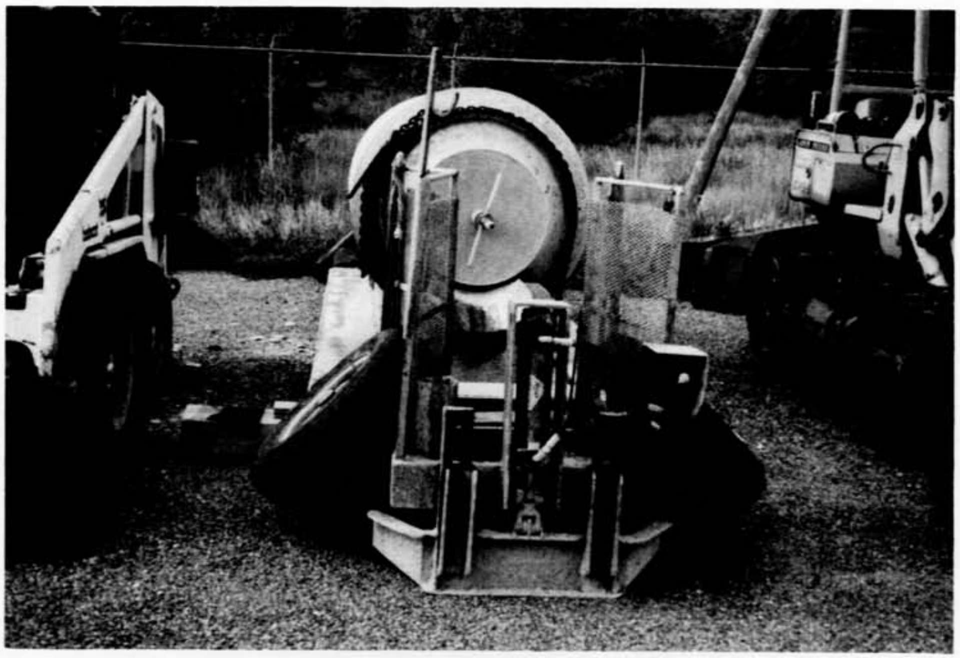
WATER OPERATION AND MAINTENANCE

BULLETIN NO. 173

September 1995



IN THIS ISSUE. . .

UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

The Water Operation and Maintenance Bulletin is published quarterly for the benefit of water supply system operators. Its principal purpose is to serve as a medium to exchange information for use by Reclamation personnel and water user groups for operating and maintaining project facilities.

Charles Swanson

Bill Bouley

Jerry Fischer

Operation and Structural Safety Group

Infrastructure Services

Technical Service Center, Code D-8470

PO Box 25007, Denver, Colorado 80225

Telephone: (303) 236-9000

Technical editing and graphics were provided by Sharon Leffel and Jim Whitfield.

Cover photograph: Front view of tunnel cart. Notice angled wheels to fit on the invert of the tunnel. Front frame acts as a screed for finishing the placed concrete.

UNITED STATES DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

CONTENTS

WATER OPERATION AND MAINTENANCE BULLETIN

No. 173

September 1995

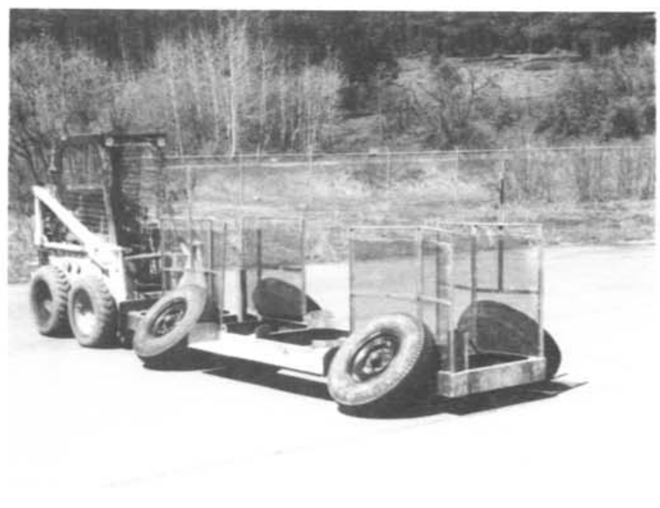
Page

PROJECT INNOVATION: SAN JUAN-CHAMA "TUNNEL" CART

The Chama operation and maintenance (O&M) crew is responsible for all maintenance on the San Juan-Chama diversion system in northern New Mexico and southern Colorado. That system, part of the overall San Juan-Chama Project, diverts water from upper tributaries of the San Juan River (west of the Continental Divide) through a series of three tunnels and siphons under the Continental Divide, into the Rio Chama, and subsequently into the Rio Grande basin where it is used for irrigation and recreation and for municipal and industrial purposes by the city of Albuquerque. The three concrete-lined conveyance tunnels are about 14, 8, and 21 kilometers (9, 5, and 13 miles) long and are of circular cross section.

CN465-528-1114NA Blanco Tunnel, Chama Field Division, New Mexico. View of concrete bucket on the concrete cart used to repair the invert of Blanco Tunnel. Notice the man standing on the running board while operating the dump handle. The screed at the end of the cart helps spread the concrete when bolted in place.

During the normal April through September diversion season, very high volumes of water flow through these 43 kilometers (27 miles) of tunnels. Several years of high flow rates caused severe scouring and chipping of the bottom surfaces of the tunnels by gravel and other abrasive materials carried along by the fast-flowing water. Severe damage to the concrete results and the system would be ruined if extensive repairs to portions of the tunnels were not made each year. The system first became operational in 1971. The repairs, conducted during winter months when water flow is shut off, were first contracted out in 1984 at an annual cost of about $300,000. The Chama O&M crew was employed on other aspects of the San Juan-Chama Project (El Vado and Heron Dams and Reservoirs, river channelization, etc.) during the spring and summer months but was underused during late fall and winter months while private contractors were repairing the tunnels.



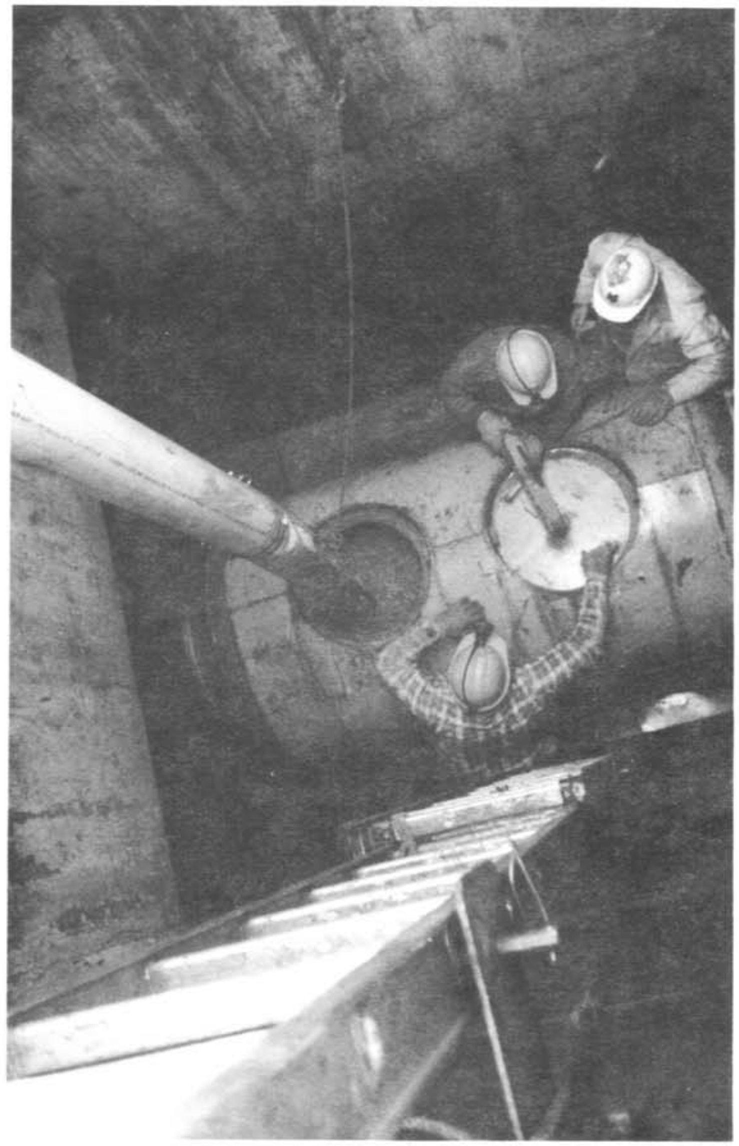
CN465-528-1110NA Blanco Tunnel, Chama Field Division, New Mexico. View of concrete cart and Bobcat 611 Loader used to repair the invert of Blanco Tunnel. Notice wheel angle on the cart. Wheels are on radius lines to fit in the tunnel.

