WATER OPERATION AND MAINTENANCE

BULLETIN NO. 111

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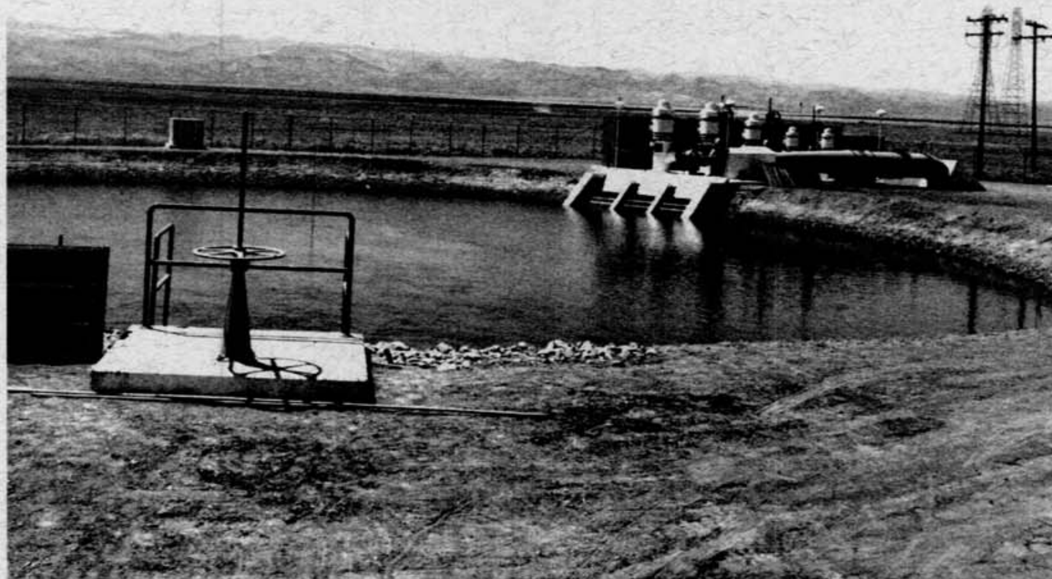

IN THIS ISSUE

UNITED STATES DEPARTMENT OF THE INTERIOR

Water and Power Resources Service

The Water Operation and Maintenance Bulletin is published quarterly for the benefit of those operating water supply systems. Its principal purpose is to serve as a medium of exchanging operation and maintenance information. It is hoped that the reports herein concerning laborsaving devices and less costly equipment and procedures will result in improved efficiency and reduced costs of the systems for those operators adapting these ideas to their needs.

To assure proper recognition of those individuals whose suggestions are published in the bulletins, the suggestion number, as well as the person's name, is given. All Service offices are reminded to notify their Suggestions Award Committee when a suggestion is adopted.

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Division of Operation
and Maintenance Technical Services
Engineering and Research Center
Denver, Colorado 80225

View of pumping plant 7R-B, a regulating reservoir that controls the pumps at pump lateral 7R-A, a few kilometers west of Tranquility, California. This is one of three reservoirs needed to pump and deliver water on the uphill side of the San Luis Canal. It is part of the Westlands Water District distribution and drainage system being constructed by the Water and Power Resources Service as part of the San Luis Unit, Central Valley Project.

On November 6, 1979, the Bureau of Reclamation was renamed the Water and Power Resources Service in the U.S. Department of the Interior. The new name more closely identifies the agency with its principal functions–supplying water and power.

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INTRODUCTION

Selecting the correct wire rope and its care are described in an excellent article, "Guidelines for Effective Buying and Efficient Handling of Wire Rope," beginning on page 1.

Trouble with gophers? Read about a new underground cable that has proven to be gopher resistant. See page 5.

The article on page 8 describes an improved method of driving spikes safely devised by employees at the South Platte River Projects Office.

On page 9 is an article on how the crew at the Edmonston Pumping Plant made disassembly of pumping units easier with the aid of quartz-gas radiant heaters.

Problem areas, proper care, and maintenance of pumps and motors are described in the article starting on page 11.

Would you believe gasoline can spoil? See page 15.

Check the article on page 16. Your cigarette lighter is an explosive hazard.

GUIDELINES FOR EFFECTIVE BUYING AND EFFICIENT HANDLING OF WIRE ROPE[1]

Approximately 225 000 t (250,000 tons) of steel wire rope, valued at more than $300 million, are sold annually in the United States. The muscle of modern industry, wire rope is used wherever heavy weights have to be moved and mechanical energy transmitted expeditiously.

