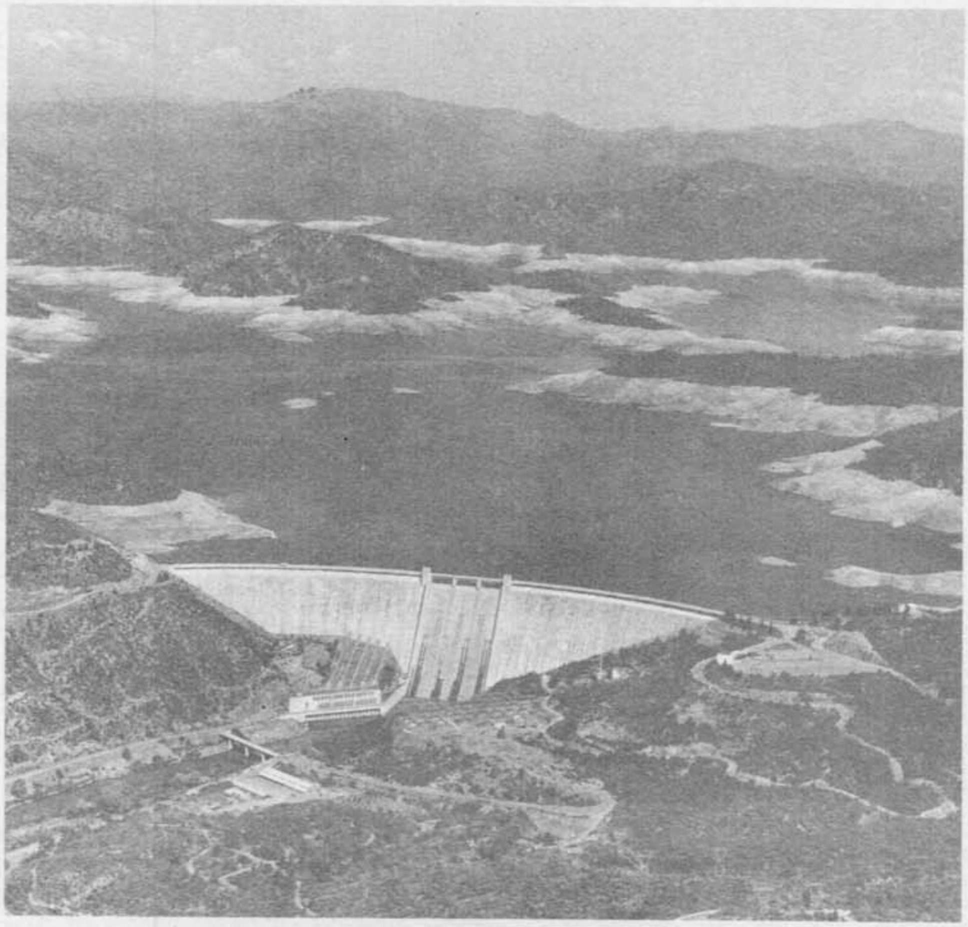
WATER OPERATION AND MAINTENANCE

BULLETIN NO. 100

JUNE 1977



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 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 Bureau offices are reminded to notify their Suggestions Award Committee when a suggestion is adopted.

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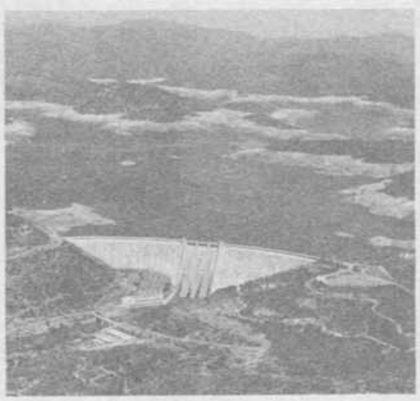

COVER PHOTOGRAPH:

This is an aerial view looking upstream at Shasta Dam and Lake on the Sacramento River north of Redding, California, during low water elevations. Storage capacity of reservoir is 5615 million cubic meters (4 552 000 acre-ft). Storage in reservoir when photo was taken is 1590 million cubic meters (1 291 000 acre-ft).

UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

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WATER OPERATION AND MAINTENANCE
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INTRODUCTION

"Drought Assistance for 1976-1977" is a most timely article giving an overall presentation of the Bureau of Reclamation's assistance program available to those entities in drought-stricken areas.

The article on page 5 describes the use of aeration systems by the Southern Field Division, Department of Water Resources, California, to improve and maintain control of water quality.

"Add More Life to Irrigation Motors" is an article beginning on page 10 which describes how good motor management puts more water on your crops for less money.

Using material on hand, the San Luis Field Division, Department of Water Resources, California, came up with an innovative piece of equipment for drilling and grouting cracks and gaps behind aqueduct lining.

"Beware of Equipment with Worn-out Wiring" lists major precautions which owners and operators of center pivot systems should observe to prevent electrical accidents.

DROUGHT ASSISTANCE FOR 1976-1977[1]

Precipitation in most of the Western United States during 1976-77 has been at or near an alltime low, resulting in deficient water supplies for irrigation, power, and other uses. This drought will result in major economic losses in the form of reduced agricultural production, reduced energy generation, and reduced recreation and fish and wildlife benefits. In addition, production of perennial crops, such as orchards, alfalfa, and pasture will be reduced or stopped for several years if these crops receive insufficient water to survive. Even with a normal water supply in 1977-78, many areas will experience lower than average water supplies due to water depletion in their reservoirs. It is apparent that, at best, the impact from the present drought will have a lasting effect on the nation's economy and living conditions. Consequently, President Carter authorized funds in the amount of $844 million to alleviate the impact of the present drought. The Department of the Interior received authorization to expend about $130 million of these funds for drought assistance under Public Law 95-18 ($100 million) and broadened use of the Emergency Fund Act of 1948 ($30 million).

