heating, ventilating and air conditioning—HVAC—and lighting), and is commonly the most misunderstood system. Compressed air systems hold one of the keys to greater productivity, efficiency and profitability.

The Compressed Air Challenge® (CAC) is a national collaboration created to assist industrial facilities in achieving greater reliability, improved quality control, and lower operating costs for their compressed air systems. The CAC encourages facilities to take a systems approach to optimizing compressed air operation. Taking a systems approach means looking beyond individual components to assess how well your compressed air system meets actual production needs. This is known as "matching supply with demand". It also means identifying the root causes of system problems, rather than treating the symptoms.

The CAC has one purpose in mind—helping you improve the performance of your compressed air system.

In the United States, compressed air systems account for $1.5 billion per year in energy costs, and 0.5% of emissions. Many industries use compressed air systems as power sources for tools and equipment used for pressurizing, atomizing, agitating, and mixing applications. Optimization of compressed air systems can provide energy efficiency improvements of 20% to 50%. The Industrial Technologies Program, a program within the DOE's Energy Efficiency and Renewable Energy Network,

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Coors Brewing Co./PIX 03232

In industrial settings, 90% of companies use compressed air in some aspect of their operations.

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provides an assortment of tools and resources to help industrial end users achieve efficiency improvements and related cost savings.

The CAC has developed two levels of training for plant engineers: "Fundamentals of Compressed Air Systems" and "Advanced Management of Compressed Air Systems." Compressed air systems can give you fairly direct indications that a problem exists, but finding the right solution and fixing the problems aren't always obvious.

- That new super-fast packaging machine you just installed was supposed to package 1,000 widgets an hour. However, the compressed air pressure delivered to the machine just can't seem to be sustained. It fluctuates by 20 PSI during different times of the day. In order to avoid shutdowns, the output of the packaging machine has been reduced to only 300 widgets per hour. The machine seems to run properly at this level and the pressure fluctuations don't result in shutdowns. However, the costly end result is lower productivity.
- The computer numerical control (CNC) milling machine, which can mill an aluminum component in two hours, is critical for a new contract your company just received from a major aerospace manufacturer. You need to produce three of these components per shift. The low-pressure safety switch on the milling machine is set at 95 psig (that's where you were told to set it by your boss). Any pressure below that will shut it down. Momentary pressure dips during the day are indeed causing the milling machine to occasionally shut down. Scrap rate is at two pieces per shift. The end result is less productivity, overtime to make up lost parts, and a high-dollar scrap rate.

There are many more examples of how compressed air systems behave erratically. Perhaps you are already thinking of your own compressed air system-related problems. You're not alone.

Problems Widespread

In today's industrial settings, approximately 90% of companies use compressed air in some aspect of their operations. Of this percentage of users, approximately two-thirds have some form of problem with their systems (either obvious or not). Some of these problems have arisen from installing incorrect types of compressors, improper cleanup equipment, inappropriate control methods or unsound installation practices. The bottom line is that the

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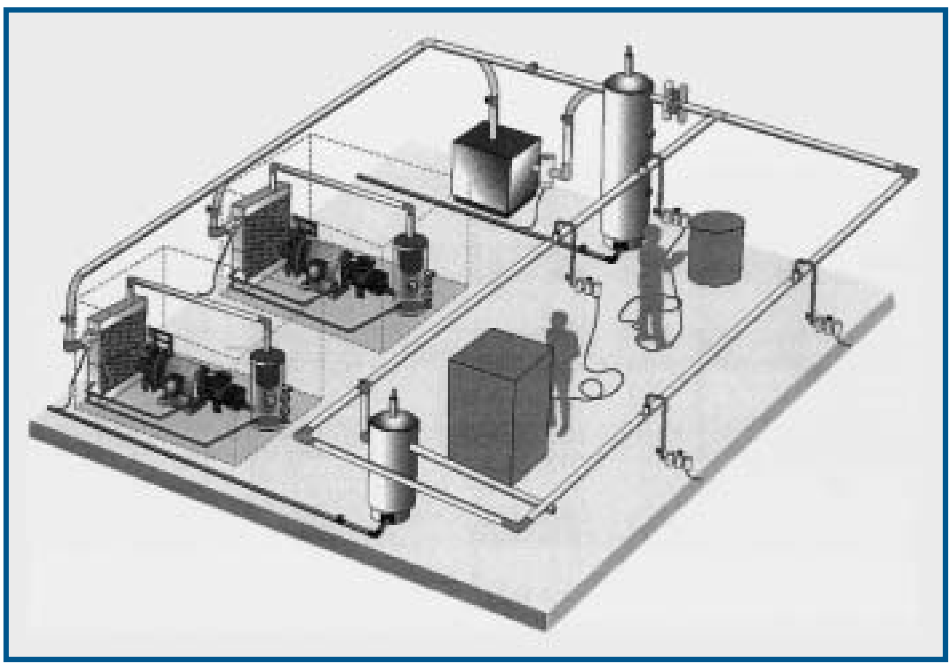

Schematic of a typical compressed air system used in an industrial setting.

problems are costly in the long run. These hidden costs can be seen in reduced equipment life and noticeable operating costs. These are all symptoms of a much larger problem: the general lack of understanding of compressed air systems. There is no such thing as a foolproof compressed air system. Even the best of systems have the potential for serious problems.

Almost every compressed air system has room for performance improvement, from a modern system in a two-year-old plant to one that has been modified and updated over the last 40 years.

If you use compressed air in your facility, your best defense against such experiences is to have a fundamental understanding of how your compressed air system functions and what forces (outside or inside) are influencing it.