Despite its role as the lifeline of innumerable operations, not every buyer, and certainly not everyone connected with its application, is fully acquainted with two essentials: How to select exactly the right wire rope for the job; and the care needed to maximize its service life. Providing basic information on both is the purpose of this article.

In a very real sense, wire rope is a complicated machine with many moving parts. A typical 6 by 25 rope, for example, encompasses 150 steel wires, all of which move together and independently as the rope bends. Internal rope tolerances are measured in thousandths of a millimeter (ten-thousandths of an inch), the same level of precision found in automotive engines. A complete knowledge of wire rope necessitates an understanding of wire strand arrangement, cores, and construction, rope-using equipment and myriad other elements involved in rope manufacture and use.

Although many users, through experience, have settled on the right rope for its specific task, first-time buyers and those selecting rope for new applications would do well to seek the recommendations of technical specialists at supplier firms. In some cases, this may entail a specialist's visit to the work site to analyze the operating conditions. In all cases, it will mean stipulation of key requirements so that rope tailored for the job can be selected.

By briefly examining what the rope engineer has to evaluate, the buyer or user can gain a basic knowledge of what modern wire rope is all about. These are some of the specifications in rope selection:

Diameter and Length.–Wire rope is available in diameters from 0.4 mm (1/64 in), as bought for control cables and brake levers, up to the 127-mm (5-in) size employed on the world's largest dragline. Length bears some relationship to diameter, but wire rope can be produced in lengths up to several thousand meters and, in general, is limited only by the size of the wire rope plant's stranding and closing machines.

Construction.–Basically, wire rope is a combination of strands, each of which contains precise numbers and patterns of steel wires (in diameters from 0.13 to 6.4 mm (0.005 to 0.250 in). The wires in each strand are helically laid around a center wire (or occasionally, a fiber center) in one or more layers. Ropes are made by helically laying several strands (usually six to eight) around a core.

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[1] Written by special permission of the Editor, Public Works Magazine, from October 1979 issue.

Six-strand wire rope is by far the most popular. It accounts for 95 percent of the ropes made today. Actually, the most common rope constructions are into five standard classifications, based on the number of strands and wires per strand. In each instance, the first figure refers to the number of strands–6 (strands) x 7 classification, 7 wires per strand; 6 x 19, 16 through 26 wires; 6 x 37, 27 through 49; 6 x 61, 50 through 74; and 8 x 19, 16 through 26.

As a general rule, a strand that contains a small number of larger wires will be more abrasion resistant than a similar-sized strand made up of many smaller wires. On the other hand, strands composed of many small wires will make the rope easier to bend. Thus, in rope design/selection, securing the expertise of the technical specialist is important.

Wire Grades.–Today, most rope is available in two grades – (IPS) Improved Plow Steel and (EIPS) Extra Improved Plow Steel. Both are tough, strong, wear- resisting carbon steels, with the latter grade providing about 15 percent greater tensile strength. Where special anticorrosion characteristics are desired, galvanized steel or stainless steel wire may be used.

Cores.–Rope cores serve as a foundation for the strands. They are usually one of three types: (FC) fiber core such as natural sisal or hemp, or synthetics such as polypropylene closed into a fiber rope; (IWRC) an independent wire rope core; or a (WSC) wire strand core, normally only used in small-diameter ropes. Fiber core ropes bend more easily. The steel cores provide more substantial support to the outer strands, resist crushing and heat, reduce stretch, and increase the rope's strength.

Lay.–In wire rope, the term "lay" has two main meanings, both involving the direction in which the strands or wires spiral. In a right lay rope, strands spiral clockwise to the right. In left lay, the strands rotate left, or counterclockwise. In regular lay rope, wires are laid in a direction opposite to the strands; the external wires appear to run parallel to the axis of the rope. In a Lang lay rope, wires lay in the same direction as the strands, both diagonal to the rope's centerline.

Regular lay rope is more stable and resistant to kinks, untwisting, and crushing. (Right regular lay is furnished for most rope applications, unless otherwise specified.) In Lang lay, the longer length of exposed outer wires presents a greater wearing surface and more resistance to abrasion. It also possesses better fatigue resistance.

Application on Equipment.–A major influence in rope selection is the type of operating equipment on which it will be used, be it on cargo falls, conveyor systems, elevators, hoist lines, overhead cranes, power shovels, or ski lifts. Specifying the application, machine, make, and model number will help to pinpoint the most suitable rope for the purpose.

Other Considerations.—The preceding information has described some of the basics in buying wire rope and keying rope to the task it must perform. But specific applications and/or operating conditions can require a number of other characteristics. The forces that act upon wire rope in service–tensile loading, abrasive wear, bending fatigue, and lateral crushing–are among the factors that have to be accounted for in rope specification.