These funds may be used for the purposes specified and in the amounts shown in the table on the following page, and as described below:

a. Establish a water bank to assist water users to purchase water from willing sellers, including producers of lower-value annual crops, and to redistribute such available water supplies for the maintenance of higher-value perennial crops, crops to support foundation dairy and beef cattle herds and other breeding stock; and other uses as appropriate.

b. To augment water supplies in 1977 by permitting water user organizations to undertake construction; develop wells; build pipelines; pump water from dead pool storage, rivers, streams, and drains; and other activities to alleviate the impact of the drought.

c. To conduct studies to identify opportunities to augment, utilize, or conserve water supplies and evaluate potential facilities to mitigate the effect of a recurrence of the current emergency.

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[1] This article was written especially for this publication by the Chief, Operations Branch, Division of Water Operation and Maintenance, Engineering and Research Center, Denver, Colorado.

Drought Assistance Program in 1977

Funds assumed available from following sources:

Emergency Fund Act of 1948 - Available Carryover Funds	$ 2,356,000
Emergency Fund Act of 1948 - Supplemental Appropriations 1977	30,000,000
Emergency Drought Act of 1977	100,000,000
Total funds available for drought assistance in 1977	$132,356,000

These funds may be used as follows:

Program Activity	Eligible Entity	$100,000,000 Drought Emergency Act (1977) Funds	$32,356,000 Emergency Act (1948) Funds
Loans			
Water Bank (purchase & redistribute water)	Fed. Rec. Proj.[1] Indian Irr. Proj.	$75,000,000	-
Construction & Conservation Activities (wells, pumps, dikes, lining, pipes)	Fed. Rec. Proj.[1] Indian Irr. Proj.	2/	$25,885,000 (80% of total)
Water Bank, Construction & Conservation Activities	Non-Fed. Irr. Projs.	-	4,853,000 (15% of total)
Grants			
Water Resource Agency Programs (diffuse use-F&WL, water qual., educ., etc.)	States[3]	-	1,618,000 (5% of total)
Water for Fish & Wildlife Programs	State or Federal Agency	[4]10,000,000	-
Studies and Reports[5]	Appropriate Entity	2/	-

[1] Includes small Reclamation projects.
[2] Total of these items is $15,000,000, no specific distribution has been made.
[3] Limited to $1,000,000 per entity.
[4] From Section 10(c) of Drought Emergency Act of 1977.
[5] Relative to Section 1(a), 1(c), and 7 of Drought Emergency Act of 1977.

To be eligible for assistance under this law, it is necessary to be in a drought designated area. These areas were listed in the Federal Register dated April 29, 1977. Additions have been made to this list since that time.

Entities which are eligible to participate in the loan program under Public Law 95-18 are those authorized and constructed under Reclamation laws, Indian irrigation projects, those having approved loans under the Small Reclamation Projects Act of 1956, those having a water supply contract with Reclamation, and non-Federal projects under certain conditions.

Deferment of 1977 construction charges and/or O&M charges owed to the United States by irrigators may also be made, provided these deferred charges are recovered at a later date.

Provisions also exist under Public Law 95-18 to provide grants to fish and wildlife interests for water bank purchases and redistribution and other activities which will mitigate damages resulting from the drought. Grants may also be made to State water resource agencies for drought assistance programs. This program must provide benefits of a widespread and diffused nature.

The Bureau of Reclamation is authorized under this law to perform studies to identify opportunities to more effectively utilize or conserve water supplies on Federal Reclamation projects.

Individual irrigators were not initially considered eligible to receive assistance under this law. However, provisions were later made to provide drought assistance to individual irrigators on Federal Reclamation projects.

Application procedures for loans and grants are described in the Federal Register of April 14, 1977. The appropriate Regional Directors approve or disapprove all loans and, upon approval, request funds from the Commissioner for designated work. Grant requests are submitted to the Commissioner's Office by the Regional Directors with evaluations and recommendations for further action.

All authorities under this law will terminate on September 30, 1977, and all work should be completed by November 30, 1977.

As of June 1, 1977, numerous applications have been received for the various program items. It is apparent that only a small portion of the water bank funding will be used. Applications for fish and wildlife and State water resources programs have been received in excess of money available for these program items. The initial allotment under these grant programs will be made in June. Construction activities include constructing wells, pumping from drains and inactive storage, converting hydraulic turbines to electrically driven pumps, and converting unlined ditches to lined ditches or pipe. Several requests have also been received for deferment of construction and/or O&M payments.

One of the objectives of the law was to save orchards and other perennial crops which would have a long-term economic impact if they were lost. Preliminary indications are that this objective will be achieved in most areas. Some water normally used in California for high water use annual crops; i.e., rice; was diverted to save perennial crops, and individuals in the Yakima area have sold water to other water users for similar purposes.

Even though assistance to drought-stricken areas under this law will terminate on November 30, 1977, the impact from the 1976-77 drought will be felt in many areas during 1978. The short water supplies this year emphasize the need for efficient and effective use of our water resources in the West. The water supply situation this year is not good, but it would be disastrous without the existing water storage and distribution facilities. Even with well-planned and -developed water projects, shortages will be experienced in dry years. Continued emphasis must be placed on systems and water management improvements. Numerous articles in earlier editions of Water O&M Bulletins relate to more efficient use and management of water.