Improving the performance of your compressed air system will not only reduce energy costs, but will lead to:

- Reduced downtime
- Increased throughput
- Lower scrap rate
- Improved product quality
- Longer equipment life.

Using compressed air systems efficiently can have a significant effect on costs as well as increase productivity and reliability. For a compressed air system to work efficiently and reliably, both the supply side (the compressors, air treatment equipment, and primary storage) and the demand side (the distribution, secondary storage systems, and the end-use equipment) must be managed. A properly managed supply side will result in clean, dry, stable air being delivered at the appropriate pressure in a dependable, cost-effective manner. A properly managed demand side minimizes wasted air and uses compressed air for appropriate applications.

How Can the Compressed Air Challenge® Benefit You? By Helping You Learn to Do the Following

1. ***Calculate compressed air as a cost of production.*** *Compressed air is seldom considered as a contributing cost of production. Instead, compressed air costs are typically blended into overhead and often thought of as free. Do you know your actual costs for producing compressed air?*
2. ***Control energy costs at the source.*** *Existing compressed air systems in the U.S. consume an estimated 90 billion kilowatt-hours per year of electricity. Are your compressed air energy costs under control?*
3. ***Balance your compressed air system and save.*** *Many of today's compressed air systems have been pieced together over the years in an attempt to meet the growing needs of production and facility expansion. The result is often an unbalanced system with various components negatively interacting to create artificial demands and poor air quality. This certainly has a negative effect on man-hours and production. Do you experience inconsistent air quality and fluctuating air pressure?*
4. ***Sharpen your competitive edge.*** *Compressed air is vital to the operation of every industrial plant. An efficient compressed air system will increase productivity and ensure better product quality. The more reliable your compressed air system, the lower the cost is to produce your product—not to mention on-time delivery and increased customer satisfaction. Are you looking for a competitive edge?*
5. ***Optimize your compressed air system.*** *Compressed air energy can cost 7 to10 times more than electrical energy when it comes to doing mechanical or process related work. An optimized system ensures that efficient and effective compressed air is available for the lowest possible cost. Have your production and management teams implemented a plan to enhance your compressed air system?*

Systems Approach

Improving and maintaining peak compressed air system performance requires addressing both the supply and demand sides of the system and how the two interact. This practice is referred to as taking a "systems approach" because the focus is shifted away from the individual components to the total system performance. Applying the systems approach usually involves the following:

1. Develop a basic block diagram of your system
2. Measure your baseline (kilowatts, pressure, and leak load) of your system to determine the costs to operate
3. Work with your compressed air system specialist to implement an appropriate compressor control strategy
4. Once controls are adjusted, re-measure to get more accurate readings of kilowatts, pressure and leak load
5. Walk through to check for obvious preventive maintenance items and other opportunities to reduce costs and improve performance
6. Identify and fix leaks, correct inappropriate uses; then, knowing costs, remeasure and adjust controls as above
7. Evaluate results from the first six steps and implement an awareness and continuous improvement program.

With compressed air systems, system dynamics (that is, changes in demand over time) are especially important. The use of controls, storage, and demand management to effectively design a system that meets peak requirements, but also operates efficiently at part load, is key to achieving a high-performance compressed air system.

Demand Side Issues

Production interruptions are usually caused by the demand side. Let's identify several common areas where energy savings might be available:

- Find and fix leaks: Leaks are constantly occurring in an operating system, and often consume up to 30% of the total demand in a plant. Check all of the plant's point-of-use connections for the

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slightest hissing sound. An ultrasonic leak detector can identify leaks, even in a noisy industrial plant.

- Avoid the improper, yet common, practice of leaving manual condensate drains partially open in an effort to ensure moisture-free performance at a particular point-of-use. Even a timed electrical drain operating for 10 seconds open every 30 minutes can cost hundreds of dollars in compressed air each year. Look into zero air loss-type drains.
- Regulate all point-of-use operations at the lowest practical pressure using a good quality regulator. Be sure to use a good quality regulator, as poor quality regulators tend to drift and track. If the regulator tracks or drifts up 5 PSI, the application will use more air.
- Modify and, if possible, eliminate blow-offs. Because many blow-off applications use compressed air simply because it is there, check to see if a blower or fan could accomplish the same objective. Engineered nozzles are an excellent substitute for open pipes or hoses.
- Shut off the air supply to "idle" production equipment.
- If one point-of-use requires air pressure at a much higher level than the rest of the system, consider putting it on its own dedicated system. Don't run the entire system's pressure for a single use or point-of-use application. Consider using a separate compressor, amplifier, or booster that is sized for the function.

Piping Issues

The piping should be of the proper diameter to ensure that the air gets where it needs to go, when it needs to get there, and as close to the originating pressure and in the quality and quantity required.

- Minimizing pressure drop requires a systems approach in designing and maintaining the system. Air treatment components, such as aftercoolers, moisture separators, dryers, and filters, should be selected with the lowest possible pressure drop at specified maximum operating conditions of flow and temperature. When installed, the recommended maintenance procedures should be followed and documented.
- The pressure drop through the system also increases as the square of airflow rate (velocity). High volume intermittent demands can create peak airflow rates causing significant pressure fluctuations.

Supply Issues

In a multiple compressor system, all compressors should be baseloaded except for one, which should be trimming.