Wire Rope Care

Buying the right rope is a good beginning. Giving it the proper care–to prolong useful rope life–is equally important. Here are some of the recommended practices.

When unloading a shipment of wire rope, don't drop loaded reels onto the ground from the truck or dock. Reels are not designed to withstand this abuse. The rope's weight can collapse the reel, and it is difficult to remove wire rope from a collapsed reel without severely damaging the rope.

When removing wire rope from the reel or coil, it is imperative that reel or coil rotate as the rope unwinds. (Unwinding wire rope from a stationary coil or reel may kink the rope, causing permanent damage.) The reel should be mounted on a shaft supported either by two jacks, a roller payoff, or an unreeling stand. Rope should be pulled from the rotating reel by holding its end and walking away from the reel, taking care to keep slack from accumulating.

If no unwinding stand is available, the rope end should be held and the reel rolled along the ground. When rope is to be unwound from a coil, use a revolving stand or place the coil on edge and roll it (like a wheel) in a straight line away from the free end.

When a new moving rope is first installed, run it for a short break-in period with a light load. By doing this, the component parts will "set" themselves to the working conditions. When full operation is begun, the rope will work more efficiently.

Wire rope is lubricated during its manufacture so the strands and wires can move and adjust as the rope moves and bends. Subject to the same internal wear as any other machine, a wire rope cannot be lubricated sufficiently in manufacture to last its entire life. New lubricant must be added periodically to replace the factory lubricant which has been used or lost.

The rope surface should be cleaned of grit and dirt, which might prevent lubricant pass-through. It is advisable that the oil or grease then applied be light-bodied enough to penetrate into the core of the rope. Application can be by bathing, brushing, dripping, pouring, or spraying–ideally at the top of a bend in the rope, where strands are spread and more easily penetrated. A rope's service life is usually directly proportional to the amount of lubricant retained in its working parts.

When not in use, wire rope should be stored in a dry area, free from acid fumes and other corrosives, off the bare ground, and protected against the weather. If storage is to be lengthy, rope should be cleaned, lubricated, re-reeled, and put under a protective wrapper. Keep it away from heat, which could tend to dry out the lubricant.

Besides the detrimental practices mentioned previously, here are some other faulty operating and handling conditions that should be avoided:

Keeping damaged ropes in service, using ropes with improperly attached end fittings, employing ropes that provide less than the minimum design safety factor.

Drums or sheaves of insufficient diameter, or out-of-alinement; improper winding of the rope on drums; undersized or worn sheave grooves; sheaves that operate improperly or damage the rope.

Jerking or shock loading, too rapid acceleration or deceleration (sudden stop) of the load.

Regular and thorough inspections must be made (they are mandated by Government regulations) throughout the rope's service to detect damage, measure wear, and determine, as far as possible, the useful life remaining. Rope life will vary, depending upon the equipment, operating conditions, degree of lubrication and maintenance, type of rope, climate, and even operator handling traits.

Inspection findings should be recorded. From these records, optimum wire rope replacement intervals can be decided more accurately. When inspecting the rope, the condition of the drum, sheaves, guards, and end fittings should also be noted, for these parts affect rope wear. Obviously, any irregularities detected should be repaired or parts replaced.

A multitude of additional facts are available on wire rope selection and care, including the Government regulations and standards pertinent to specific applications and to rope-using industries. Such information can be obtained from rope distributors and from the member companies of the Wire Rope Producers Committee of American Iron and Steel Institute.

* * * * *

NEW ELECTRICAL CABLE FIGHTS OFF GOPHERS, ELEMENTS[2]

When Ken Kraus installed his electrically-driven center pivot in 1976, he expected it to work for years to come. And the first couple seasons, it did work, just fine, on his farm near Hays, Kansas.

Last spring, however, when he flipped on the power, nothing happened.

The fault was not with the center pivot. Rather, the trouble was underground where it couldn't be readily seen. In the short time since the irrigation system had been erected, moles and gophers had eaten through the insulation on the single conductor power cables which had been buried in a ditch running from the power source to the center pivot control box. Once the sharp-toothed rodents had eaten through and exposed the aluminum wires to water and other minerals in the soil, it didn't take long for them to short out. Result: crop stress, lost yields plus the extra expense of new wires.

Kraus' experience has been shared by many other irrigators during the last few years. Failure of underground wiring has been tagged as one of the primary reasons for downtime early in the life of otherwise trouble-free sprinklers.