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WATER QUALITY IS AN ONGOING EFFORT IN THE SOUTHERN FIELD DIVISION[1]

Among many methods and techniques for improving and maintaining control of water quality, the Southern Field Division has been using and testing aeration systems for some time in their reservoirs. Aeration introduces circulation in otherwise rather stationary bodies of water by pumping air in at different levels, or sometimes from the bottom up. It is desirable to eliminate thermal stratification within a lake and introduce more oxygen into the lower portions where it might have been eliminated through the decay of organic material or the inability of oxygen to circulate down from the surface. This non-oxygen condition (an anaerobic condition) increases the amount of nutrient material for sustaining algae growth, which might trigger an algae bloom. Algae causes many water quality problems, as well as disagreeable odors. All four reservoirs in the southern division (Castaic, Pyramid, Silverwood, and Perris) have experienced some of this water quality problem. Since 1973, the Field Division has been installing and improving various aeration systems at Castaic and at Perris Reservoir; two air compressors are on standby also for use at Silverwood. The aeration systems include, in general, four basic types of equipment: a compressor system, or source of air; a delivery system to take the air into the lake; a diffuser system to inject the air into the water; and some form of suspension system to support the diffusers. They have never run the diffusers along the lake bottoms because sediment would be constantly circulated into the lake causing adverse water quality effects.

The typical compressor used is an electrically powered type capable of producing 8.9 m^3 (315 ft^3) of air per minute, at 690 kPa (100 lb/in^2 pressure). They are connected for power to the control locations such as the outlet towers. These tower locations are also usually the deepest spots, which are best for aeration.

The conveyance system is composed of 75-mm (3-in) diameter steel pipe floated at 3 m (10 ft) below the water surface. A flexible section of hose is connected at various critical points along this pipe. The floating pipe is anchored to the bottom to prevent sway. Bottom location of these pipelines was rejected because of the necessity of moving them now and then. Floating the pipe on the surface would make changing of connections easier but would involve severe temperature change problems, and increase danger of damage from flexing.

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[1] Reprinted by special permission of the Editor from a recent issue of Technical Bulletin No. 30, a State of California Department of Water Resources publication.

The diffuser system was found to be the most critical area. Several of these have been tried. A straight-line system with "T" or "Y" branchings was discontinued because the necessarily rigid connections at the branching point were subjected to stresses of too severe nature, particularly when the compressors were operating. A system of vertically hanging diffusers suspended from 25-mm (1-in) hose was tried. There were four diffuser lines approximately 30 m (100 ft) apart, suspended nearly 30 m (100 ft) below the surface. This system worked well enough, but the maintenance and adjustment problems were great because of the whipping of the diffuser hoses when air was pumped through them. Anchor lines also became tangled around the leaping hoses. In spite of this, it was a serviceable system.

All of the past effort may be worthwhile, however. There is a new diffuser system which appears to be a more perfect answer. With appropriate support, diffusers such as this may be moved to any part of a lake. The heart of the new system is a 15.2-m (50-ft) wheel made of pre-arced segments of 50-mm (2-in) diameter, black steel welded together. This wheel rim is perforated with a total of sixty-four 2.4-mm (3/32-in) holes. The central hub consists of a 1.8-m (6-ft) long length of 75-mm (3-in) galvanized pipe with circular plate welded across each end. Spokes similar to bicycle spokes in appearance and function connect the rim to the hub. These spokes are constructed of 6-mm (1/4-in) high tensile wire. The hub end of each spoke is welded to one or the other of the steel hub plates. The rim end is fitted with 1/4 by 20 threaded elements for the adjustment of tension on the spokes.

In fabricating the wheel rim, great care had to be taken to prevent kinks from occurring when the segments were welded together. Care also had to be taken to assure that the spoke tension was taken up properly. It is essential that the wheel be supported at the hub when tensing the spoke, particularly the lower spokes.

The ring is supported by 10-mm (3/8-in) wire cable which passes through the hub. On the surface of the water, the support system consists of two 2.4-m (8-ft) square floats made of concrete held in a welded steel framework. There is an A-frame and a hand winch provided to raise and lower the wheel. Weight can be added, if required, to balance the wheel and assure the proper attitude in the water.

The air hose which feeds the diffuser wheel is a 50-mm (2-in) diameter type, tapped off of the delivery pipe and lightly secured at intervals to the support cable for the wheel. Down at the lower end, this hose branches into two, so that air enters the wheel from opposite sides. A drawing of the wheel and its support float is shown on the following page (fig. 1). This diffuser system has been used, with success, at Castaic and at Perris. Figure 2 shows a typical installation.