- Evaluate your need for modulating compressors. A modulating compressor operating at 40% output could still be consuming 80% of its power. There are other compressor controls that may be better suited for trimming.
- Lower the output pressure: For every 2 PSI change from rated pressure, the brake horsepower (BHP) required will change 1% from the rated BHP. Increase the pressure by 10 PSI and the BHP will go up 5%. Decrease the pressure by 20 PSI and the BHP will go down 10%.
- The electrical energy used by an industrial air compressor is converted to heat. A properly designed heat recovery system can recover 50% to 90% of this thermal energy. The recovered heat can be used for supplemental space heating, industrial process heating, water heating, makeup air heating, and boiler makeup water preheating.
- Utilize pressure/flow controllers. The higher the pressure delivered to the plant, the higher the artificial demand and the leakage. Pressure/flow controllers are high-performance pressure regulators installed on the supply side of the compressed air system. They have two simple effects on compressed air systems: they create stored air volume to handle peak requirements and lower system pressure to reduce artificial demand and leaks. ●

Evaluating Compressed Air Challenge® Training

In 2002 a Compressed Air Challenge Training Program Evaluation was conducted for the U.S. DOE in cooperation with Lawrence Berkeley National Laboratory and Oak Ridge National Laboratory.

As of July 2002:

- *3,872 individuals had attended the Fundamentals of Compressed Air Systems training course*
- *966 individuals had attended the Advanced Management of Compressed Air Systems training course*
- *Phone surveys interviewed 200 participants (100 end users +100 vendors)*
- *Technical review by CAC Ad Hoc Committee, to be published by U.S. DOE*

CAC Training Evaluation Findings

- *Estimated annual savings from participants in the training is approximately $12 million*
- *76% of customers participating in CAC systems training reported making significant capital or operating improvements to their compressed air system since attending the training*
- *Participants found the sessions both useful and of high quality*
- *Using conservative estimates, participants saved 8% of compressed air system energy on average as the direct result of the training*
- *End users who implemented compressed air system efficiency measures experienced significant non-energy benefits, including:*
  - *Reduced downtime*
  - *Reduced system moisture and contamination*
  - *More consistent system pressure.*

What are you waiting for? Visit the Compressed Air Challenge® web site for more information on training and events: ***www.compressedairchallenge.org***

Get Pumped: Meet the Newest PSAT Instructors

Tom Angle and Dan Wood want to pump you up.

Tom and Dan are among a growing number of pump specialists who scored high marks on a challenging exam and successfully completed a challenging training course, enabling them to become Qualified Pump System Assessment Tool (PSAT) instructors.

PSAT is a software program that helps users assess energy savings opportunities in pumping systems by relying on field measurements of flow rate, head, and either motor power or current to perform the assessment. Using algorithms from Hydraulic Institute standards and motor performance characteristics from U.S. DOE's MotorMaster+ database, PSAT estimates existing pump and motor efficiency and calculates the potential energy and cost savings of a system optimized to work at peak efficiency.

Tom Angle, PSAT Instructor, Weir Specialty Pumps

Dan Wood, PSAT Instructor, Flowserve

DOE has offered PSAT training sessions since 1999. Demand has been high for the software and training, and continues to grow. To meet the demand and increase the number of PSAT experts to assist end users, DOE is working with the pumping industry and its Allied Partner, the Hydraulic Institute, to train and qualify experts in the use of PSAT.

Among the latest to become Qualified PSAT instructors are Tom Angle, Director of Engineering and R&D at Weir Specialty Pumps in Salt Lake City, and Dan Wood, Manager of Educational Services at Flowserve Corp. in Irving, Texas. *Energy Matters* spoke with Tom and Dan to learn more about what PSAT can do to enhance pump efficiency, lower costs and help industry use energy more wisely.

Tom Angle sees PSAT as particularly important because few university engineering programs teach pump system applications. The techniques of the trade become "almost tribal knowledge" as a result, he says. PSAT training helps disseminate this important knowledge throughout industry.

Tom sees two big advantages to training. First, it helps demonstrate to pump users that there's a big upside potential to getting a better system in place. Second, it shows that better system will pay off in terms of lower operating costs and greater efficiency.

"By educating our customers, it lessens the chances that a pump is misapplied," Tom said.

Misapplied? How could that happen? Easily, Tom said.

A basic issue is that most everyone working on a system design tries to ensure that the system has enough capacity to handle production needs. After all, so the thinking goes, no one criticizes a system that includes a 50% safety factor. But almost everyone knows what happens if a system's 5% "shortfall" affects productivity.

But overspecifying a system can have its down side. For one thing, operating a pump below its optimal level can lead to cavitation and excessive wear and tear, Tom said. For another, the overall system may not work optimally.

Tom cites an extreme real-world example of overengineering to make his point. A few years ago, a customer wanted a high-speed pump. Based on the customer's system condition points, the pump had to run at 6,300 RPM. The process was a low-flow application of about 200 gallons per minute at 4,600 feet of head, translating to about 420 hp. The problem was that the net positive suction head simply wasn't going to work. The customer rethought the system in its entirety and asked what might happen if the application needed 2,000 feet of head instead of 4,600 feet. In that case, just 173 hp would be needed to operate the pump system. This meant not just a 50%-plus savings in horsepower, but a savings of 2,600 feet of head, too.

Had the customer not taken a systems approach to looking at his system, Tom said, he would have lost half of the total pressure across a control valve that in the end wasn't needed after all.

Dan agrees that a big benefit of taking the sort of systems approach that PSAT offers is that end users can see not only big energy savings, but first-cost savings as well. Designing an optimal system increases

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Meet the Newest PSAT Instructors
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reliability (by reducing vibration, radial loads, and pump failures, among other things), improves efficiency, and may lead to energy savings.