The O&M employees had a better idea, and during the mid-1980's, they began doing the off-season repair work themselves. Working inside the cramped, wet concrete tubes under the Continental

Mobile concrete batch plant operating near the inlet to Blanco Tunnel, a component of the San Juan-Chama diversion system. The plant was designed to the custom specifications of the Chama Field Division.

Divide, some 8 to 13 kilometers (5 to 8 miles) from the nearest entrance, is very difficult work. Originally, only small loads of concrete, about 0.20 cubic meter (0.25 cubic yard), could be mixed at the tunnel mouths and transported inside with small front-loader tractors. Inside, the concrete had to be agitated, placed, leveled, and finished by hand. These techniques resulted in relatively slow rates of repair and high costs to meet adequate quality standards.

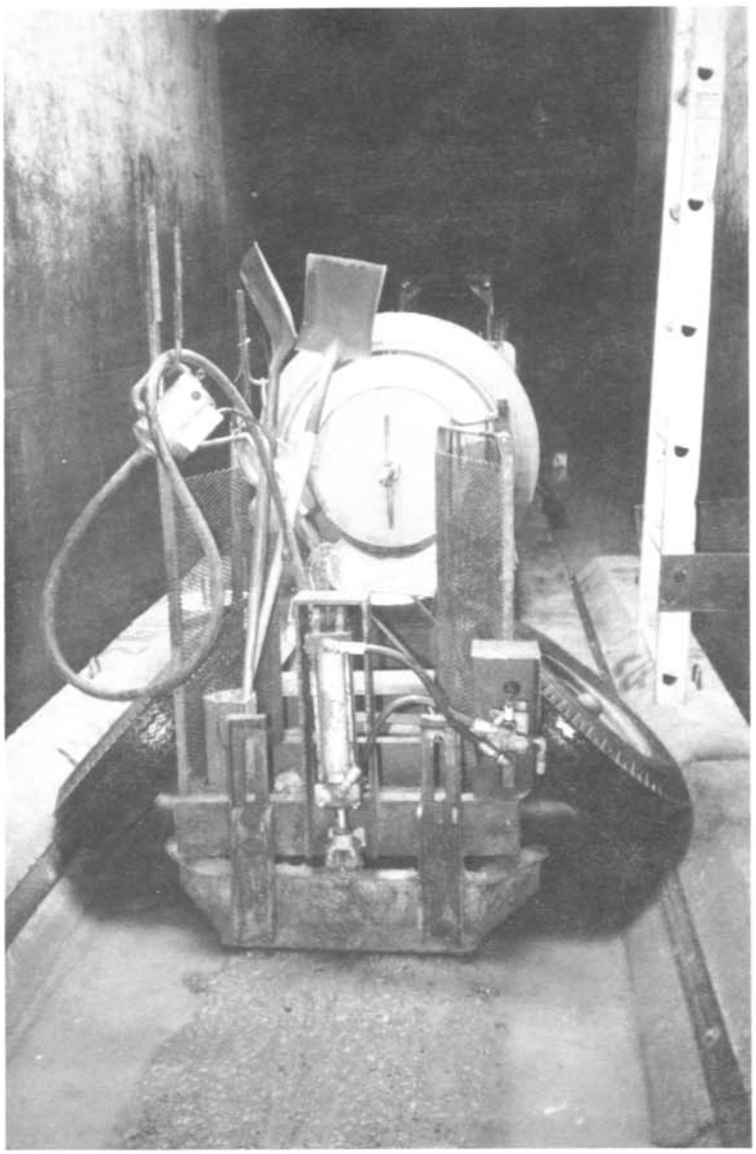
In 1986, Charles Fisher, civil engineer, designed a four-wheeled cart that would carry twice the concrete load as the Bobcat tractors, in addition to a three-man crew and necessary tools. This cart, which had a splayed suspension system that centered it in the circular-shaped tunnels, was powered by the same tractors already employed. The tractors could push the loaded cart into the tunnel at a much higher speed and with greater safety and could then pull the empty cart back to the tunnel opening for additional loads. With assistance from other crew members, Richard Russom constructed the cart in the Chama Field Division shop at a very low materials cost of about $1,500. With it, the Chama employees were able to more than double the rate of repair on the tunnel interiors, preventing deterioration and damage beyond the point where such manual repairs would be effective. For their initiative and effort, the Chama employees were recognized by the Bureau of Reclamation Group Performance Award.



Chama O&M crew filling 3-cubic-yard hopper from the mobile concrete batch plant located at ground level above tunnel opening.

However, the employees were not satisfied that they had developed the optimum techniques or equipment to accomplish their tasks. During 1991, they purchased a mobile concrete batch plant, built on a low-bed trailer chassis to their custom specifications. The plant allowed a greater volume of concrete to be mixed at the tunnel openings and used in the off-season relining. To transport this additional concrete load, the O&M employees redesigned their cart, which now carries a revolving, agitating hopper of 2.3-cubic-meter (3-cubic-yard) capacity on a "stretched" chassis. The hopper mechanism is run off the hydraulic system of the Bobcat tractor, which still pushes and pulls the cart into and out of the tunnels. The employees redesigned the connection between the tractor and cart with a floating link mechanism that takes vertical loads off the tractor, greatly increasing tire life and saving associated costs.

The new cart, which was used throughout the 1992 winter and fall off-season repair operations, carries the work crew deep into the tunnels safely and more rapidly than was previously possible and also carries a more efficient, larger concrete load. In addition, the O&M employees designed an adjustable blade fastened to the cart. That simple but effective mechanism allows the cart itself to level, or "screed," the concrete load it has just unloaded onto the tunnel floor, greatly reducing the manual labor involved with the relining work and allowing the same number of crew members to reline a much longer reach of tunnel in the same amount of time with a higher level of finish. That, in turn, increased resistance to damage during subsequent conveyance seasons and reduced the repair cycle for the tunnel system.



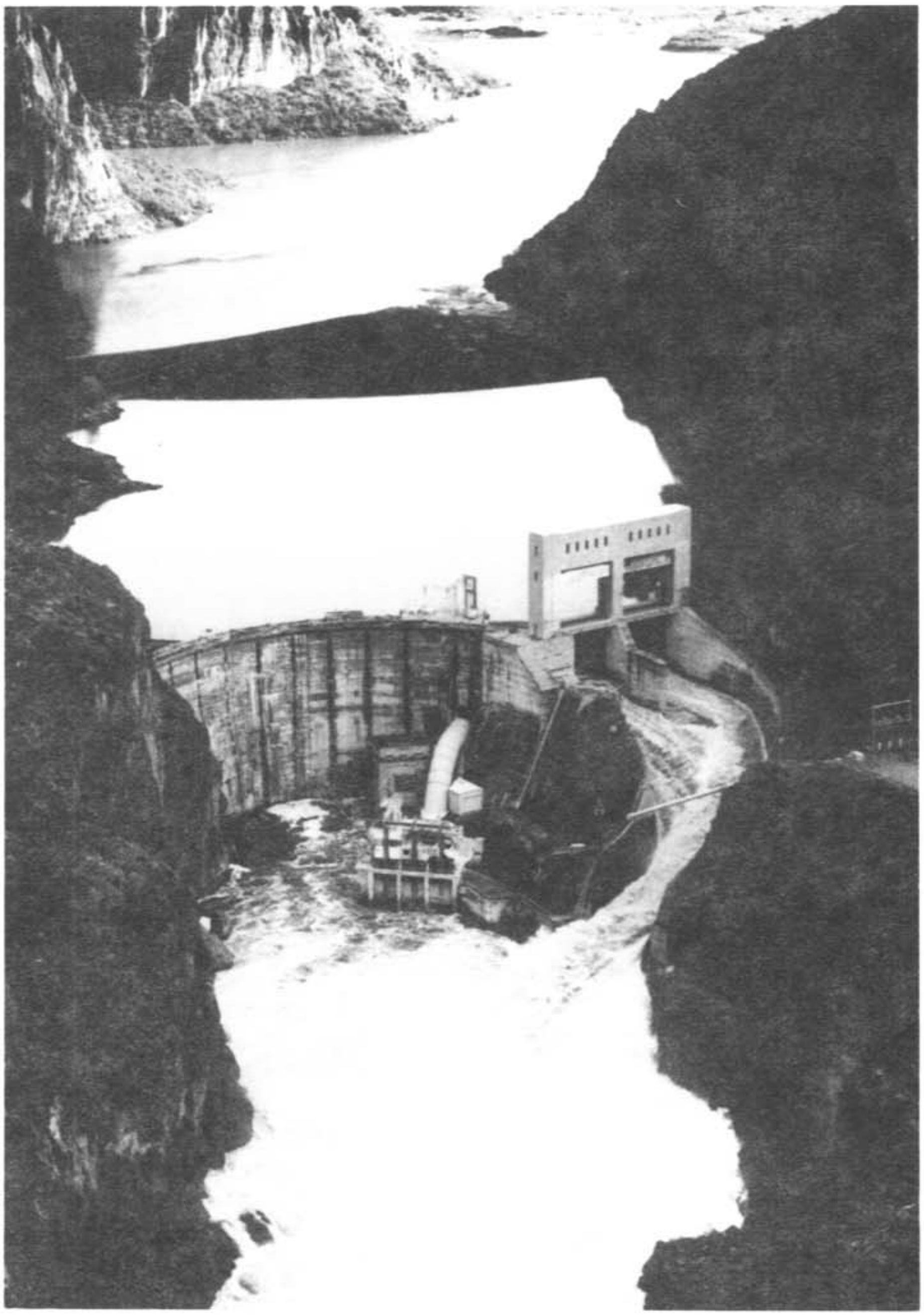
Front view of "stretched" tunnel cart, showing tool stowage and adjustable "screed" blade that levels the concrete just unloaded from the hopper.