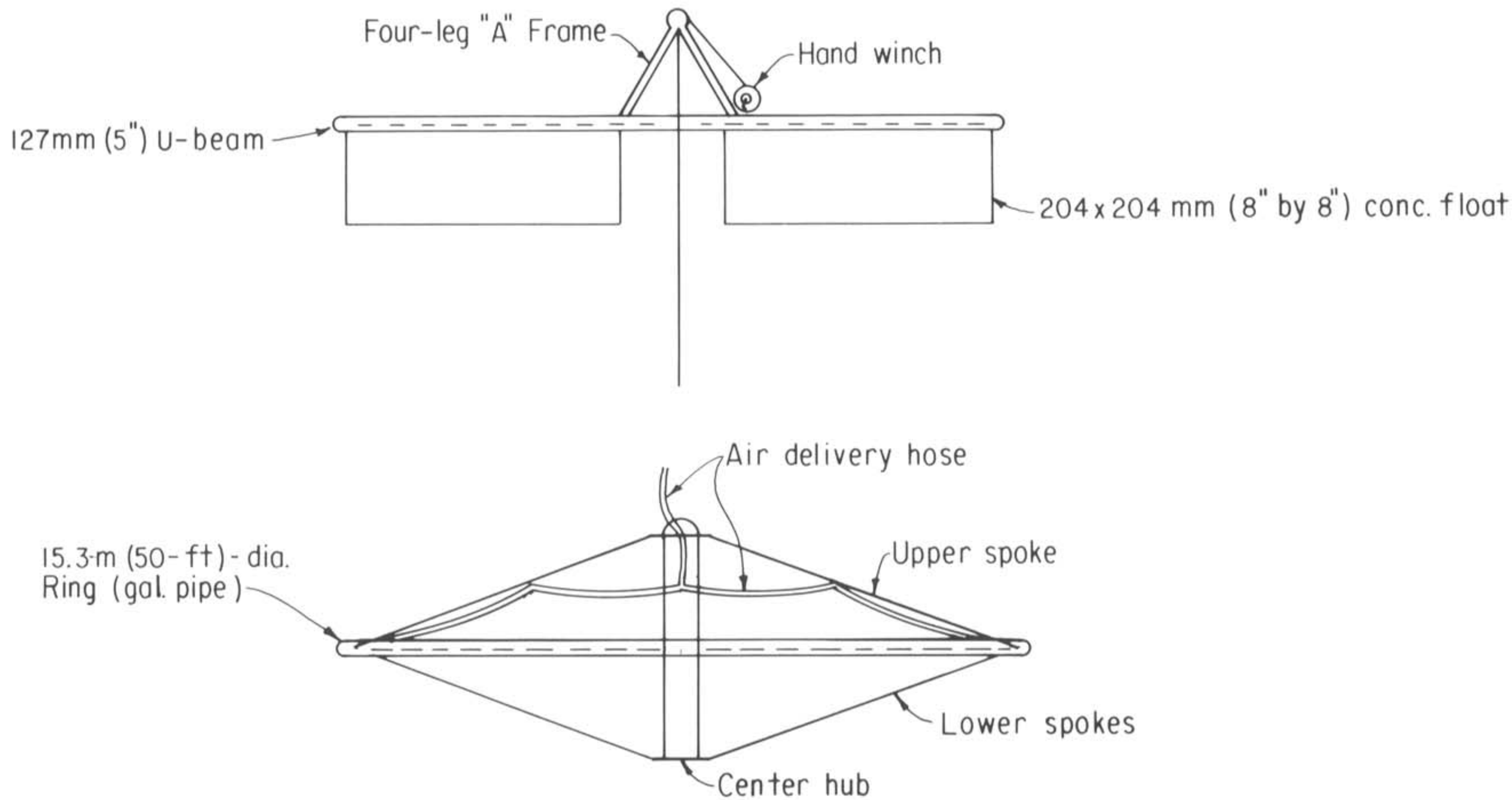
Four-leg "A" Frame
Hand winch
127mm (5") U-beam
204 x 204 mm (8" by 8") conc. float
Air delivery hose
15.3-m (50-ft) - dia.
Ring (gal. pipe)
Upper spoke
Lower spokes
Center hub

Figure 1

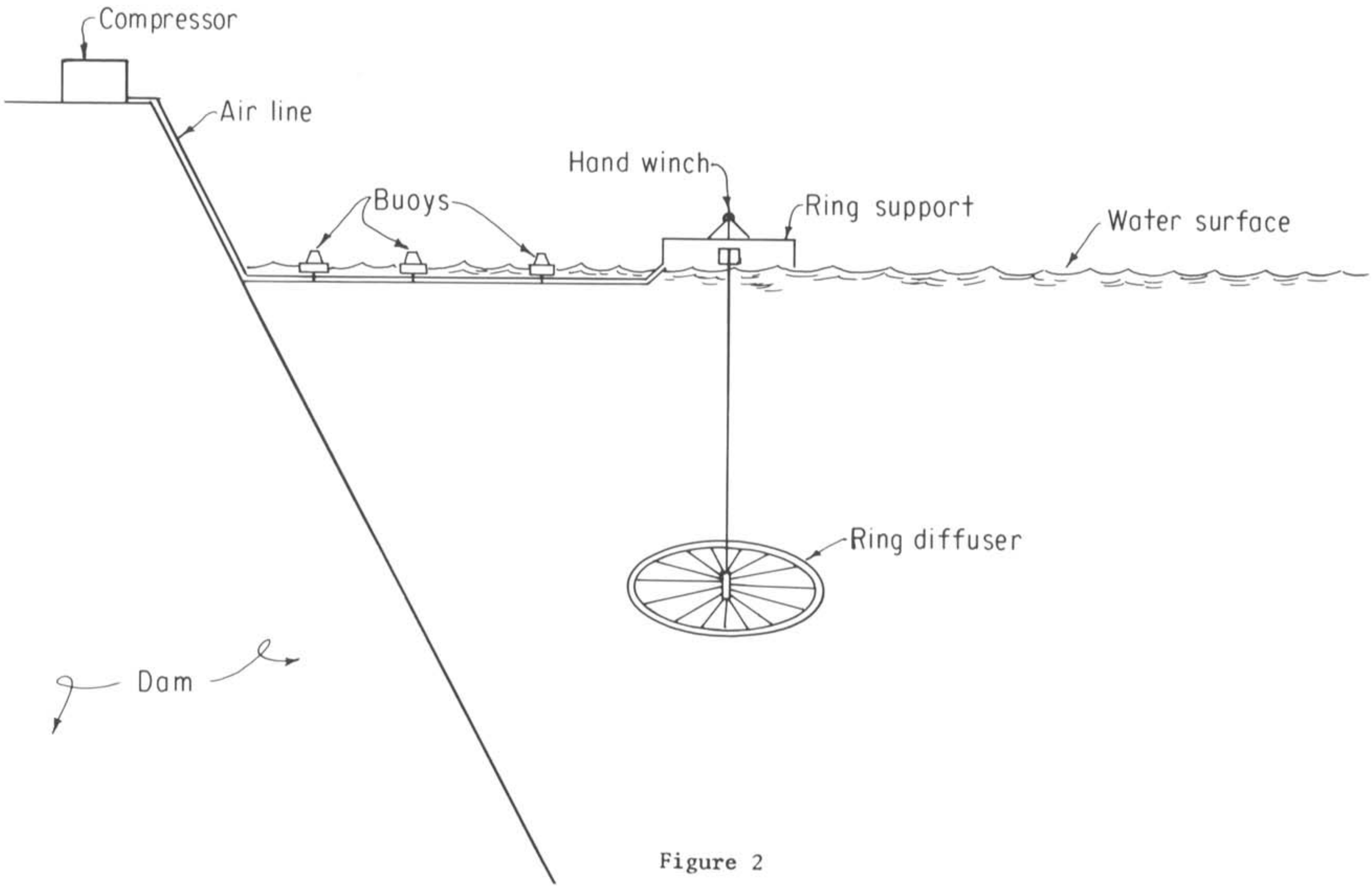
Compressor
Air line
Hand winch
Buoys
Ring support
Water surface
Ring diffuser
Dam