In an effort to correct his crisis, he contacted center pivot dealer Maurice Martin in Quinter, Kansas. After studying the situation, Martin advised Kraus to install new underground wiring, rather than try to fix the old. But instead of single strand conductors, he recommended using a new product developed exclusively for underground service to center pivots–Tuf-Hide Cable, from Paige Electric Corporation.

The cable contains four insulated power conductors, plus two shielded pump shutdown wires, wrapped in a heavy-duty gopher-resistant, polyethylene jacket.

"We used to provide some protection by pulling several single strand conductors through a PVC water pipe and then bury that," Martin continued. "But we would spend an entire afternoon putting in 0.4 km (1/4 mi) of wire doing it that way. With Tuf-Hide, we can have it done in a fraction of the time," he said.

Actually, metallically armored cable–preferably stainless steel–is the only "guaranteed" way to make cable gopher proof, according to tests made by Bell Laboratories. The tests have shown that the menacing rodents can exert pressure as great as 275 MPa (40,000 lb/in^2) with their tough jaws and razor-sharp incisors. Yet, say Bell researchers, the larger the diameter of the cable, the less damage a gopher can do, since the opening between the tips of the upper and lower incisors seldom exceeds 25 mm (1 in).

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[2] Written with special permission of Editor, Irrigation Age, November-December 1979 issue.

A gopher-proof cable, with a stainless jacket, is also available from Paige Electric Corporation but is more expensive than Tuf-Hide.

Gopher resistance, however, is only one advantage of a multiconductor cable vs. single conductor installation, added Warren Brown, Brewster, Kansas. Brown hooked up 13 center pivots this year with Tuf-Hide cable.

"You're much more likely to damage single strand conductors during installation," Brown stated. "All you need to do is cause the slightest nick on the insulation of single strand cable and the aluminum wire will be corroded within 2 years. Many times, gophers take the blame for what was an installation problem."

Brown, a farmer as well as dealer, said his own center pivot systems were installed with single strand conductor several years ago. "We couldn't tell for sure if it was gophers or poor installation, but we had to go back in with new wiring a year and a half later–and we had to plow through 0.8 km (1/2 mi) of growing corn to get the systems running again. That taught us to do it right the first time."

Voltage induction is another problem that Brown said can be avoided with the new cable. Voltage induction is a problem that occurs when power and control wires are laid parallel with each other without some type of shielding. When control cables are buried in the same trench with the power cables, induced voltage can cause misoperation of controlled equipment by overriding the contact signal.

One method of reducing the induction from the voltage of the power conductors is to provide shielding of the control wire pair. This is achieved with an aluminum/mylar shield which is tied to ground in Tuf-Hide, and thus drains the induced voltage off the control wires.

Voltage induction can be a real problem when PVC water pipe is used for a conduit, Brown said. "Putting the wires into PVC pipe doesn't prevent voltage induction," he said. "The straighter you have the wires laid out, the easier it is to get them into the pipe. This just makes voltage induction all the more likely."

LaVerne E. Stetson, USDA agricultural engineer stationed at the University of Nebraska, agrees that multiconductor, underground cable is preferred for center pivots over single conductor cable. Stetson, one of the authors of the first Irrigation Standard, written for the National Electrical Code, makes these comments:

> "First, having a grounding wire in the cable is a good reminder to do a proper job of grounding.
>
> "Second, the shielded and twisted control wires will definitely help get away from induced voltage.

"Also, having the wires all protected inside a tough outside material certainly makes it easier to install. Having only one cable to watch rather than four separate wires will certainly narrow the chances of damaging individual conductors."

Tuf-Hide has been field tested for 3 years with excellent results, said John Anderson, Manager, Paige Electric Corporation, Columbus, Nebraska.