"It all blends together," Dan said.

A number of chemical and refinery customers are currently requesting PSAT training through Dan's office at Flowserve. Dan estimates the number of professionals who ultimately could benefit from this sort of training may number in the thousands.

Tom agrees, saying that more people than ever before are talking about life-cycle costing.

That's one of the chief positive aspects to the systems approach that PSAT offers, he said. "The economics are so irrefutable, it's something that will and has to succeed."

And the benefits don't flow just to large contractors who are building systems from scratch. Smaller-sized contractors working on site upgrades can benefit from the systems approach that PSAT training affords.

The PSAT workshops offered by dedicated industry professionals like Tom Angle and Dan Wood prepare other professionals by offering them extensive experience in pumping systems to use PSAT in their system assessments. Participants learn:

- How to accurately acquire input data for PSAT
- How to prescreen pumping systems to select the "vital" systems for further review
- How to use the PSAT software
- The difference between measurements and requirements
- The importance of a systems perspective.

Participants who complete the workshop and pass a qualifying exam will be recognized by DOE as Qualified Pump System Specialists, and will be listed on the BestPractices Web site. Specialists assist industrial customers in using PSAT to evaluate their pumping systems.

If you are a pump system professional interested in the PSAT qualification process, please contact Vestal Tutterow, Lawrence Berkeley National Laboratory at 202-646-7957. Check the BestPractices training calendar for announcements of upcoming PSAT qualification workshops. ●

Refinery ID's $52.5 Million in Savings Via Plant-Wide Energy Assessment

The Equilon oil refinery in Martinez, California, conducted a plant-wide energy assessment in May 2001. The assessment focused on three key areas: utilization of waste energy, process debottlenecking, and operations optimization. The resulting recommendations can be implemented in refineries throughout the industry.

The assessment identified potential annual savings of $52,485,000 with an estimated capital requirement of $30,993,000, and a 6-month payback. The study identified energy savings of 6,230,600 million British thermal units per year (MMBtu/year). This represents savings of approximately 12% of the total energy used at the facility.

The Martinez Refinery, located 30 miles northeast of San Francisco, began operating in 1915. It is now part of Equilon Enterprises LLC, a joint venture between the U.S. refining, marketing, and transportation assets of Shell Oil Co. and Texaco Inc. Equilon refines and markets gasoline and other petroleum products under both the Shell and Texaco brand names in 31 western states.

The refinery processes primarily San Joaquin Valley crude oil at the rate of 165,000 barrels of oil per day. It is a high-conversion refinery comprising catalytic cracking, hydrocracking, and coking operations as well as the basic distillation and catalytic reforming processes. The plant includes lubricants and asphalt facilities. Energy costs for the facility were approximately $185 million in 2000. This energy was provided by a combination of purchased natural gas and power from waste streams from the petroleum refining processes.

Assessment Overview

Encouraged by the Industrial Technologies Program, the Martinez plant initiated the plant-wide energy efficiency assessment in the spring of 2001. The Industrial Technologies Program co-sponsored the assessment as part of its efforts to improve industrial efficiency, waste reduction, productivity, and global competitiveness for Industries of the Future. Plant assessment partners included the Martinez refinery and Houston-based Shell Global Solutions.

The Martinez Refinery was the focus of a plant-wide energy assessment.

The study's objectives were to identify operational savings and highly leveraged investment opportunities to reduce energy consumption. Operational savings include those gained by modifying the operation of existing equipment, generally requiring no initial capital investment. Highly leveraged capital is that invested in a project that returns the initial investment in 2 years or less. Assessment personnel considered process operation requirements as well as the efficiency of energy procurement, distribution, and conversion to useful work.

Assessment staff reviewed the entire energy supply and use chain, including:

- Procurement of supplemental energy (usually natural gas and electrical power)
- Conversion of chemical to thermal energy (combustion efficiency or conversion from electricity to horsepower)
- Distribution efficiency (losses in getting the heat or power to its process use)
- End use of energy in the refining process.

The analysis revealed that optimizing the refining process operations to require less energy, while maintaining throughput and product specifications, would provide much of the available benefit. The assessment team employed a methodology that identified a wide range of conservation opportunities that met a 2-year or less sim-

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ple payback period. The total cost of the energy assessment was $275,000; DOE provided $100,000 in cost-share funding.

Assessment Implementation

The plant assessment began with a benchmarking evaluation of energy use, identifying both the procedural and hardware differences that distinguish the Martinez plant from the industry leaders in energy-efficient refining. As part of the data collection for this evaluation, all of the fired equipment (i.e., any equipment that burns fuel, including all process heaters and boilers) was performance tested using API-532 methodology. This methodology uses the flue gas temperature and stack stoichiometry to calculate the thermal efficiency of fired equipment.

Assessment personnel collected process data that included material properties, flows, temperatures, and pressures for most of the major process streams in every unit. Next, they compared actual performance to the petroleum industry's best practices standards to identify opportunities for improvement. The team then estimated the cost of each proposed change and evaluated the return on investment against the criteria for highly leveraged investment.

A joint team of refinery and corporate personnel then met with the operating and technical support personnel for each of the refinery processing units. This team conducted a data-based review of current operations, looking for opportunities to apply industry-leading operational practices and hardware design. Because many process-related ideas involve some tradeoff between process yields and energy use, the team supported whichever outcome resulted in the greatest economic benefit.

Opportunities were considered in the following three primary areas.