Figure 2

O&M personnel gave a demonstration of the system to representatives of the Metropolitan Water District of Southern California recently, and these observers were greatly impressed with the potential of the device. In fact, the Metropolitan Water District built an identical type of system in hopes that it might improve conditions at Lake Skinner, where a disagreeable odor problem existed. After a few weeks of operation, the stratification of Lake Skinner had been completely destroyed and the odor problem was alleviated. Results were so dramatic that the Metropolitan Water District is planning to build a second system for their Lake Mathews facility.

If further information is desired, please call Wade Brim, Chief Project Surveillance at Castaic; or Bill Wells, Head of Special Investigations of the Water Quality Control Unit at Castaic (ATSS 654-2233).

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ADD MORE LIFE TO IRRIGATION MOTORS

by

Frank Buckingham[1]

Successful operation of electric motors requires more than simply throwing a switch when you want water.

The first step to longer motor life involves careful selection and matching of pump and motor. Continuous overloading leads to speed reduction, overheating, and waste of electric power. A greatly oversized motor also wastes power and ties up capital which might be better spent on other phases of your operation.

Remember too that electric motors require regular maintenance just as diesel, gasoline, or natural gas engines do. Cleaning and lubricating motors and drives at recommended intervals can add years to the useful life of your equipment.

Power Supply

You know that you have to buy quality fuel and keep it clean to get the best performance from internal combustion engines. But how much attention do you give the "fuel" you provide for electric motors? Unbalanced voltage severely reduces motor life. It's not hard to see that low voltage reduces motor torque. But were you aware of the tremendous temperature rise caused by minor voltage unbalance?

A formula developed by NEMA illustrates temperature increase due to voltage variations as follows:

$$\%\text{ of voltage unbalance} = 100 \times \frac{\text{Maximum voltage deviation from average voltage}}{\text{Average voltage}}$$

$$\text{Temperature rise} = 2 \times (\%\text{ of voltage unbalance})^2$$

For instance, if voltage readings are 220, 215, and 210, the average is 215. Plugging this into the first formula, we have:

$$\%\text{ of voltage unbalance} = \frac{100 \times 5}{215} = 2.3\%\text{ temperature}$$

$$\text{Motor temperature rise} = 2 \times (2.3)^2 = 2 \times 5.29 = 10.58\%\text{ temperature increase}$$

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[1] Reprinted by special permission of the Editor from January 1977 issue of Irrigation Age.

As a rule of thumb, motor life is doubled for each -7.8 °C (18 °F) reduction in operating temperature. So it's not hard to see that skimping on wire size to irrigation motors is false economy. If you have questions or problems with low voltage, consult your power company for possible corrective action.

You can also reduce motor operating temperatures by shading motors from direct sunlight, providing plenty of ventilation around the pump and motor, regular lubrication, avoiding overloads, and keeping motors clean of dust, dirt, grease, or chaff.

Under normal operating conditions, an electric motor may last 20 years or more. But unfavorable conditions can cause a burnout in a matter of minutes. For instance, interruption of power on one line of 3-phase power will cause the other two lines to furnish about twice the normal current to part of the motor winding. Increased current results in greatly increased heating of the windings, with the heating effect proportional to the square of the current.

Motors also draw more than normal current any time the supply voltage is reduced below normal. Use of thermal-type overload relays, which open automatically if current overloads persist, help protect motors from damage. Because line conditions sometimes cause more current to flow in one lead than the other two, a relay in each line is necessary for complete protection.