The initiative and dedication of the Chama O&M employees have resulted in tangible savings to date of about $1.1 million after an investment of about $250,000. Gary Rowe pointed out that "those savings will become even more impressive over the next few years with the increased efficiency of repair operations and with equipment costs being amortized over a longer period of time." Additional benefits have been the increased level of personal safety realized and the opportunity for trained and skilled employees to be retained on a year-round basis, thus using their experience and abilities to make the San Juan-Chama Project maintenance operations more cost effective during both the fall/winter repair season and the spring/summer facilities maintenance season.

Recognition as the Federal Executive Board Federal Employees of the Year was certainly well earned and much appreciated by the Chama Field Division and emphasized the key role played by the Bureau of Reclamation within New Mexico.

ZINC THERMAL SPRAY.....THE CORROSION SOLUTION FOR THE MORMON FLAT DAM

Thermal spraying has proven to be an asset at the Mormon Flat Dam located 51 miles northeast of Phoenix, AZ. The concrete arch dam was completed in 1926 with an addition of two 50' x 50' fixed wheel spillway gates in 1937-38. The riveted steel gates are raised vertically by a massive concrete counterweight connected to a drive chain.



Mormon Flat Dam.

During the first 30 years of operation, the exposure conditions of these gates varied greatly. They were exposed to total immersion, alternately wet and dry, or complete atmospheric exposure to desert heat and sunshine depending only on total water storage and usage. In the early 70's new turbine generators were installed increasing the generating capacity and pumpback capability of the dam, leaving the fixed wheel gates immersed. Maximum generating capacity is obtained when the lake elevation is kept as high as possible.

The search was on for the coating that would provide the longest service life with zero maintenance. Coal tar enamel, coal tar emulsion and coal tar epoxy, all provided decades of service for Salt River Project, but all required periodic repair and touch up.

The water transmission and distribution systems of the Salt River Project had been using zinc metal spray without sealer or top coat for years. They would blast clean small and large components fabricated in the machine shop. They found it to be ideal because the parts were immediately serviceable, the zinc could be sprayed in a one coat application and it was extremely durable, rarely needing a touch-up after transportation.

In 1970, the coating maintenance department decided to zinc thermal spray the 50' x 50' fixed wheel gates. The zinc thermal sprayed coating was considered a sacrificial anodic coating. Therefore, the more anode weight directly translated to a longer service life. In recognition of the consumable nature of the zinc thermal spray coating, it was decided to apply twice the normal weight per square foot in the hope of achieving a 30 to 40 year service life. Thickness of the zinc thermal spray coating was tested in numerous locations using an eddy current film thickness gage. The average readings of the zinc was in the 6 - 11 mil range.

In 1992 the gates were inspected, zero rust was observed. No rust stains were observed at the rivet heads or at the seams between adjacent plates. No white rust or damage from floating debris was observed and there was no indication that any significant corrosion had occurred. In spite of the excellent condition of the zinc thermal spray coating, it was decided to assume that between 10 and 20 percent of the useful life of the coating system had passed. This translates to an estimated service life of between 100 and 200 years with no maintenance.

Thanks to Mr. John Brodar from Salt River Project for this case history. For more information, contact: Salt River Project, 903 E. 7th Street, Mesa, AZ 85203.

Salt River Project has listed the following tips to reduce costs and improve reliability for similar work:

1. Inspect each rivet for soundness and tightness of fit.

2. Prior to removing existing coatings, have a knowledgeable individual evaluate, inspect and test for chloride ion contamination. Decontaminate before proceeding with the work.

3. Determine the desired thickness of zinc metal spray.

4. Blast clean the rivets and seams first. Apply zinc metal spray at 1/3 to 1/2 of total thickness to the rivets and seams before proceeding with work.

5. Take advantage of the coating system AS AN APPLICATOR. There is no no cure time, there is no intercoat adhesion problem, it is self priming.

6. For large uniform surfaces consider automation. A simple mechanical device will greatly reduce labor and material costs while producing a more uniform finish.

7. Document actual thickness at several locations in all exposure conditions. This is essential to future evaluations. Remember to be sure that the test area is sufficiently marked that future readings are taken at the very same spot. If the original specification is for 6 to 8 mils and the reading in twenty years is 9 mils it will be very difficult to determine the corrosion rate.

8. Begin a comprehensive corrosion testing program NOW. Prepare suitable coupons and expose them to your actual conditions.

Reprinted from

METALLINZE

THE PLATT BROS. & CO.
Box 1030
Waterbury, CT 06721
(203) 753-4194

SPECIFYING HIGHER-EFFICIENCY MOTORS

Getting full benefit of high-efficiency motors requires carefully matching up the motor and load profile

by Richard Cole and Terry Thome

Alerted by the Energy Act of 1992, many users of a-c induction motors are eyeing premium-efficiency motors with mixed feelings, perhaps some confusion. When the October 1997 deadline arrives for compliance, the clearest winners will be the environment (due to reduced need for more power generating plants) and the petroleum economy (because of reduced dependency on foreign oil).

But what will it mean for industrial users? Most obvious is the potential for smaller electricity bills. Motors account for approximately 64% of electricity use in the U.S., at a yearly cost of $112 billion. Every 1% reduction in motor demand cuts 0.64%—or $716,800,000—off the industry-wide bill.

Higher-efficiency motors also run cooler, which lightens the load on air conditioning systems and further reduces plant demand. Lower total demand can lead to lower rates by helping minimize peak-demand surcharges. As rates increase over time, these savings get bigger.

But electricity bills aren't the only place where savings show up. Premium-efficiency motors are built better and provide longer service life backed by longer warranties, which means lower maintenance costs.

On the other hand, because they're built better, premium-efficiency motors typically cost up to 25% more than a comparably rated standard motor. Buying higher-priced equipment always needs to be cost-justified, so let's get that out of the way with the following example.

EVALUATING PAYBACK

Standard-efficiency motors typically incur yearly operating costs of 10 to 20 times purchase price, compared to 8 to 12 times purchase price for premium-efficiency motors.

A 100-hp standard-efficiency motor with an efficiency of 91.0 and a list price of $3,785, running a 100-hp load continuously (8,760 hr/yr) at 8¢/kWh, can rack up $57,450 in one year's bills. A 100-hp premium-efficiency motor with an efficiency of 95.4 and a list price of $4,404 costs $54,800 per year to operate under the same conditions (Figure 1).

[illegible]	[illegible]	STD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	93.2	88.5	$149	$223	$298	$372	$447
25	93.0	90.2	$218	$327	$436	$545	$654
50	93.6	90.2	$526	$790	$1,053	$1,316	$1,579
100	95.4	91.0	$1,325	$1,987	$2,650	$3,312	$3,975

Figure 1.—Projected energy savings based on continuous operation (8,750 hrs/yr), motor operating at full load.

Typical construction features of premium-efficiency motors:

A. Heavier-gauge wire windings used throughout.

B. High-efficiency stator built with longer core of low-loss electrical steel laminations, having increased slots to accommodate heavier-gauge copper wire.

C. Tighter tolerance air gap between rotor and stator to reduce magnetic flux losses.

D. Low-resistance rotor with special slot designs and high-grade aluminum rotor bars to improve performance and efficiency.

E. Higher-grade, oversized ball bearings to help reduce friction losses and increase bearing life.

F. Smaller, more-efficient fan design to reduce windage losses and noise levels.

The $619 high-efficiency price premium returns an annual $2,650 saving, so in this example, it pays back the price difference in 2.8 months. The savings pay off the full price of the premium-efficiency motor in less than 20 months. (This example doesn't factor in savings in peak-demand rate reduction, lower air conditioning and motor maintenance costs, or payback offered by local utilities through energy rebate programs, which can drop down the payback closer to one year.)