1. **Utilization of waste energy**
   - Flaring
   - Steam vents and leaks
   - Fouling in condensing turbines and educators (i.e., steam-powered venturis used to draw a vacuum on a steam turbine surface condenser)
   - Boiler blowdown control
   - Surface condenser vacuum
   - Heat exchanger bypassing
   - Fired equipment excess air and excess draft
   - Unit recycle and minimum flow
   - Energy conservation equipment (This equipment includes waste heat boilers, air preheat, hydraulic turbines, steam turbines to minimize letdown, feed/effluent exchangers.)
2. **Process debottlenecking**
   - Furnace limits (tube metal temperature limits that constrain the maximum firing rate on furnaces in coking service)
   - Condenser limits (heat transport limitations in distillation column overhead condensers that limit column capacity at a given operating pressure).
3. **Operations optimization**
   - Management systems and targets (optimization instructions given to operating personnel to control unit operation)
   - Distillation
   - Use of minimum steam pressure
   - Furnace and heat exchange
   - Cost of power
   - Hydrogen system optimization
   - Condensate return
   - Heat integration.

Once the energy-saving opportunities were reviewed, the assessment team estimated the energy savings that would be gained by implementing the most promising ideas. This was accomplished by using historical operational data and by developing a scope estimate of the necessary changes. The team also identified process risks associated with these changes. Recommendations were limited to process technology already successfully implemented in other facilities.

The assessment produced recommendations with an estimated annual benefit of more than $52 million. The scope of these changes ranges from procedural modifications to significant hardware redesign.

Actions Identified

The assessment identified opportunities in the following primary areas.

- **Improve the efficiency of fired equipment.** Fired equipment accounts for most of the heat release within a refinery. Some efficiency improvement can be achieved by lowering furnace draft and excess oxygen. The majority of the savings will result from additional stack heat recovery. *Estimated savings: $11,796,000.*
- **Utility system optimization.** Utility system savings can be obtained from minimizing condensation on turbine drives and by biasing steam production to the most efficient boilers. *Estimated savings: $5,368,000.*
- **Maintenance. Refinery energy systems often require periodic renewal.** The opportunities at Martinez will involve heat exchanger cleaning and insulation repair. To achieve significant energy and cost savings, Equilon would need to invest in maintenance measures, primarily for insulation repairs and heat exchanger cleaning. Total expenditure is estimated at $9,850,000. *Estimated savings: $14,288,000*
- **Quench elimination.** Quenching a process (reducing a process temperature by mixing with a colder fluid) often occurs in refinery operations. The recommendations focus on optimizing stripping steam and water injections needed for process control. *Estimated savings: $13,106,000*
- **Hot rundown between units.** Retaining the heat in the intermediate processing stream going from one unit to another is much more efficient than cooling the streams for storage and then reheating them when needed. Implementing the process control necessary to do this has the additional benefit of reducing working inventory. *Estimated savings: $4,270,000*
- **Eliminate waste.** These recommendations identify processing that can be eliminated without affecting output. *Estimated savings: $2,667,000*
- **Other process changes.** Most of these recommendations involve adding hardware or controls to improve process results while reducing energy consumption. *Estimated savings: $1,000,000.* ●

Here is how your company can adopt the PWA methodology and strategy to achieve significant savings. For PWA program information, contact Grace Ordaz, DOE, 202-586-8350; e-mail, grace.ordaz@ee.doe.gov. To start your own PWA, contact Bob Leach, Oak Ridge National Laboratory, 865-946-1352; e-mail leachre@ornl.gov. And, to respond to annual PWA solicitations, visit ***www.oit.doe.gov.***

Making Good Motor Decisions –The Ellensburg Wastewater Treatment Plant

All wastewater treatment plant operators know that sooner or later they are going to have to make an expensive decision: do they rewind or replace a failed motor?

Making this decision means knowing facts about the motor's efficiency, maintenance history, and costs—not only the initial costs to buy or rewind a motor, but also its lifetime operating costs.

An important part of making this decision is having confidence "that we will be making the most economical choice," said Irma Grogan, Ellensburg, Washington's Wastewater Treatment Plant Foreman. She knows first hand what it's like to make these decisions.

The Ellensburg Wastewater Treatment Plant was constructed in 1974 and remodeled in 1982. The plant services the City of Ellensburg, which has a population of approximately 15,000. This secondary treatment facility was designed as a complete mixed activated sludge plant with capacity to treat 8 million gallons per day. It currently processes an average of 3.5 million gallons daily.

Ellensburg's dilemma: replace or rewind a 50 hp aerator motor?

In 2001, Grogan had to determine whether to replace or to rewind two large 50 horsepower (hp) aerator motors in the North Pond. The aerator company's representative had made a recommendation for a premium efficiency motor, but Grogan wanted to do her own analysis. She used the MotorMaster + 3.0, a motor management software program to analyze two alternatives: rewind the existing motors, or replace them with energy-efficient models.

MotorMaster+ proved a useful tool at a Washington State water treatment plant.

MotorMaster+3.0 is a software program that analyzes motor and motor system efficiency. Designed for utility auditors, industrial plant energy coordinators, and consulting engineers, MotorMaster+3.0 is used to identify inefficient or oversized facility motors and compute the energy and demand savings associated with selection of a replacement energy-efficient model.

The MotorMaster+ 3.0 software program was developed by the Washington State University Cooperative Extension Energy Program, and is funded by the U.S. DOE.

Initial use of the MotorMaster+ software by Ellensburg showed it was more cost-effective to purchase new motors than to rewind the existing motors. Grogan then used the software to compare the cost-effectiveness and simple payback of various new 50 hp motors. Review of MotorMaster's database information, depicted in the accompanying chart, showed that buying a new standard efficiency motor was warranted.