Be sure all wiring meets applicable code requirements and that fuses or circuit breakers are provided according to motor specifications. A well grounded lightning arrestor on each motor provides additional protection against accidental motor damage. If you have questions concerning motor protection, consult a qualified electrical contractor, your motor dealer, or your power supplier.

A mechanical backstop on the motor or pump drive will prevent the motor from accidentally reversing due to power interruption or water receding in the well immediately after the motor is stopped. And a water flow relay attached to the discharge pipe protects the pump from damage if suction is lost due to low water level.

Lubrication

Proper lubrication of electric motor bearings has four major benefits:

1. Longer motor operation
2. Reduced maintenance costs
3. Lower power consumption
4. Reduced lubrication costs

Proper lubrication encompasses oil type used; frequency of changes or addition of oil; and motor environment - including moisture, temperature, and contamination such as dust.

The obvious costs of improper motor lubrication may include replacement bearings, damage to other motor parts, burnout of motor windings, plus time and labor to make repairs. But your other related expenses may be many times greater, and less evident. These costs could involve reduced yield due to lack of water at critical stages of crop growth, increased electrical power consumption and increased motor depreciation.

Use of improper oil in large electric motors is a major source of trouble according to motor manufacturers. Some motors require oil for constant lubrication and cooling of thrust bearings which provides longer bearing life and efficient motor operation.

But ordinary motor oils are not adequate for this application. First, detergent in motor oils keeps contaminants and wear particles in suspension in the oil. This means they continue to circulate with the oil and cause wear between moving parts instead of settling out in the bottom of the case.

In addition, motor oils are simply not formulated for the extended heavy-duty service encountered in irrigation motors. For instance, even if you only change engine oil in a car or truck every 8000 km (5000 mi), you have used that oil only 167 hours at an average speed of 48 km/h (30 mi/h). But oil in irrigation motors is seldom changed more than once each season. This means 168 hours of motor operation every week on a continously operated pump.

Oxidation of oil results in the formation of gums, varnishes, organic acids, and other compounds, all of which reduce lubricating capacity of the oil and accelerate corrosion and wear of bearings and other parts.

Excessive heat speeds up oxidation. For instance, tests have shown that for each -9.4 °C (15 °F) rise in temperature, oxidation is doubled - or oil life is cut in half. This provides added incentive in keeping motors as cool as possible.

Motors which require regreasing of bearings should be lubricated at least once a year, or more often, according to the manufacturer's recommendations and motor operating conditions. On some motors of this type, an exit plug must be removed before greasing to permit old grease to be flushed from the bearing for better lubrication. If the plug is not removed, these bearings become overpacked with grease which causes balls to slide in the bearings instead of rolling, and generates excess heat. This can soon lead to premature bearing failure and possibly severe motor damage.

Use only the oil or grease recommended by the motor manufacturer to reduce maintenance problems and ensure maximum motor life. If local oil dealers don't handle the proper oil, contact the motor dealer or manufacturer. Do not operate new or repaired motors or gear drives without first checking oil level in the bearings.

On equipment with water-cooled bearings, provide adequate water flow at the recommended pressure to ensure proper cooling. Always drain water-cooled cases and blow out remaining water with compressed air before cold weather to avoid possible damage from freezing. If equipment must be operated when there is danger of freezing, it may be possible to run without water cooling because of lower ambient air temperatures. Check with your motor dealer or the manufacturer concerning proper cold weather operating procedures.

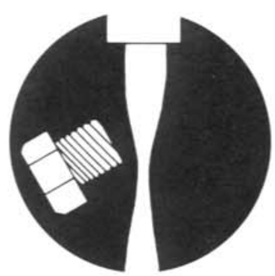
Foundations

A major cause of motor and pump drive failure is misalinement of the drive shaft. A suitable foundation, preferably of concrete, should be provided to maintain proper motor-pump alinement and to reduce equipment-damaging vibration. An inadequate foundation even voids the guarantee on some drive units.

After a period of time, foundations may shift and cause tremendous radial loads on shafts and bearings which can result in extensive equipment damage. Therefore, foundations, motors, and pump drives should be inspected for misalinement at least once a year and more frequently if shifting is suspected or likely, due to soil conditions.

Always lift electric motors and gear drives by the eyebolts provided in the frame of the unit. Supporting equipment by the motor or input shaft could damage bearings and seals. Also, attaching a chain, sling, or hook to wooden shipping crates for lifting could break the crate and damage the motor or drive.

Shutdowns



When irrigation motors will not be used for extended periods, it is recommended that old oil be drained from bearings while the motor is warm and replaced with the proper grade of new oil. To avoid possible seizure of bearings and gears during shutdown, some manufacturers recommend that equipment be operated for at least 5 minutes once a month. This circulates oil through the bearings in motor and drive, covers internal parts with a film of corrosion-resisting oil, and keeps parts turning freely. At least once a year, you should check the wear pattern of gear teeth and gear backlash in the pump drive for possible abnormal wear. Such preventive maintenance could avoid serious downtime later.

Noise

Noise in pumping equipment may be caused by misalinement of the motor and pump, failure to bolt the equipment securely to the foundation, water rushing through pipe elbows, valve operation, and other sources. Misalinement and insecure fastenings also result in vibration which can lead to bearing failure and other damage.

The sound level of electric motors is generally low enough to not cause any particular problems, particularly when compared to the noise of internal combustion engines. However, pumping installations near residences, businesses, or other areas of frequent human activity may have objectionable noise levels.