Note, however, that maximum savings will not always accrue to every installation, for several important reasons this article will discuss. Anyone considering a switch to premium-efficiency motors should be aware of those reasons before plotting a changeover strategy.

First, let's look at what makes a motor energy efficient and why that costs more. Understanding this is an important part of the essential cost justification.

WHY EFFICIENCY RAISES PRICE

Motors lose energy in several ways. Biggest among them are the copper losses that result naturally from current passing through the copper-wire windings (Figure 2).

Premium-efficiency design employs larger-diameter wire, increasing the volume of copper 35% to 40%. To accommodate larger wire, the steel laminations that support the windings need larger wire slots, which reduces the amount of active steel in each lamination. To compensate for the loss of steel, more laminations must be added. Consequently, the rotor and stator core must be lengthened, and the motor's shell length increased. More metal adds more cost.

Next comes magnetic core loss. In premium-efficiency designs, the longer rotor and core help decrease magnetic losses, but the makeup of the laminations is the key factor.

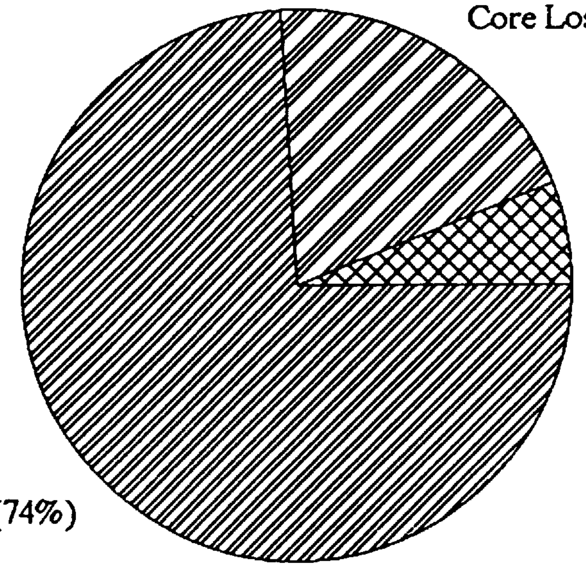


Figure 2.—Typical distribution of motor losses at full load.

Most standard-efficiency motors use low-carbon steel laminations around 0.025 in. thick, rated for electrical loss at 3.0 W/lb. Premium-efficiency motors use high-grade silicon steel laminations around 0.018 in. thick, having an electrical loss of 1.5 W/lb.

The chemical makeup and thinner gauge of premium-efficiency laminations, plus a coating of inorganic insulation on each piece, combine to reduce eddy current losses. However, better steel costs more.

Hysteresis losses, a result of molecular magnetic alignment properties too complex for this brief discussion, are reduced in premium-efficiency motors by special annealing and plating of rotor and stator components, plus use of high-purity cast aluminum rotor bars.

Friction losses are reduced by higher-grade bearings, and windage losses in fan-cooled motors are reduced by smaller, more-efficient fan designs. Overall, generally tighter tolerances and more-stringent manufacturing process control are applied to minimize losses from unplanned conducting paths and stray load phenomena.

While all the above differences in material and manufacturing discipline combine to increase motor price, they also make premium-efficiency motors run cooler than their standard-efficiency counterparts.

Aside from cutting down ambient air conditioning costs, cooler operation lengthens the motor's service life in two important ways. For every 10 °C reduction in temperature, motor insulation life doubles; premium-efficiency motors tend to operate 10° to 20 °C cooler than standard-efficiency units.

Heat also is the primary cause of grease breakdown, which shortens bearing life; premium-efficiency motors tend to run 10° to 15 °C cooler at the bearings. Consequently, premium-efficiency motors can provide up to four times longer winding life and twice the lubricant life of standard motor designs.

CANDIDATES FOR CHANGE

When evaluating a changeover to premium-efficiency motors, look first at two main factors—cost of electrical power and hours of operation.

The utility cost-benefit begins to diminish when industrial power rates drop below 6¢/kWh. Note that the true kWh cost very often is 1¢ to 2¢ higher than the actual base rate, due to the addition of peak demand charges and other penalties. True kWh cost is most easily determined by dividing the facility's total electric cost by its kWh usage.

Rates can vary widely by geographic area; wherever true kWh cost moves above 6¢, the economic argument for changeover gains strength. Hours of operation indicate which motors in your plant might provide the quickest and best opportunities to save money with higher efficiency.

Motors that run at least 2,000 hours per year (eight hours per day, five days per week) are your best candidates. As operating hours increase, payback period shrinks (Figure 3).

Remember that lower rates and shorter running times should not automatically rule out a change. Many utilities offer energy-saving rebate programs that might shorten payback to make premium-efficiency motors more cost effective. Also consider that the other benefits of better construction, cooler operation, and longer life might still make the motors attractive, regardless of how much they help cut utility bills.

The third factor to review is the size and type of motor. The potential for premium-efficiency cost savings is greatest in motors rated 1 through 125 hp (Figure 4). The ratings that are most readily replaced are T-frame, NEMA design A, B, or C, and which operate at 3,600, 1,800, 1,200, or 900 rpm.

In those applications where changeover to T-frame is difficult, premium-efficiency direct replacements for older U-frame motors are available, which eliminate the need for adaptations on the replacement motor to match the original mounting dimensions.

Any application where seasonal or peak-load requirements must be accommodated by an oversized motor, but non-peak periods will force the motor to run at less than 50% of rated load throughout most of its duty cycle, usually cannot be justified on utility cost basis alone.

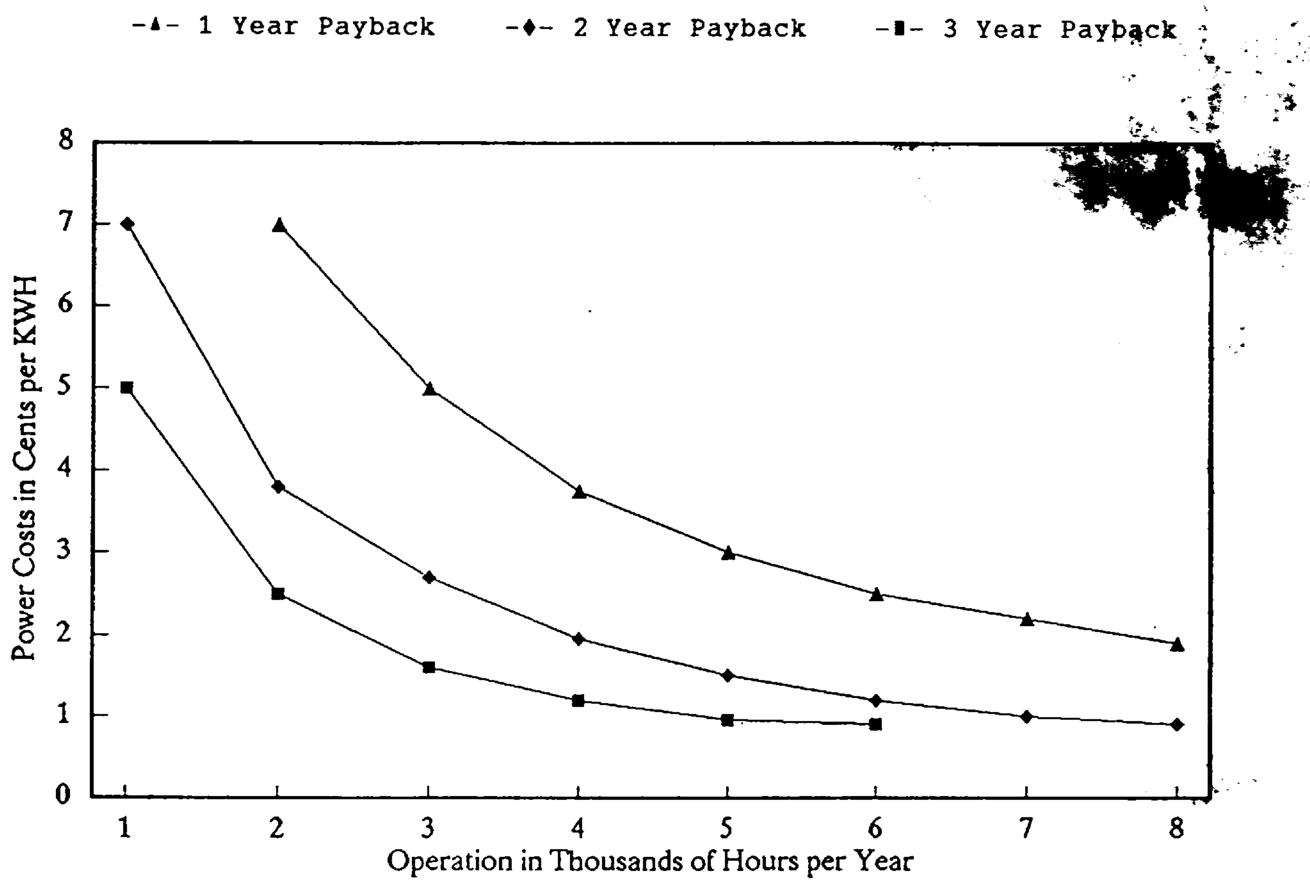


Figure 3.—High-efficiency motor payback based on cost/kWh vs. hours of operation.