Lessons Learned

MotorMaster+ software simplified the repair-versus-replace decision-making process. Grogan first had to determine if Ellensburg should replace or rewind the motor, with all expenses considered. Then she looked at costs and her budget. Finally, she presented the idea to her boss, her recommendations supported by hard data from Motor Master+.

"MotorMaster+ gave me the numbers I need to justify the purchase," Grogan said.

Her review provided her with a number of tangible results:

- A reliable process to determine repair versus replace decisions for motors
- A complete, plant-wide database of 80 motors ranging in size from ½ hp to 100 hp
- Knowledge that the plant's motors are not wasting energy

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COMPARISON OF MOTOR REWIND V. REPLACEMENT COSTS AND EFFICIENCIES

Options	Cost/Motor	Efficiency	Annual Savings/Motor (kWh and $/year)	Simple Payback (Years)
Rewind existing motor	$10,275	89%	None	N/A
Replace with new standard motor	$ 6,878	92%	2,970 kWh and $110/yr ($1,650 savings over motor's life)	Immediate
Replace with NEMA Premium motor	$12,673	93.6%	4,837 kWh and $179/yr ($2,685 savings over motor's life)	32

When Utility Costs Rival Labor Costs, Management Takes Notice

Mark Rawlings, Plant Maintenance Manager, thought he had the numbers wrong when a recent calculation showed that his company, Woodgrain Millwork, Inc., was paying almost as much in utility costs as his annual salary – just to run a single 250 hp motor.

The motor had failed and Rawlings had to decide whether to repair it or replace it with a new one. Company policy for this type of decision was simple—compare the cost of repair to the cost of buying a new motor, then pick the less expensive of the two.

For this particular decision, however, Rawlings factored another cost into the equation—the cost of electricity to run the motor. This made all the difference in his final decision: replace the old motor with a new, energy efficient one.

At 93% efficiency running 24 hours a day, 6 days a week, the existing motor was costing Woodgrain $52,000 a year in electricity bills. The electricity cost was so surprising that "I called our representative at Idaho Power to confirm the rate information I was using," said Rawlings. Idaho Power confirmed the rate schedule and encouraged Rawlings to explore efficient motor options.

With the help of Dennis Bowns, a field consultant with the Electric Motor Management program, Rawlings used MotorMaster+ software to compare the existing motor t comparable new energy efficient models.

The MotorMaster+ software program was developed by the Washington State University Cooperative Extension Energy Program (the Energy Program), and is funded by the U.S. DOE via the Industrial Technologies Program's BestPractices Program (formerly the Motor Challenge Program).

MotorMaster+ analyzes motor and motor system efficiency. Designed for utility auditors, industrial plant energy coordinators, and consulting engineers, MotorMaster+3.0 is used to identify inefficient or oversized facility motors and compute the energy and demand savings associated with selection of a replacement energy-efficient model.

In its application at Woodgrain Millwork, the software identified a new motor with 1.3% greater efficiency, which would save the company as much as $600 annually. The new motor was also priced comparably to the cost of the rewind and mechanical repairs, which were expensive due to catastrophic failure.

Rawlings concluded it was the best choice and bought it to replace the failed motor. This decision is estimated to save Woodgrain $600 annually, equivalent to an electricity savings of 20,700 kWh.

Lessons Learned

Rawlings learned much from this simple analysis. First, the company's current repair/replace policy ignored the costs of operating a motor and is costing them money in the long run. Second, there are good software tools available to make life cycle costing and comparison shopping easy, and help make the pitch to management.

"The fact that I could generate a written report for management comparing our options helped convince management to buy the new efficient motor," said Rawlings. Third, the analysis tools are only as good as the information at hand on the motors in the plant. Without an inventory that provides good data such as rewind and repair history, hours of operation, nameplate data, and more, the tools won't be of much help. Finally, since it takes time to do this analysis, doing it in advance of a motor failure can prevent a hasty decision that costs more in the long run.

Using these lessons, Rawlings committed his department to develop a motor inventory for its 500 motors. Once established, the inventory will track spares on hand, rewind history, and be used for repair/replace decision making with energy efficient motors. Rawlings worked with consultant Bowns to streamline the process by collecting only the most important motor data, and focusing on one set of motors in the plant at a time. He's now completed work on some 75 of the largest support systems motors that keep the buildings running. The next phase of the inventory focuses on specialty motors that run equipment such as molders and are hard to replace.

Rawlings and Bowns are exploring ways to speed up the collection process by using a handheld computer loaded with the inventory spreadsheet to enter data directly from the plant floor. Data is entered directly from the plant floor into the handheld computer then transferred to a computer for analysis later. With equipment motor nameplate data accessible on the plant floor, decisions are made based on amperage evaluations at motor control centers without interruption of the production process. The handheld computer is also used to anticipate materials that might be required prior to dispatching electrical staff to problem motor locations, again saving valuable time.

Rawlings plans to use the inventory data collected to date to generate reports that demonstrate savings opportunities. He expects these to be convincing enough to change the way the company makes repair/replace decisions. He knows that when utility costs rival labor costs, his management takes notice.