Installing a wall or simple baffle between the pumping station and the affected area may provide sufficient sound reduction in the critical direction. But such structures may reflect enough sound to cause additional noise problems in the opposite direction. Use of sound-absorbing structures of acoustical tile or insulation, or hollow cinder blocks with openings to sound-deadening inner cavities can help solve this problem.

Three-sided enclosures of sound absorbing materials provide even more noise control and still permit relatively easy access to equipment. Completely enclosed installations usually have the lowest noise level, but such structures must be designed and built to be easily opened or removed for access to equipment.

Below-ground installations of pumping stations provide maximum sound control, better visual appearance, and reduce danger of tampering vandalism. But if pits are used, be sure there is sufficient space around the equipment for servicing and making repairs, and for possibly larger future equipment.

With any pit or pump enclosure, be sure to provide adequate ventilation for proper cooling of the motor and other equipment.

Avoid direct transfer of sound by insulating the enclosure from the motor, pumphead, and concrete foundation with foam rubber or similar cushioning materials.

Remember that flat sections of material such as large sheets of plywood may pick up and amplify sound like a speaker cone and thus actually increase noise levels. If such vibrations occur, the panel may be stiffened by adding cross bracing, or apply a heavy mastic compound or sprayed-on insulation.

Caution: Never enter a pit or pump enclosure or start to inspect, service, or repair any pumping equipment until power is disconnected and equipment has completely stopped. Provide locks or other positive means of preventing accidental starting of motors during servicing or repair of equipment - especially if more than one person is working in the area or if equipment is operated by a timeclock.

Get More For Your Money

Selection of properly matched equipment and carefully following the manufacturer's installation and service instructions are the first steps to long motor life. To help reduce pumping costs, consult your power company about possible operation during offpeak hours when power demand is lowest. If part or all of your water can be pumped during such periods, power costs may be reduced substantially.

Offpeak periods usually occur during the night, when temperatures are lower and motor operation is more efficient. Then, due to reduced demand by other users, power fluctuations may also be reduced, which helps further improve motor operation and useful life.

Good motor management puts more water on your crops for less money.

* * * * *

YOU MAY HAVE THE ANSWER TO YOUR PROBLEM, AND NOT BE AWARE OF IT[1]

There has been quite a lot of subsidence in the San Luis Field Division since the project was activated. Because of this, joints in the aqueduct lining have moved and opened. In some places, the lining has cracked. These cracks and gaps are repaired as soon as they are discovered, but the continued subsidence resulted in a certain amount of seepage into the surrounding landscape. There were one or two spots where seepage warranted grouting of the aqueduct bank to eliminate or slow up the condition. The usual method in this case is to drill a series of holes in the affected area and then pump grout down into the holes to help seal the strata. A commercial drill rig was not available to do the job. Also, some of the holes needed to be drilled at an angle under the side of the aqueduct lining, which would have been a problem for a large power drill. John Walls, Civil Maintenance Superintendent at San Luis Field Division, reluctantly gave the order for hand drilling the necessary grout holes. Frank Correia, Bill Jackson, and Frank Bettencourt formed the grouting team. The earth alongside the aqueduct was hand-packed; after drilling one hole with the hand auger, Frank knew that there had to be a better way.

Once on a previous assignment, a pipe had been required under a road. Frank used the drive head of a pipe threading machine from the O&M shop as a portable drill motor that time. The machine was powerful enough, and an auger bit, welded to a length of steel pipe, clamped tightly into the pipe jaws, did a creditable drilling job. The same bit was still available around the shop. They welded it to a new length of pipe equipped with a threaded coupling at the opposite end, so that additional lengths of pipe could be attached. The threading machine was then mounted, by bolts, to a square of heavy plywood. To allow this board to slide up and down, and so let the bit move in and out, two uprights were made by bolting pairs of 2-by-4's and 4-by-4's together. It was decided to use the maintenance boom truck to transport the drill rig and the additional pipe drill rod because the boom could help move and steady the drill motor. For power, there was a standard gasoline-driven portable electrical generator of 110-volt capability. The first sets of holes to be drilled at the leak site were those that would parallel the aqueduct lining. The boom on the truck lowered everything into position: the drill rig slid on top of the two uprights, the bit was positioned at the correct angle and location. When the generator was turned on, one of the crewmen braced his feet against the plywood square and pushed

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[1] Reprinted by special permission of the editor from a recent issue of Technical Bulletin No. 26, a State of California Department of Water Resources publication.

the bit into the earth. The boom cable hauled the motor back up when it came time to attach more drill pipe. Figures 3 and 4 show two views of this setup.