Perhaps the least likely place to consider switching is in harsh environments, where a motor's life expectancy is so short that neither payback period nor the long-life benefits of better construction have any real relevance.

CALCULATING SAVINGS

The process of deciding whether to switch to premium-efficiency motors typically begins with an attempt to calculate the savings that will result. Standard PC-diskette programs are available for this purpose, usually built around the following formula:

$$S = 0.746 \times hp \times C \times N(100/SE - 100/PE)$$

Where:

S = savings per year

hp = motor horsepower

C = energy cost ($/kWh)

N = running time (hr/yr)

SE = efficiency (%) of standard-efficiency motor

PE = efficiency (%) of premium-efficiency motor

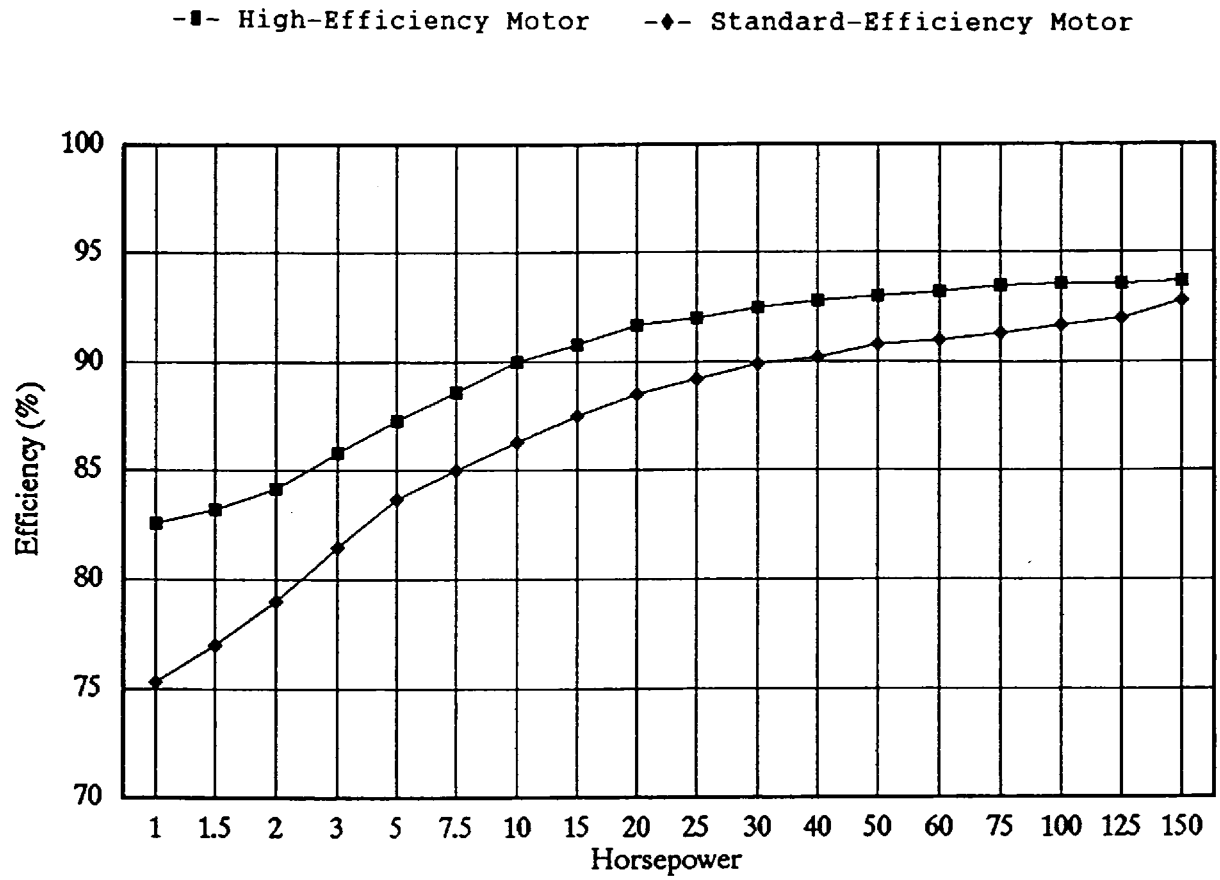


Figure 4.—Efficiency comparison—industry average high-efficiency motor vs. industry average standard-efficiency motor.

Note, however, that using this formula (or the diskette programs) often gets users into trouble because it presumes constant load (does not account for load variation), and assumes a true hp value (i.e., worst-case hp requirements of the driven load). One cannot simply plug in the hp nameplate rating of the existing motor for two reasons:

1. The motor presently operating may be an inadvertent or incorrectly specified replacement for what was originally there.

2. The motor presently operating, even if identical to what was originally specified, may not be operating close to its rated nameplate hp.

These are critical cautions when considering a switch to premium-efficiency motors. In order to deliver their promised economies, premium-efficiency motors must run between 75% to 100% of rated load. Operated at less than 50% load, they might even use more electricity than standard motors in the same service.

Determining the correct hp value to plug into the formula requires some homework. First, someone intimate with the drive process must profile that process to determine when and for how long the motor works hardest.

Many industrial processes move through regular cycles of varying difficulty in the course of a normal day. Some applications experience different levels of motor load, or different operating conditions, depending on season or time of month.

Likewise, determine when the motor workload is lightest, and for how long.

Unusual aspects of the candidate motor's load profile also should be noted. Intermittent or pulsating loads, such as a reciprocating pump or compressor, may need a motor built for that purpose. Replacement with a premium-efficiency motor not built for that purpose may result in higher current pulsations and an apparent low power factor.

Measurements taken during the times of hardest service must be compared to the motor's nameplate rating to determine how closely that relates to fully loaded condition. This can be done within reasonable margin of error in two ways:

1. Measure the motor's rpm and compare with nameplate full-load rpm.

2. Measure the motor's amperage and compare with nameplate amps.

Note that for both measurements, motor input voltage must be checked at the same time to make sure the motor is receiving full rated voltage. Motor performance varies with the square of the voltage change, so even a small voltage variation, such as a mild brownout, can make a big difference in your measurements.

If voltage is chronically erratic or off nominal at the measuring site, consult the manufacturer for assistance in determining performance variations during voltage fluctuations.

If rpm and amp measurements taken under full voltage fall close to their respective nameplate values, the motor is running at or near its rated load. If they aren't close to nameplate values, these measurements can be used with standard amp-watt-hp charts to approximate the motor's hp output at the time of measurement.

It's not a bad idea to graphically plot the motor's duty cycle, to show how much of that cycle keeps the motor above 75% of rated load. Savings that result from premium-efficiency motors vary according to how much of the motor's operating time is spent above 75% of rated load.

Load hp is most reliably determined when the motor can be temporarily replaced with a calibrated motor—one for which the amp-watt-speed profile has been documented—but the expense of doing this often makes it impractical.

Measurements also should be accompanied by notation describing the motor's operating environment, including ambient temperature, airborne dust or falling particulate, and water or other liquids. As with the duty cycle, it should indicate whether environmental factors are continuous or periodic.

SYSTEM CONSIDERATIONS

Centrifugal pumps, fans, and blowers that run 24 hours a day are good candidates for changeover. Premium-efficiency motors, however, tend to run a bit faster than their standard-efficiency counterparts.

When applied to "diminishing-torque" loads—where the load hp changes by the cube of the speed change—this small increase in speed will demand a large increase in motor output hp, in turn causing the motor to draw more power and lose part or all of its energy-saving benefit.

In belt-driven applications of this type, motor rpm can be compensated by variable-pitch sheaves to adjust the fan or pump back to specified speed. Slowing the load rpm too much, however, might cause the motor to run at less than 50% of the rated load.

Direct-drive loads typically require additional engineering evaluation to ensure energy-saving benefits.

Premium-efficiency motors also draw higher locked-rotor (standing-start) current. Installations using thermally protected motor starters usually need to be checked for properly rated heater elements. Likewise, circuit breakers with higher trip ratings may be needed in the motor service line.