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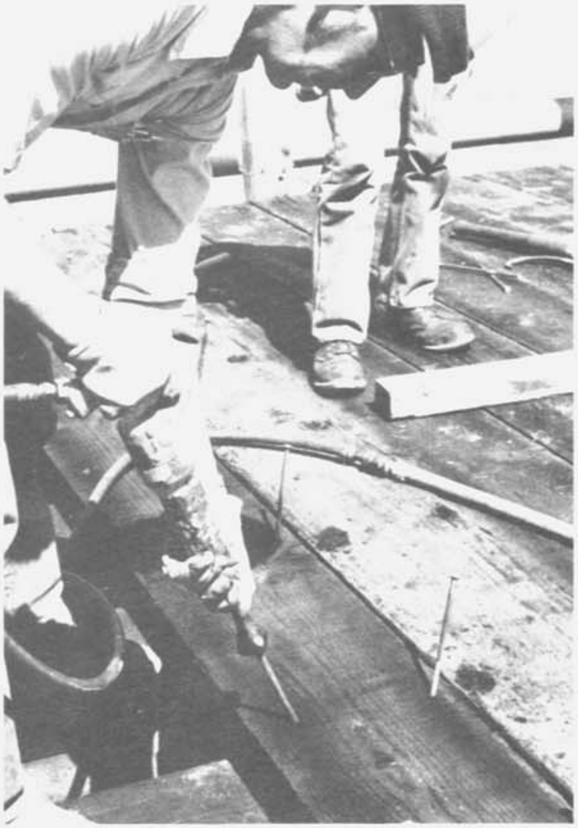
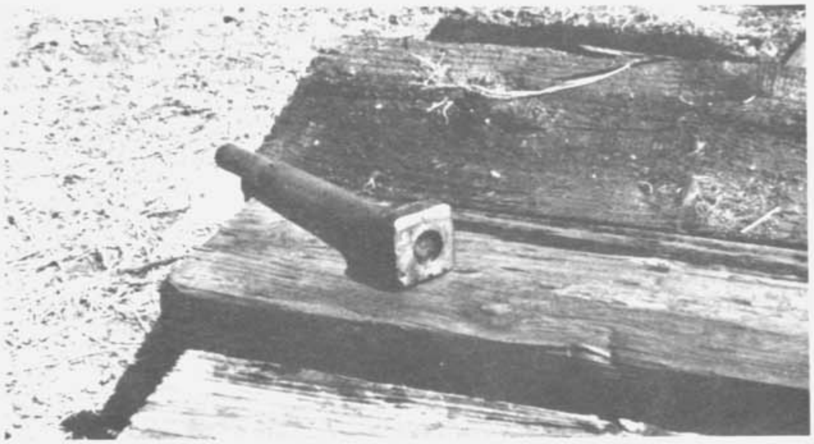
EMPLOYEES IMPROVE SPIKE DRIVING METHOD[3]

Messrs. Del E. Cherry and William R. McKendry, employees of the South Platte River Projects Office, Loveland, Colorado, devised a method of driving wire spikes by using an air hammer and a modified bushing tool as shown in the photographs. This improved procedure of driving 300-mm (12-in) spikes using a powered tool is far superior and safer than using a 1.8 kg (4-lb) sledge hammer.

The estimated monetary saving on the redecking of the wooden country road bridge over the Pole Hill Canal last summer was $300 to $400. The intangible benefits are labor savings; less worker fatigue; reduction of accident potential from missing the spike; defective hammer head or handle; and ricocheting spikes causing eye, hand, leg, and foot injuries.





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[3] Reprinted by special permission from Reclamation Safety News, Third Quarter 1979.

USING PORTABLE, QUARTZ-GAS RADIANT HEATERS TO WARM PUMP PARTS FOR SAFER, EASIER DISASSEMBLY[4]

The main pumping units at Edmonston Pumping Plant (San Joaquin Division, California Department of Water Resources) are unique, high-lift, multistage types. One lifting stage fits on top of the other like layers of a cake. These sets of pump case diffusers and guide ring assemblies all slipped together quite easily when they were originally assembled. Each segment was fitted with "O" rings, and they were all bolted together securely. The units have operated without serious flaws since then lifting the water up the Tehachapi Mountains. Recently, however, a small trickle developed from a diffuser guide-ring assembly case of unit No. 1. Apparently, it was a deterioration of the "O" ring, and would probably be repeated in the other pumps. To replace the "O" rings, each assembly case would have to be unbolted and lifted off of the pump. The maintenance workers would remove the bolts and then the big, overhead crane would lift off the upper half of each assembly. Simple! But, it did not work quite that way.

The retaining bolts came out without any trouble, but the upper half of the case was apparently glued tight with some form of corrosion. All the rest of the cases would probably be the same. There was enough power in the overhead crane to pull the case apart, but the halves might be badly distorted in the process. Also, quite a strain would fall on the wire ropes of the crane hook; they would stretch considerably so that there might be a terrific backlash when the parts let go. Anything could happen with parts weighing several tons bouncing around like a big wrecking ball. It was too dangerous to consider. Something was needed to break the corrosion bond.

Otto Fullen, the HEP Mechanical Supervisor, conferred with his work crew. If a little movement could be introduced between the two halves of a case, the halves might be worked apart. Hydraulic jacks were available to help work on separating the two; and why not use heat to expand and move the upper case? Thermocouples attached at intervals around the shell of the case would control the heating rate and prevent any local damage. Ordinary gas-radiant heaters could be used, set at intervals around the casing. Then the top of the case was covered by fireproof blankets to hold in the heat. The idea was to maintain a temperature of between 71-82 °C (160-180 °F). Strip recorders connected to the thermocouples provided a profile of the heating.