Benefits

- Annual electricity cost savings of $600 from replacement of just one 250 hp motor with a new energy efficient model. Over the life of the motor, a savings of $6,000 is expected. Rawlings has more than 500 motors in its plant.
- Annual electricity savings of 20,700 kWh
- Rapid data collection using hand-held computer motor inventory tool– 55 motors in one month's time
- New motor inventory will track spare motors on hand, provide rewind history, be used for repair/replace decision making and choosing efficient motors. ●

Ask the Clearinghouse

Benefits of Reducing Steam System Pressure

This column highlights key questions from industrial customers to the Industrial Technologies Program's Clearinghouse. Through the Clearinghouse, you can access the full portfolio of resources and get technical advice about motor, steam, compressed air, combined heat and power, and process heating systems.

Clearinghouse engineers and technical staff expertly answer industrial efficiency questions, 11 hours a day, Monday-Friday. The Clearinghouse also has access to industry experts around the country. Call the Clearinghouse at 800-862-2086, or go to **www.oit.doe.gov/clearinghouse/**.

Q: How much energy can I save if I reduce my boiler pressure from 120 psig to 75 psig? My local natural gas company says I would save nothing, but the U.S. Department of Energy's *2001 Steam Digest* contains a case study that claims a chemical plant saved more than $142,000 annually by reducing its steam pressure. I am confused.

A: There is no simple way to determine the energy and fuel savings due to reducing your steam system operating pressure. Savings can come from at least seven sources. Each source's contribution depends heavily upon how your steam system is currently designed and operated. In addition, some operational disadvantages and steam quality concerns may arise from operating at low pressure.

Steam at 120 psig is at a higher temperature than steam at 75 psig. The steam also contains more enthalpy, or energy per pound. Saturated steam and liquid properties are summarized below:

Pressure (psig)	**Steam Enthalpy** (Btu/lb)	**Liquid Enthalpy** (Btu/lb)	**Temperature** (°F)
120 psig	1,192.7	321.8	350
75 psig	1,185.5	290.4	320

Examining the sources of boiler losses will help you understand how lowering boiler pressure saves energy. The seven ways that energy savings occur are:

- **Reduced thermal losses through steam distribution line insulation** (due to the lower steam temperature). The amount of the reduction depends upon the distribution line size, length, and insulation type and thickness.
- **Reduced losses through uninsulated steam distribution system valves and fittings.** The amount of the reduction depends upon the number, size, and type of valves and fittings, and whether removable insulated jackets are used at the facility.
- **Reduced boiler blowdown losses.** This energy savings benefit occurs because the liquid being blown down is at a lower temperature. The savings depend upon the blowdown rate (which, in turn, is dependent upon whether an automatic blowdown control system is in use), and whether a blowdown heat recovery system is in place.
- **Reduced energy losses from steam leaks and failed steam traps.** At lower pressures, the leak rate or mass passing through an orifice is reduced resulting in energy savings. In addition, each pound of steam lost has a lower enthalpy and contains less energy. Savings also depend upon the magnitude of current steam losses.
- **Reduced makeup-water heating requirements.** The boiler makeup water must be heated to 320°F, rather than 350°F. The quantity of makeup water required depends upon water treatment considerations (which dictate the boiler blowdown rate), plus steam leaks, deaerator steam venting, condensate return, and other steam losses. Makeup water heating requirements also depend upon whether the makeup water is preheated by a blowdown heat exchanger and/or a stack gas economizer.
- **Reduced stack gas temperature.** The boiler flue gas exit temperature must be greater than—on the order of 100°F—the boiler water temperature in order for efficient heat transfer to occur. A reduction in steam temperature can allow for a corresponding decrease in flue gas temperature. A rule of thumb is that a 40°F reduction in stack gas temperature leads to a 1% improvement in boiler efficiency. The amount of energy saved depends upon whether or not an economizer is used to recover stack waste heat. Flue gas minimum temperature limits must also be maintained to minimize the formation of acidic condensate that can cause corrosion in flue gas passages.
- **Reduced boiler skin losses.** Since the temperature of the liquid in the boiler is reduced, there is a reduction in surface heat transfer losses. Energy savings are dependent upon boiler type (firetube versus watertube), surface area, and current degree of insulation.

The Boiler Efficiency Institute's *Boiler Efficiency Handbook* indicates that a typical annual savings due to reducing boiler pressure is 1%. A number of operational issues must be considered when reducing pressure. By running a boiler at a lower pressure, the boiling action in the boiler becomes much more violent, causing water to be carried over into the steam system. Producing low-quality steam can lead to boiler shutdowns due to low water level trips; damaged steam pipes and valves due to water hammer, vibration, corrosion and erosion; reduced capacity of steam heaters; and, overloaded steam traps.

Other experts recommend conducting a detailed investigation to determine operational effects before reducing steam pressure on an individual boiler. As the steam density and enthalpy are reduced, the steam velocity in the distribution system must be increased to supply the same thermal energy to various loads. Increased velocity increases friction losses and leads to pressure drops within the system. Insufficient steam supply could result. Pressure reducing stations (if present) must be reset, and mud blowdown must be timed at a point when the boiler is operating at partial load to avoid upsetting circulation. A change in pressure relief valve sizes may also be necessary. We recommend you consult your local boiler manufacturer's representative.

Initiate your steam system improvement program by visiting Industrial Technologies Program's BestPractices Steam website at **www.oit.doe.gov/best practices/steam**. From this website, you can download steam tip sheets, case studies, technical references, and financial tools. You can also download the useful Steam System Survey Guide (Oak Ridge National Laboratory ORNL/TM-2001/263, May 2002) at **www.oit.doe.gov/bestpractices/steam/pdfs/steam_survey_guide.pdf**, or order it through Industrial Technologies Program's Clearinghouse. A *Steam System Assessment Tool* is under development and should be available in late 2002.