With the benefit of higher power factors than offered by standard-efficiency motors (Figure 5), premium-efficiency designs require less total current for an equal amount of work. Lower current demand on the line means less energy is wasted in all feeder circuits serving the motor, thereby enhancing distribution system efficiency.

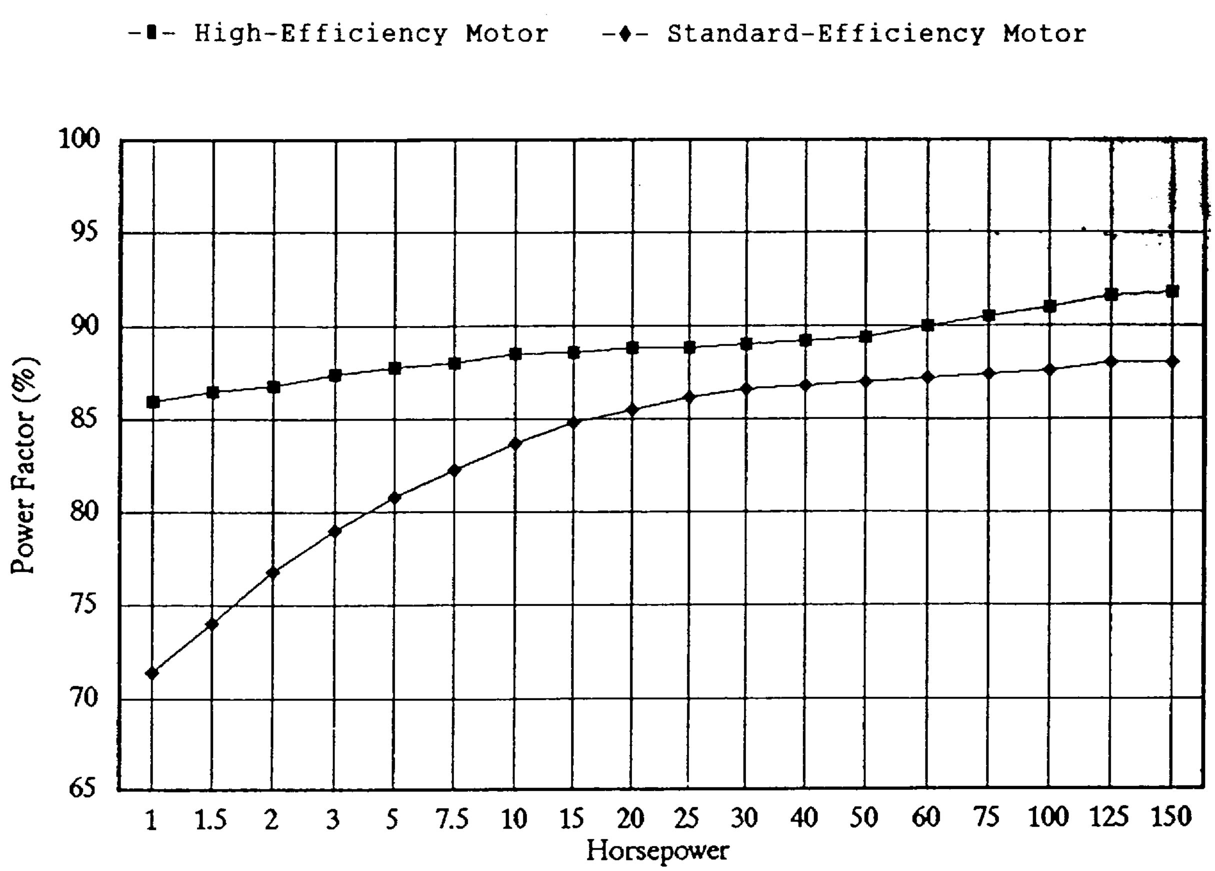


Figure 5.—Power factor comparison—industry average high-efficiency motor vs. industry average standard-efficiency motor.

This power factor advantage begins to erode as motor operation drops below 75% of rated load, and declines sharply below 50% of rated load (Figure 6), which accounts for the general recommendation to operate the motor at or above 75% of rated load.

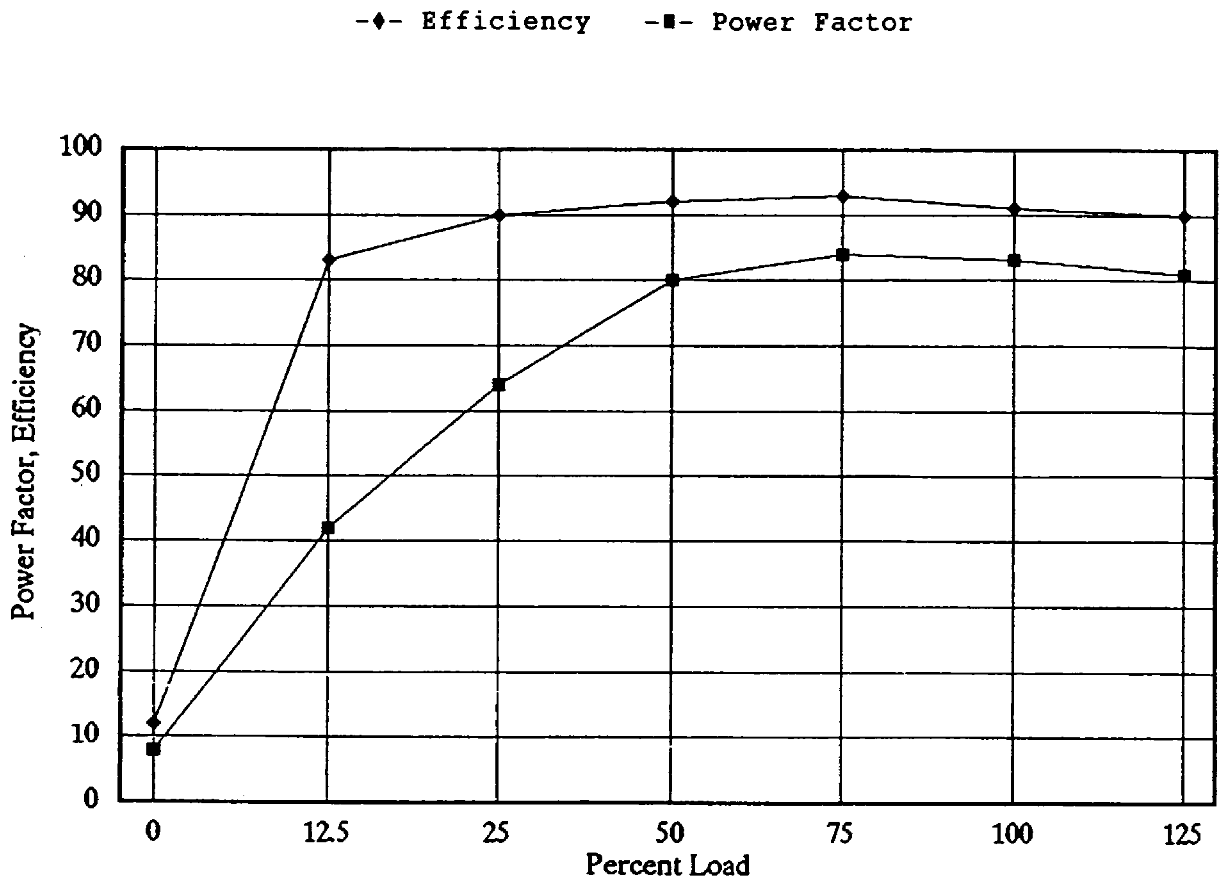


Figure 6.—Variation of efficiency and power factor with motor load.

Note that premium-efficiency motors actually retain fairly high efficiency through loading as low as 12.5% of rated values; but at that level, efficiency is negated by power factor decay. In applications where motors must be oversized to accommodate occasional peak loading but can stay below 50 percent of rated load for prolonged periods, the operating economy of premium-efficiency motors can be preserved by adding simple, inexpensive power factor correction devices to the line.

The main caution regarding the switch to new energy-efficient electric motors is old, familiar, and simple: Look before you leap.

Dole is product manager, Ac Industrial Motors, Dayton Electric Manufacturing Co. Thome is senior product engineer, Ac Industrial Motors, Dayton Electric Manufacturing Co.

Reprinted from

Engineered Systems

P.O. Box 2600, TROY, MI 48007

WRAP PROTECTS WATERING SYSTEM FROM CORROSION[1]

The above-ground portions of the golf course watering system at the Glenview Naval Air Station in Illinois were difficult to protect with conventional coatings because cold water inside the pipes subjected the outside surfaces to constant moisture condensation. As a result, above-ground valves and piping outside the pump house were rusting severely with little hope of reversing the situation.