Four 91-t (100-ton) hydraulic jacks were used; one at each corner flange of the upper assembly casing. The jacks were positioned in this way so that upthrust (or varying the thrust) could be exerted at will to separate the casings. A portable hydraulic compressor, capable of 69,000 kPa (10,000 lb/in^2) pressure, was manifolded (through a controller system) to the jacks. With this setup, any one or all of the jacks could be activated.

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[4] Reprinted by special permission of the Editor, Technical Bulletin No. 41, California Department of Water Resources publication.

The Division rented some gas-radiant heaters and set them up. Lifting cables from the crane hook were attached to the upper half of the assembly. The jacks were positioned and set to exert 178 000 to 222 000 N (20 to 25 tons) of force. Heaters were then arranged around the cover. The crane took up the slack on the cables. After the heat had been maintained for an hour or so (different lengths of time, depending upon the ability to control heating), the jacks were "rocked." This use of the jacks was the final safety factor; the cover could be jarred loose without much problem. Then, the crane lifted the casting up and away from the pump. To get to the next cover assembly, the diffuser and guide ring assembly would have to be jacked loose and lifted off. Each cover assembly was heated and removed in the same way. For some of the assemblies, the heaters had to be hung down around them from chains when they could not be set on a floor. To pull off the diffuser and guide wheel assembly of the second stages, down below floor level, the maintenance crew made lifting beams attached to long, threaded rods. The rods were screwed into holes on the wheel, the beams extending up above the floor level. Jacks were then positioned under the ends of the beams and the wheel was lifted off.

All corrosion can be cleaned out of the pump, any repair work done, then the "O" rings can be replaced. When the time comes to reassemble the pumps, all assemblies should slip back together just as they did when they were first put together. Since it is probable that all of the pumping units will be worked on in time, the Field Division bought the gas-radiant heaters that had been rented.

For additional information, please write to Otto Fullen, HEP Mechanical Supervisor, or Dick Kuntz, HEP Mechanic II, A. D. Edmonston Pumping Plant, San Joaquin Field Division, California Department of Water Resources.

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PUMP AND MOTOR MAINTENANCE[5]

Pump and electrical maintenance is really quite simple. Basic mechanical knowledge and common sense will suffice in most situations. In reality, a pump consists of three components–pump, motor, and switchgear. A failure in any one of the three will cause the pump to be out of service.

Generally speaking, electrically driven pumps are extremely reliable. One example of this is that on the A&B Irrigation District near Rupert, Idaho, the annual budget for maintaining 198 pumps, motors, switchgear, 400 distribution transformers, and substation equipment, all over 20 years old, was less than the budget for maintaining the district's mobile equipment consisting of 20 pickups and 12 pieces of heavy equipment, all less than 10 years old.

The fact that electrical equipment is so reliable may contribute to its downfall since it has a tendency to give us a false sense of security, thereby leading us to neglect proper maintenance.

Four key requirements, which if adhered to, will eliminate most problems of motor and switchgear maintenance. Almost all electrical failures are a result of neglecting one or more of these four key requirements.

Pump Maintenance

There are many types, sizes, and brands of pumps, such as vertical turbine, horizontal centrifugal, end section, and others; also combinations such as booster pumps with deep well pumps. Regardless of the type or size, the major components and maintenance items are similar.

The main problem areas are as follows:

1. Lubrication.–This is the most obvious. Be sure to use the proper type of lubricant and in the proper amounts. Too little lubricant can cause excessive wear, whereas too much can cause failure through excessive heat buildup.

2. Packing or "stuffing box". –Pump sleeves with wet lantern-ring packing can be a high maintenance item. This can be significantly reduced by flame spraying the shaft sleeves with stainless steel or other materials and carefully selecting the packing. An example of this is a pumping plant in the Rupert, Idaho area. Prior to 1960, the shaft sleeves had to be removed and repaired annually. In 1960, the sleeves were metalized with stainless steel, and grease-impregnated wood-metal packing was installed. One of the impellers was

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[5] Excerpted from Water Systems Management Workshop, 1979, Lecture Notes, Session 15-1, by Earl M. Corless, Minidoka Project, Burley, Idaho.

removed in 1976. The shaft sleeves were worn only from 0.05 to 0.1 mm (0.002 to 0.004 in) after 16 years of service.

3. Vibration.–Excessive vibration or any dramatic change in the normal vibration pattern is always a sign of trouble, and unless corrected, will almost certainly lead to a breakdown.