Figure 3

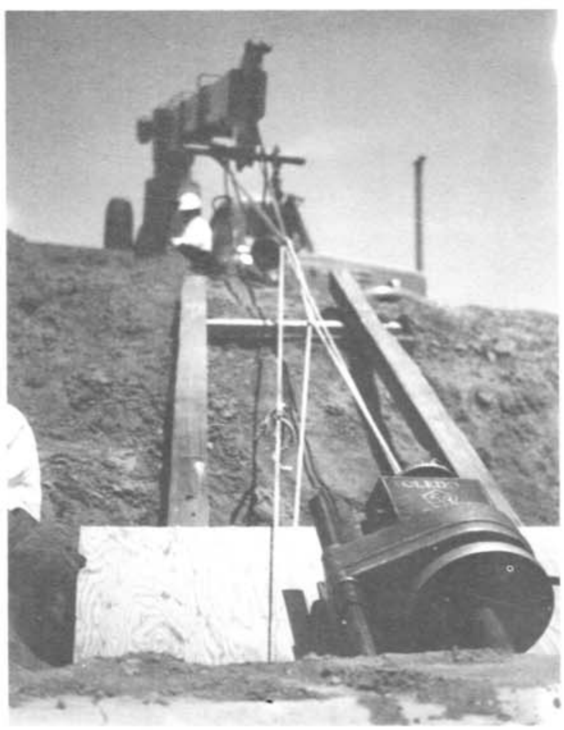

Figure 4

Figure 5

Figure 6

After the holes were drilled beneath the lining, pipes were inserted and then grout was introduced at low pressure, almost gravity-flow pressure, so there would be no danger of lifting the aqueduct lining. This first grouting slowed the leaks but did not eliminate them. The drilling operation was then moved back onto the bank, where plans were made to drill a group of grout holes. The support uprights for the drill-motor slide were installed and staked in place. The tailgate of the boom truck formed the working platform, and also helped to brace the uprights. During drilling, the crew climbed on the plywood slide and rode the drill down. More drill pipe was added from the pile kept on the truck. In this way, the holes were sunk to a depth of 10.5 m (35 ft) below the surface of the maintenance road. Figure 5 shows drilling in progress; figure 6 shows more pipe being added.

The auger does not remove much material from the hole, but rather compresses the dirt so that the opening is compacted well enough to accommodate the grouting operation. Nine holes were drilled through the roadway, and grout was put in at high pressure. The grout worked itself into the cracks and fissures well enough to nearly eliminate all leakage in the area. As a final chore, the crew puts on protective clothes to sandblast the areas where grout had seeped through cracks in the lining. These places were then cleaned and treated. Figure 7 shows this activity.

Figure 7

For any additional information, please telephone or write to Bob McPherrin, Assistant Civil Maintenance Superintendent, San Luis Field Division, Los Banos, California (209 429-2275)

* * * * *

BEWARE OF EQUIPMENT WITH WORN-OUT WIRING[1]

An increasing number of injuries and deaths are occurring from contact with center pivots which have shorted out or have worn insulation from wiring, says Rollin D. Schnieder, University of Nebraska Extension Safety Specialist.

Because the center pivot acts as a conduit for water, which is a good electrical conducter, the potential for severe electrical shock is greater when the pivot is inadequately grounded. Also, the center pivot towers are usually the highest object in the field, inviting a lightning strike.

To ensure safe operation of center pivot systems, there must be a cooperative working partnership between the manufacturer, the power supplier, and the installer. Potential problems can crop up all the way from the assembly line to the cornfield. A single break in the "chain" in a lack of understanding potential safety problems and solving them can cause an injury or death.

Schnieder says manufacturers should engineer-in safety features based on research and experience from the field. Equipment suppliers should be safety-minded, to the point of including safety equipment in bids; and equipment retailers have a moral obligation - if not a legal one - to point out safety features and practices to customers. Installers must also be "salespersons of safe equipment," Schnieder says. In some instances, installers have left safety shielding off equipment, directly leading to deaths and injuries. Power suppliers, installers, and retailers share in the responsibility of making sure an irrigator knows how to use the equipment properly and safely.

Finally, the burden falls on the irrigator-operator to observe basic safety precautions, assuming there are no inherent defects in the equipment and installation.

Some irrigators have received an early warning from a center pivot in the form of a mild shock or "tingle" upon contact. Those who ignore this warning and do not thoroughly check out the system are asking for trouble. "Procrastination in these cases may be a fatal mistake," Schnieder warns.

There is some disagreement between manufacturers and power suppliers as to proper grounding, but they are working to solve differences.

Schnieder outlines some of the major precautions against electrical accidents center pivot owners and operators should observe. The

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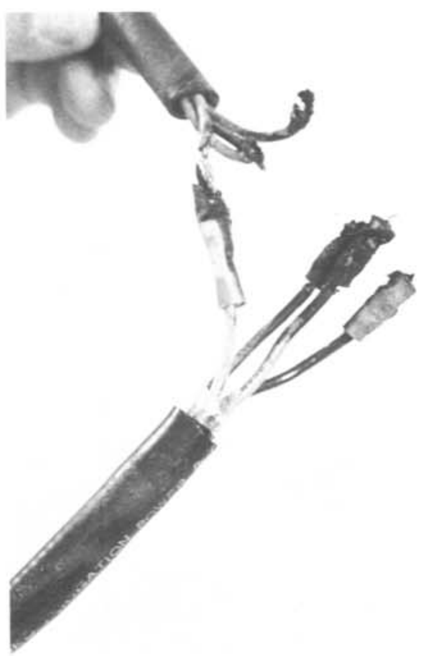
list is not exhaustive and does not include general safety practices which should be observed with all types of center pivots, such as not blocking the wheel track.

- Disconnect power before servicing machine. Lock the switch open until ready to restart the equipment.
- Stay away from equipment during an electrical storm.
- Have qualified service personnel perform any hazardous repair or maintenance.
- Be certain the system does not contact buildings, power poles, wires or other objects while in operation.
- Avoid ditches, overhead powerlines, buildings, and other structures while towing a system from field to field or from one field location to another.
- Bury or guard all powerlines around the pivot. Mark the area with a buried powerline sign. Put this information with the abstract of the farm property.
- Never overfuse. If fuses or circuit breakers keep blowing, something is wrong with the system - find the cause.
- Run engines and generators only at recommended limits as set by the manufacturer.



Frayed wiring, such as this piece removed from a center pivot, caused death of a Wyoming man this year.

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