A new protective coating—a tape coating made by Rust-Oleum Corporation (Vernon Hills, Illinois)—was chosen to prevent further corrosion. The tape coatings can be applied where conventional coatings cannot be used. The three-component system includes a thick, rust-inhibiting petrolatum primer that is applied by hand directly to wet or rusted metal, displacing any

The tape coating is covered with a plastic film, providing a neat package.

[1]Reprinted with permission from the editor, *Public Works*. The article appeared in December 1994.

water present and preventing air and moisture from contacting the surface. The tacky, jelly-like primer is covered with a petrolatum-saturated, high-tensile-strength, synthetic fabric tape to further prevent corrosion. A film outer wrap provides additional protection.

Before anything was applied to the watering system valve and piping, the surfaces were wire brushed by hand to remove rust scale and loose existing paint. It was not necessary to remove all rust because the wet/rusted surface tape wrap encapsulates the surface, cutting off air and moisture and halting further corrosion.

The next step was to smear the viscous petrolatum primer over the entire surface of the objects being coated, being sure to work the material around bolt heads and nuts and into bolt threads. This coverage can be done even if the entire surface is wet with condensation because the petrolatum drives water away and adheres to the steel substrate.

Then, petrolatum-saturated tape was simply spiral wound around smooth cylindrical shapes until the surface was completely covered. To cover the irregular valves and flanges, the material was cut into short strips that were pushed into the primer-like pressure bandages. The pliable fibrous tape was worked by hand into tight areas and stretched over bolt heads to fit snugly against them. Longer strips were then wrapped around the entire valve to help hold the shorter ones in place. The clear plastic film outer wrap completed the protective package.

The petrolatum-saturated tape wrap without plastic outer wrap can be topped with a conventional coating for color coding.

EDITOR'S NOTE: The following article illustrates some of the situations faced by public servants. Although some of the specific problems may not be applicable, the subjects covered do provide examples of how these problems were addressed.

DIRECTORS' GROUP TROUBLESHOOTS TOUGH PUBLIC WORKS PROBLEMS[1]

by Herbert F. Lund, P.E.

Mr. Lund is a public works consultant specializing in troubleshooting operational problems and productivity improvement. He has also edited The McGraw-Hill Recycling Handbook and resides in Pompano Beach, Florida.

A group of public works directors and managers met just before Thanksgiving at a Troubleshooting Seminar in Key West, Florida, to thrash out and brainstorm difficult public works problems. As the seminar organizer, I asked attendees to bring their individual problems to the meeting for study and solution. Topics ranged from improving the public works image to sick time and workers' compensation abuses to evaluating privatization of various public works operating functions. Practically all participants worked under stressful daily pressure but were amazed and consoled that their own operations were not bad off compared to some others around the table.

From a list of more than 20 topics, the group focused on 10 critical areas:

- Improving the public works image.
- Privatization trends and factors. What is important?
- Finding new creative ways to improve productivity and reduce costs.
- How to avoid poor design and construction disasters.
- Solving abusive use of sick time and workers' compensation.
- How to best plan and budget for the new ADA (Americans with Disabilities Act).
- Better utilization of stormwater fees.
- Getting the most out of contractors and consultants.

[1]Reprinted with permission from the editor, *Public Works*. The article appeared in May 1995.

- Is there a way to minimize the disruption of planned work schedules by "emergency" interruptions?

- How to improve the handling and servicing of public complaints.

Image. At one time or another each attendee suffered from that old "no-work" stigma of one laborer digging a hole while a crowd of other public works types stand around the hole watching. How to turn this bad image around?

Larry Thacker, public works director at Port St. Lucie, Florida, is preparing a video tape of his department's operations and activities. The video will be shown to city officials and on public television. At Lake Worth, I devised a trolley tour and printed agenda for the mayor, city commissioners, and public to view first hand just-completed public works improvement projects. Another participant started an "employee of the month" award program to recognize service above and beyond normal job requirements.

Most agreed that "tooting your own horn" more often was a good image builder. But there was one practical suggestion—always obtain your boss's permission and do not get more exposure in the press than your boss. Public works must get into the public relations business.

Privatization. The trend toward privatization is growing. Most municipal officials are caught between lower tax income and rising costs and look to privatization as a cost saving opportunity. The rationale is that private industry must be more efficient because it must make a profit to stay in business. But in some instances, the public works operating division may be just as efficient, plus it may offer the public a more customized, friendly service.

The attendees agreed on numerous potential target areas: custodial services, A/C repairs, recycling collection, landscape mowing, garbage and trash collection, and vehicle maintenance. But each city and its public works organization has its special character, be it employee performance and service, type and quality of equipment, or varying level of service. For instance, of those attending this seminar, trash collection frequency varied from two times per year to once a month and every week pickup.

Although the advantages of privatization are attractive—potentially lower costs, no personnel problems, and usually better equipment, it is important to prepare Requests for Proposals (RFPs) for outside private services with great care and detail to avoid vague areas open to different interpretation and subsequent cost variations. The incumbent public works division should submit its own response and bid to the RFP. In one instance, Phoenix, Arizona's public works function beat out the private firms.

However, if a private firm is successful, there are cautions. Look out for escalation pricing clauses, especially those becoming effective after the second year. Watch out for "low balling" practices. One of the first things a private company may do is put in its own equipment and offer to buy the present city equipment. This is done for two reasons: to sweeten the financial deal but more importantly to "burn the equipment bridges" to minimize the chance that city hall will have the option to cancel the contract. To protect itself, one city put its equipment into mothballs for two years. This offered the city "insurance," and the contractor provided superior service knowing that the city had the option to go back into operation easily.

Inefficient operation opens the door for privatization. One city was about to go private with garbage collection when a new public works director cut 35 percent of the costs by consolidating routes and then reduced resident garbage fees. The threat of privatization forced the solid waste division to trim its own fat. The clear message from the seminar attendees was trim down first before looking into privatization.

Another privatization target area is vehicle maintenance. If the quality of vehicle repairs needs improvement and you are not successful in correcting the problem, seriously consider privatization. Attendees pointed out that repeated repairs for the same breakdown could mean the mechanics' skills are lacking. Private companies in this field because of their size have an advantage on the cost and inventory control of spare parts. However, most city garages currently farm out heavy-duty repairs such as diesel engines, transmissions, and hydraulic cylinders. Complete replacement of garage services is feasible for some cities, not for others. Cost tempered with quality and level of service are the critical factors. There are municipalities that were unhappy with their contractor and brought back their own operations. When privatization specs and RFPs are prepared, do not overlook indirect and hidden costs, such as legal fees and administrative costs.

Productivity and Costs. Attendees complained that every time police and fire department personnel got a raise, public works took a hit of 10 percent or more. They were looking for new ways to counter these budget cuts and look like heros. Several noteworthy ideas were offered in both the personnel and equipment areas.

James L. English, P.E., director of public works for Winter Park, Florida, described a "partnership" program that he first encountered at the Florida Department of Transportation. Partnership breaks down the walls between different divisions of public works to establish mutual trust and an informal working relationship. About once a month, Jim brings together a different group of five or six employees, each from a different division, just to talk, complain, and exchange ideas. During the hour-long sessions, he encourages a free, gloves-off discussion. There are only two rules: no criticism of fellow employees and no foul language. It has paid off, for instance, on DOT construction projects. Jim told of a significant reduction in change orders and a lowering of cost overruns.

A similar practice takes place in Lake Worth, Florida, where the senior trash collection crews meet informally with the public works director and supervisors to air complaints, get things off their chests, and once in a while come up with cost-saving ideas. The director listens and responds directly whether he can or cannot correct or solve a problem. This has been a confidence builder resulting in very few formal grievances and some practical ideas. One has been to upgrade all laborers and train them to be truck drivers. With an all-driver trash crew, the supervisor has greater flexibility in forming route crews even with some absentees.

A time- and cost-saving suggestion came from a senior equipment operator. Several trucks used to be tied up in the yard each morning undergoing needed repairs such as brakes, back-up lights, turning signals, or broken side view mirrors. The operator suggested that each truck driver thoroughly check out his vehicle at the end of the work day and report problems to vehicle maintenance. Repairs were usually completed that afternoon, and trucks were ready to leave the yard on time. The result was four to eight hours of crew time saved per day.

Concerning equipment, half the attendees complained about being saddled with the lowest priced equipment. One attendee suggested that before issuing a purchase requisition, make sure you include the best productivity and maintenance specifications. Form a specification team of your division supervisor and vehicle maintenance manager. Then you as the director should meet with them to make sure the specs are tight. To "justify" the purchase of a higher cost vehicle, describe how higher productivity and less downtime result in a lower total cost over the vehicle's lifetime. Also, to minimize equipment failures caused by lack of lubrication, it was recommended that a centralized hydraulic lubrication system be installed on the vehicle to feed all lube points, including those out of sight, hard to reach points.