4. Foreign materials.–The most common problems affecting pumps that pump from surface sources are floating trash and aquatic vegetation. Even small amounts of trash will reduce pump output. Foreign objects such as plastic, sticks, rocks, and even muskrats are picked up by pumps. Adequate screening should be provided to prevent entry of foreign materials into the pump, thus eliminating damage and substandard performance.

5. Cavitation.–Cavitation can be caused by improper pump selection or operating the pump outside the range of designed head conditions.

In large pumping plants, where feasible, the pumps should be inspected annually. Cavitation and impeller wear will usually start any place within the pump where water abruptly changes direction. Applying coatings to the impeller can effectively reduce the wearing process.

6. Low pump discharge.–Perhaps the most common complaint is that the pump is low on discharge. It is essential that you know if the complaint is valid. The past operating history of the pump and motor is invaluable when determining if a pump is not operating properly. In order to obtain this history, measure the quantity of water that is being pumped. Use a good amperage meter and measure the amount of electricity that is being used by the motor. Keep a permanent record of these measurements; then when trouble arises, you will have solid information to assist in troubleshooting. To compare a one-time reading taken during the crisis with motor and pump nameplate data is not sufficient; past operating history is essential.

It should be remembered that if no other data are available, the amperage readings will provide an excellent reference as to the condition of the pump. Generally speaking, an electric motor will use only the amount of electricity that is necessary to operate the pump. If pump efficiency decreases, the amperage will also decrease.

Almost all cases of low pump discharge are caused by excessive wear or clearance at the pump seal. This is not to be confused with the shaft seal or packing gland. The seal is probably best described as the mating surfaces between the rotating impeller and the pump case. All pumps have one or more seals and they are usually fitted with replaceable wearing rings. On large pumps, the clearances should be measured and recorded during the annual inspection.

A pump that is low on discharge can be readily repaired at any good machine shop. Satisfactory repairs can be made by: (a) boring out the wear rings, assuming that there is sufficient material remaining; (b) building up the impeller with stainless steel or other materials; and (c) machining the impeller to proper tolerances. Recommended tolerances between the impeller and the wearing rings are: (1) for a 150-mm (6-in) diameter impeller, 0.35 to 0.40 mm (0.014 to 0.016 in); (2) for a 200-mm (8-in) diameter, 0.40 to 0.45 mm (0.016 to 0.018 in); (3) for impellers above 200-mm (8-in) diameter, add 0.025 mm (0.001 in) for every additional 25 mm (1 in) of diameter; and (4) for large impellers, it is best to check with the factory.

Badly damaged and broken impellers can be repaired by modern welding and flame spraying techniques.

Electric Motor Maintenance

There are at least four key requirements in electric motor maintenance:

1. Keep it clean.–Dirt and oil provide an environment for moisture to collect and remain in contact with energized parts, reducing insulation resistance. Oil and other contaminants can deteriorate insulating materials, as well as provide abrasive materials which will increase wear on moving parts.

2. Keep it tight.–Current flowing across loose connections generates heat, causing insulation failures, fires, direct short circuits, and other problems.

3. Keep it dry.–Water and electrical equipment do not mix. Moisture reduces insulation resistance. An example of this is a motor that became saturated due to a pump failure. Before saturation, the measured insulation resistance was over 1000 megohms; after saturation, the measure resistance was less than 0.5 megohm.

4. Keep it cool.–According to an article in the January 1978 Irrigation Age, "As a Rule of Thumb Electric Motor Life is Doubled for Each 18 °F Reduction in Operating Temperature."

A program of regular insulation testing should be followed. The use of a "Megger" insulation resistance tester will give a good indication of the condition of the entire electrical system. Here again, keep a record of these tests and other maintenance performed. Many potential problems can be detected by taking these tests.

One of the best maintenance procedures is a thorough visual inspection. On larger motors, special attention should be paid to the stator coils. Inspect the condition of the insulating varnish; it should have a good gloss and not be cracked or crazed. Make sure the coil ties at the end turns are tight, and that there is no looseness whatsoever, especially in the area where the coils enter the stator iron. Slip rings and commutators should be inspected. Any that are badly worn should be cleaned and repaired. New brushes should be installed and properly seated.

When it becomes necessary to regroove the commutator, be certain that the grooves are cut out to proper depth and that the bars are beveled so that none of the insulating mica protrudes to the surface of the bar. This will cause uneven wearing and arcing during operation.

During the nonirrigation season, motors that are outside should be winterized. Install snowshields. These should be painted in a contrasting color so that the pump will not be operated with them on. Fill the bearing oil reservoirs to submerge the bearings and prevent rusting. Change the bearing oil in the spring or more often if conditions warrant. Use a good grade of oil. Avoid the temptation to economize on oils. To illustrate the service we expect from lubricants, remember that 1 week of continuous operation is equivalent to driving your car at about 88 km/h (55 mi/h) three times across the United States.