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Q: We have been to several plants that utilize plastic injection molding machine technology. We have yet to see one of these machines with insulation around the barrel heaters used to melt incoming product. If insulation is applied, could damage occur to thermocouple and electrical leads due to overheating the outside of the barrel?

A: Most manufacturers of plastic injection molding machines now provide shrouds over the barrel bands to create an "oven effect." In other words, heat radiated from the barrel is reflected back. The shrouds are placed some distance from the barrel, however, so convective heat transfer still occurs.

One energy efficiency approach for uninsulated molding machines is to retrofit custom-fitted insulated vests over the barrel. Insulation should not be installed on the back of the barrel. These vests can result in overdriving the internal temperature and possibly shortening the life of lead wires. Unfortunately, the use of insulated vests can also lengthen cool down periods. A longer cool down time can decrease production rates.

A preferred alternative is to replace the mica or ceramic knuckle-type band heaters typically supplied by European companies with insulated barrel and nozzle heaters. Insulated barrel band heaters have a thin layer of highly conductive material between the heating element and the inner surface and are backed by a layer of low thermal conductivity insulation. This construction directs heat inwards toward the barrel. Insulated barrel heaters with mica or mineral insulation are available that have a temperature withstanding capability of 1000 °F to 1400 °F.

A recommended approach is to retrofit one injection molding machine within a plant, then use watt-meters to measure the "before" and "after" energy consumption per part produced. In this manner, annual energy savings and the cost effectiveness of an insulated barrel heater retrofit project can be demonstrated to plant management. Energy savings on the order of $20,000 to $40,000 per year per plant have been reported—with variations due to the number and size of injection molding machines, number of band heaters on each barrel, operating schedule, and electrical rates.

Use of insulated barrel heaters to increase productivity is possible because the replacement heaters can tolerate a higher current density than standard heaters. A higher current density means the heat-up portion of the productivity cycle can be reduced, resulting in faster and more efficient production. Insulated barrel heaters also reduce heat loss into the building space, decreasing the demands on the ventilation and space conditioning system. ●

Ellensburg Wastewater Treatment Plant

continued from page 8

- Confidence in the decision to replace an older, inefficient motor with a new, standard motor
- Savings of $1,650 over the life of each 50 hp motor replaced.

Grogan has used MotorMaster 3.0+ software for more than just making this purchase decision. With the help of Steve Dunnivant, a field consultant with the Electric Motor Management program, all of Ellensburg's motor inventory and maintenance logs have been entered into MotorMaster 3.0+. Once this was done, Dunnivant made additional visits to Ellensburg to train Grogan and her staff to take full advantage of all the software has to offer. MotorMaster+ can generate everything from a basic motor inventory list to payback comparisons using local utility rates and downsizing comparisons.

"MotorMaster+ is easy for us to work with, and having assistance was important," Grogan said. After this training, Grogan and her staff began testing all of the plant's motors to determine their efficiency.

What they learned was interesting. "We found that we don't have antiquated motors. We have old, efficient motors. The motors were good to begin with," Grogan said. She also learned that the plant's original design was energy efficient. "We aren't using as much energy as everyone thought; it's not wasted," she said.

Grogan hopes that she won't have to replace many motors in the next 5 to 10 years, but on one point, she is certain: "I'll use MotorMaster 3.0+ when I am looking at replacing or rebuilding."

To download the latest version of MotorMaster+ and the latest version of the motors catalog database, visit **http://mm3.energy.wsu.edu/mmplus/default.stm**. ●

Letters to the Editor

Energy Matters welcomes your typewritten letters and e-mails. Please include your full name, address, organization, and phone number, and limit comments to 200 words. Address correspondence to:

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We publish letters of interest to readers on related topics, comments, or criticisms/corrections of a technical nature. Preference is given to articles that appeared in the previous two issues. Letters may be edited for length, clarity, and style. ●

Energy Matters EXTRA

Energy Matters Extra contains links to help you learn more about compressed air's role in enhancing productivity in manufacturing processes, the Pump System Assessment Tool instructors, and how your plant may be able to achieve energy cost savings through a Plant-wide Assessment. Check out all the original Energy Matters newsletter articles and research topics through the online archives.

Log on to Energy Matters Extra at **www.oit.doe.gov/bestpractices/energymatters/emextra**. ●

Coming Events

AIRMaster+ Specialist Workshop, Sacramento, CA

- February 25–February 27, 2003

For more information, contact Amanda Dosch, adosch@ppc.com. Hosted by Sacramento Municipal Utility District

Chemicals and Petroleum – Texas Technology Showcase, Houston, TX

- March 17–March 19, 2003

For more information, call David Salem, Chemicals and Petroleum Team 202-586-8710.

*To keep up-to-date on Industrial Technologies Program's training and other events, check the calendar regularly on Energy Matters Extra at **www.oit.doe.gov/bestpractices/energymatters/emextra**.*

BestPractices

The Industrial Technologies Program's BestPractices initiative and its *Energy Matters* newsletter introduce industrial end users to emerging technologies and well-proven, cost-saving opportunities in motor, steam, compressed air, and other plant-wide systems.

Information Clearinghouse

Do you have questions about using energy-efficient process and utility systems in your industrial facility? Call the Industrial Technologies Program's Information Clearinghouse for answers, Monday through Friday 9:00 a.m. to 8:00 p.m. (EST).

HOTLINE: 800-862-2086

Fax: 360-586-8303, or access our homepage at www.oit.doe.gov/clearinghouse.

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