Design and Construction Disasters. All too frequently, public works has inherited the job of repairing poor, inadequate workmanship of a contractor after the warranty expired. This problem is usually the result of inadequate field inspection practices. Many attendees commented that they had to document poor workmanship with photographs. Others, to protect themselves, insisted on reviewing construction specifications before work began and participating in pre-construction meetings. The earlier the director and staff become involved in the planning stage of new projects, the better.

As an example of what can happen, a landscape program for swale areas along a major Route 1 section in Florida was designed and costed out by a city planner and architect. They overlooked the water supply and electrical pumping installation for the sprinkler system. To offset this costly change order, the amount of money set aside for annual maintenance, $11,000, was wiped out.

On the positive side, early public works involvement resulted in converting the originally planned sodded medians (high mowing maintenance) outside city hall into decorative royal palms, flowering plants, and paver block edging at no extra cost to the city. The consensus of the attendees was to coordinate very early with the planning department and city engineer in the planning and specifying of new projects for which public works will ultimately have maintenance responsibilities.

Abuse of Sick Time and Disability Claims. Any personnel manager will remind you that you are not a doctor and thus are not qualified to pass judgment on employee sickness. But the Key West group did offer some pointers to identify abusers. Gene Simmons, director of public services, Belle Glades, Florida, watches for patterns. Does an employee favor a particular day repeatedly—Mondays or Fridays to make long weekends or the day after payday? When he finds a pattern, Gene will direct his supervisor to verbally warn the employee. If that does not work, the employee is sent a written certified letter listing all the dates and informing the employee that he or she has two months to correct the problem or "more severe disciplinary measures up to and including termination may be taken."

Workers' compensation is a much different, more difficult matter. It is common practice for human resources departments to send injured employees to a doctor from a pre-screened list to verify or challenge the employee's own doctor's diagnosis. In public works, back problems are common and should be checked out by the city-recommended doctor.

Planning for ADA Compliance. The ADA is important to public works for budgeting and manpower planning. All city buildings, park facilities, museums, libraries, golf courses, etc. must be surveyed and compared to the new ADA requirements. A list of needed repairs, remodeling, protected parking locations, and even special door handles in rest rooms should be prepared in detail. Then cost out the different items.

Most attendees agreed that the major problems and costs would involve rest rooms and access ramps. Easier entry to rest rooms, wider doors, and increased turning radius to accommodate wheel chairs would be critical. In many park facilities, rest room walls would have to be extended for wider access and doors. Those areas used most frequently should be installed first. One director, because of lack of manpower, suggested contracting out the ADA program on a five-year basis to spread out the cost. Another uses ADA projects as rainy day fill-in work. Many agreed that the least difficult, most visible, and least costly items, such as blue painting parking spaces, should be accomplished first. A detailed ADA list accompanied by a five-year cost and installation plan should be presented to the city manager and commissioners as soon as possible.

Effective Relationships with Contractors and Consultants. One municipality had been locked in with an engineering consulting firm for 35 years. Although it served the city well, annual billing for this south Florida community of 26,000 exceeded a million dollars. When a new director of public works was hired, one important message from the city manager was to cut down the million-dollar expense. Meeting with the consultant on billing changes resulted in 10 percent savings related to telephone time, unnecessary field trips, and tying consulting fees to inflated construction costs. Further reductions were made by opening up the engineering services to other qualified firms for various technical disciplines: civil, electrical, mechanical, solid waste and recycling, environmental, facilities planning, construction management, etc. By preselecting these consultants, the city instituted more practical control of engineering services.

Other attendees reflected on the importance of tight quality contract specifications and, if possible, withholding a higher percentage of the contract fund, about 20 percent of the total, until all the workmanship is judged acceptable. Several pointed out the need to withhold payment until a complete set of as-built drawings is delivered, inspected, and accepted.

Managing Emergency Interruptions. "Drop everything and fix Mrs. Martin's broken sidewalk." Inspectors and street crew are out on scheduled catch basin cleaning work because of a hurricane warning and the urgent message comes from city hall. "Do it now. Mrs. Martin is threatening a lawsuit." There goes the planned schedule, and you know the end result will be many flooded areas from overflowing catch basins.

Some interesting ideas surfaced. Dean Schuett, stormwater maintenance services manager for Port St. Lucie, offered this procedure. Depending on your rapport with your city manager, suggest that you will personally look into this matter. Visit Mrs. Martin, explain why the catch basin cleaning must be done, and schedule a specific date for the sidewalk repair (and don't forget to block off the damaged sidewalk to avoid a tripping accident). Another idea was to schedule only 4- or 4 1/2-day work weeks for float time to accommodate these unscheduled interruptions. If the interruptions exceed one work day of labor per week, a meeting with the city manager was recommended to establish priorities and sensible procedures to minimize the interruptions that decimate productivity.

Using Stormwater Management Program Fees. Nearly 60 percent of the cities represented at the seminar were operating or planning stormwater management programs. Most welcomed the additional capital funds to purchase new equipment, such as street sweepers and asphalt paving equipment, related to drainage improvements. However, there was agreement that the program and fees should be used to stimulate much needed correction of deteriorating underground infrastructure. Many operated on extremely costly emergency repairs. The cry was to convert from emergency repairs to a planned preventive program. This means inspecting the whole system to identify weak underground pipe, cracks allowing infiltration, and possible installation mistakes. Underground TV monitoring equipment is available to map a whole system. The fees will cover the equipment and the cost of an inspection crew. A review of the TV reports should indicate priorities for repair or replacement. Some cautioned that the street sweeping operation should be completed first and the underground pipes should be cleaned out to give the TV crew clear access. Therefore, the troubleshooting recommendation was to map the underground condition, record the finding on a computer mapping program, establish priorities, and establish a long-term maintenance and replacement program.

Handling Complaints. Many directors reported being evaluated on the number of complaint calls received and how well the public works staff handled them. Complaints range from trash not being picked up, to dirty rest rooms, to city trucks observed parked in front of fast food stores during working hours. The nature of the public works business is that crews are outside in full view of the public. Any apparent wrongdoing is quickly reported. Several countermeasures were discussed. All agreed that fast response was critical. It is important for the director or staff to make contact and visit the complainer to not only calm the person but, more importantly, to inspect the nature of the complaint. Then, where possible, fast corrective action could be ordered. Records of recurring complaints, such as leaving a trail of garbage after pickup, could indicate the need for employee retraining or disciplinary action. Radios are important for quick response to complaints. Several attendees reported that not all their vehicles or personnel in the field had radios. The cost of radios is a small price compared to an angry resident appearing before your city commissioners.

One attendee arms all field personnel with their individual supervisor's business cards, and each supervisor carries the director's business card. When an irate citizen stops a public works employee in the field, the employee has been instructed to listen to the complaint politely but ask the resident to contact his supervisor at the phone number on the card. This director reports a 90-percent reduction in formal complaints logged in at city hall. All directors agreed that the complaining resident greatly appreciates quick, personal contact, even though the cost of the repairs might be too expensive and a delay necessary.

At the end of the seminar, the unanimous cry was, "When do we do this again?" Attendees came away with several ideas and tips to try out in their own operations. Jim English from Winter Park said that he learned more from this informal idea exchange than from most of the formal conferences he has attended. This "learn with leisure" format was enlightening, encouraged a free communications exchange, and uncorked many practical, clever solutions of current, individual problems.

Printed on Recycled Paper

☆U.S. GOVERNMENT PRINTING OFFICE: 1995—841-951

Mission

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The purpose of this bulletin is to serve as a medium of exchanging operation and maintenance information. Its success depends upon your help in obtaining and submitting new and useful operation and maintenance ideas.

Advertise your district's or project's resourcefulness by having an article published in the bulletin—let us hear from you soon!

Prospective material should be submitted through your Bureau of Reclamation regional office. Regional editorial staff contacts are as follows:

Vicki Hoffman, Pacific Northwest Region, ATTN: PN-3234, 1150 North Curtis Road, Boise, Idaho 83706-1234; (208) 378-5335, FAX (208) 378-5305.

Dena Uding, Mid-Pacific Region, ATTN: MP-430, 2800 Cottage Way, Sacramento, California 95825-1898; (916) 979-2422, FAX (916) 979-2505.

Ron Smith, Lower Colorado Region, ATTN: LC-4842, PO Box 61470, Boulder City, Nevada 89006-1470; (702) 293-8436, FAX (702) 293-8042.

Don Wintch, Upper Colorado Region, ATTN: UC-434, PO Box 11568, Salt Lake City, Utah 84147-0568; (801) 524-3307, FAX (801) 524-3034.

Tim Flanagan, Great Plains Region, ATTN: GP-2400, PO Box 36900, Billings, Montana 59107-6900; (406) 657-6243, FAX (406) 657-6418.