Motors should be reconditioned on a regular basis. The reconditioning procedure consists of a thorough steam cleaning and drying. The motor is then dipped in an insulating varnish and baked. Worn or cracked leads may be replaced and any mechanical parts repaired or replaced. The interval between reconditioning should be determined by the number of motors involved and budgetary considerations. However, it should not be extended longer than 5 years. With a good reconditioning program, failure rates of motors can be reduced to less than 2 percent from all causes.

Switchgear Maintenance

Here again, keep it tight, keep it clean, keep it dry, and keep it cool, with the emphasis on keeping connections tight and dirt out. In the switchgear, as in no other place, the failure of a small, seemingly insignificant component will keep the pump out of service. The main contactor is the major component of the switchgear. It should be inspected at least annually. Special attention should be given to the contact points. When the contactor closes, the points should meet simultaneously and have equal tension. Any contactor points that are badly pitted or worn should be replaced. Spare contact points and main holding coils should be on hand.

Safety

All of the maintenance procedures are fairly easy to accomplish while the switchgear is not energized. If you have to work it hot, it becomes much more complex. You may get only one mistake. Only qualified personnel should attempt to work on energized equipment, and then only in extreme situations.

Transformer Maintenance

The same principles that apply to motor and switchgear maintenance also apply to transformers. The best indicator of what is going on inside a distribution transformer is the insulating oil. Test the oil for dielectric strength; this will indicate the presence of water and other contaminants. Testing the oil for acidity is a fairly simple, inexpensive test. This test will indicate when the critical point of acidity is reached and sludge begins to form.

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STOCKPILED FUEL CAN "SPOIL"[6]

Fuel stockpiling is becoming more common as fuel costs increase, according to Al Rider, Agricultural Engineer, University of Nebraska Institute of Agriculture.

Many people are aware of the dangers of storing large amounts of fuel, but few realize the wastage that occurs, he adds.

Rider points out that fuels "spoil" within a specific length of time, and that farmers buying enough diesel fuel in the fall to last through irrigation next year should be forewarned that its quality may deteriorate before then.

He said that after the fuel has spoiled, using it can create problems with the injector system, the carburetor, the intake manifold and the valves. These can cause unfavorable engine operation and excessive engine wear.

Proper cleaning of storage tanks is one way to prolong the quality of fuel, according to Rider. Also include fuel additives to prevent oxidation and gum formation. These additives are usually available through local fuel dealers. However, they are expensive and make storing the fuel more expensive.

Instead, he suggests, don't store gasoline more than 45 days in the summer, nor more than 3 months in the winter. Diesel fuel can be stored 3 months in warm weather and up to 6 months during colder weather. These figures are for above-ground storage and usually can be doubled for underground storage.

One problem, fungus growing in the fuel, has been occurring with increasing frequency.

Fuel losses also can occur through evaporation. This can be alleviated by examining all fuel filler caps and correcting leaks that may occur at the connections between the tank outlet and the hose nozzle as well as the hose itself.

Tank color can make a big difference in fuel wastage. A tank that is white will result in less loss than one that is a dull red or rusty color. Gasoline containers holding fewer than 227 liters (60 gallons) must be painted vermillion red.

A tank which is located in the shade also will result in a smaller quantity of fuel being wasted than one located in the sun. A tank located directly in the sun will lose about four times as much gasoline as a similar tank totally shaded.

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[6] Reprinted by special permission of Editor, Nebraska Farmer, from September 15, 1979 issue.

DON'T LET DISPOSABLE LIGHTERS LIGHT YOUR FIRE[7]

Disposable butane lighters may be fine for lighting cigarettes, but they can present a serious hazard on construction sites.

One man was killed and another was seriously injured when the lighters they were carrying exploded during the operation of their work.

One workman was using a welding torch and a spark from the torch struck the lighter which he was carrying in his breast pocket. The lighter exploded, killing the workman. Another man was carrying a lighter in the pocket of his trousers. While he was welding, a spark from the torch caught the lighter. It exploded and the workman received severe burns to his hips and groin area.

The company which employed these two men has since instituted a policy whereby personnel working in the maintenance shops are prohibited from carrying these disposable lighters while on duty.

If you use one of these lighters and carry it with you, think carefully the next time you are about to begin using a welding or cutting torch. Keep lighters away from temporary heaters on the jobsite.

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[7] Reprinted from Reclamation Safety News, First Quarter 1979.

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