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Chapter XI

OPERATION AND MAINTENANCE*

The correct design and installation completes only the first step in successful sprinkler irrigation. The manner of operation and maintenance of all components will determine the success or failure of any sprinkler system. ASAE Recommendation R-264, entitled "Minimum Requirements for Design, Installation and Performance of Sprinkler Irrigation Equipment," states: "The dealer-purchaser responsibilities recognize successful operation of a sprinkler system as depending on both buyer and seller."

The ASAE recommendation defines the dealer-purchaser responsibilities for operating instructions as follows:

> "The dealer or dealers furnishing equipment required for a complete sprinkler system shall furnish to the purchaser in writing, such instructions, performance charts, and layout drawings as are required to insure proper operation, in accord with design conditions and normal expected life for the type of equipment furnished."

The operation of a sprinkler system involves the following steps for the owner-operator:

(1) Acquiring complete information and instructions on operating procedures from the designer and dealer as described above and as given on the preceding pages (309-310).

(2) Determining when and how long to irrigate, as discussed below.

(3) Proper positioning of sprinkler equipment for best results.

(4) Shut-down procedure.

(5) Complete and timely careful maintenance.

WHEN TO IRRIGATE

When the completed system is installed and ready for operation, the next owner-operator decision is when to irrigate. Crop, soil, weather, and water supply are factors to consider in making this decision. The irrigation must be started early enough to allow all parts of the area to be irrigated before the soil at the last sprinkler setting gets too dry.

For a discussion of crop, soil and weather factor influence on when to irrigate, see Chapter V.

*Revisions in this chapter were by: Claude H. Pair, P. E., Research Engineer (Irrigation), USDA-ARS-SWC, Snake River Conservation Research Center, Kimberly, Idaho

The influence of water supply on when to irrigate depends on the source of water for the sprinkler system. Wells, lakes, rivers, reservoirs and continuously flowing canals and streams have no effect on when to irrigate, but on some irrigation projects water is delivered to the farm on a rotation basis. Under those conditions, the when-to-irrigate determination must be made to coincide with the availability of water for sprinkler operation.

Decisions on when to irrigate should be made on the basis of soil moisture conditions in the root zone of the crop. Soil moisture conditions in the soil profile are determined by appearance of crop, appearance and feel of soil, (See Appendix Table L), electrical resistance methods, tensiometers and the neutron soil moisture meter. All these methods are discussed in Chapter IV.

STARTING THE SYSTEM

The user should be furnished with a map showing the location of all major parts of the sprinkler system and the area it is planned to irrigate. Written instructions showing in detail how to operate each part of the system, together with the manufacturer's operating and maintenance instruction booklets for such items as pump, power plant, automatic control equipment and sprinklers should be given to the user. The user of a system should have an operator's map showing the routing of sprinkler lateral operation to accomplish the irrigation of the design area with a minimum of labor. An irrigation schedule or timetable indicating the routing of sprinkler laterals, the time of setting for each crop, and the interval between irrigations at peak moisture use should be given and explained to the owner-user.

Finally, the supplier should explain and demonstrate to the owner and user how to place the system in operation and how to stop the system after it is operating.

Starting and Operating

The supplier should start the system, demonstrating the steps needed for starting and priming the pump, filling the pipelines and adjusting the speed of engine-driven pumping units. The danger of creating line surges or water hammer while filling main lines and sprinkler laterals should be carefully explained.

In windy areas, the supplier should discuss with the user ways and means to operate the system for best water distribution with varying wind.

Stopping

The procedure for shutting down an operating sprinkler system should be explained and shown to the system operator. This may be only to push a button to close an electrically controlled valve, or to stop an electric motor or engine-driven pump. In other systems it may involve storage or disposal of the water while the system is off, the closing of valves to prevent backflow of water in mains, or the

draining of some pipelines filled with water under high pressure.

The supplier should stay with the user through the first operating period and the starting of the second to check the procedures followed and make sure that all instructions for the system operation are completely understood.

OPERATING AND MAINTENANCE INSTRUCTIONS

Pump Operation

Many manufacturers have written instructions for operation, maintenance, and a troubleshooting guide for their pumps. These instructions should be followed for long life and satisfactory performance of the equipment.

Pumps are oil lubricated or water lubricated. In oil-lubricated turbine pumps, the oil must be turned on and be properly lubricating the pump turbine shaft according to instructions before the pump is started. The oil level should be checked for all oil-lubricated pumps before starting and periodically during operation according to manufacturer's instructions.

In water-lubricated turbine pumps, the line shaft bearings must be prelubricated each time the pump is started. This may be done by filling the pipe column from some other source of water. Some pumps have water under pressure from a domestic system which can be used to fill the pipe column. Other pumps have a prelubricating tank that is filled while the pump is running, and water is stored for starting purposes. Some are automatic in operation; others are manual.

Many pumps have a stuffing box to prevent leakage along the drive shaft from the pump to the engine or motor. If excess leakage is occurring at this point, the packing can be tightened by turning the gland nuts. Do not overtighten. Slight leakage is necessary for proper operation. Judge this by the heat in the water leaking from the box—it should be cool.

The gate valve that controls discharge from the pump should be opened before starting the pumps.

Power Plant Operation

The source of power for driving sprinkler system pumps is either electric motors or internal combustion engines. Power units vary in size from a fraction of a horsepower to several thousand horsepower. Consequently, the starting equipment and procedure also vary from simple to very complex operations. The instructions furnished by the manufacturer and supplier of the equipment should be followed in starting, running and stopping these power units.

(1) **Electric Motors:** Starting an electric motor usually consists of closing a switch or pushing a button that activates the relays or other starting devices needed to limit the electrical current through the motor windings until it has reached operating speed.

If the motor fails to start when the starter button is pressed or switch closed, check to see that the power line is energized, while observing electrical safety rules. An energized power line may be indicated by electric lights being on, or a neighbor's pump running. Check fuses in switch box if proper equipment is available for this; or push stop button, pull main power switch to motor and replace fuses with new ones. Depress overload relay button or buttons. If these steps do not permit the starting of the motor, call an electrician.

To stop the motor, push the stop button or pull the stop switch. Do not try to stop an operating motor by pulling the main supply switch or circuit breaker except in an emergency.

(2) **Internal Combustion Engines:** Internal combustion engines used in sprinkler irrigation use four types of fuel: Gasoline, diesel, butane, and natural gas. The items common to each engine that need checking before attempting to start the engine are:

(a) Oil level in crankcase

(b) Water level in radiator of water-cooled engines

(c) Water pressure, loss of oil pressure, and heat safety switches should be turned off

(d) Amount of fuel.

The manufacturer's literature will give the proper instructions for starting each engine. Starting most internal combusion engines is like starting an automobile. A starting switch activates an auxiliary electric starting motor, which turns the crankshaft of the internal combusion engine until it starts and runs from its own fuel combustion. After the engine has reached operating speed, the safety switches should be turned on to protect the engine. An internal combusion engine may be stopped by shutting off the fuel. Internal combusion engines having an electrical ignition system can be stopped by a switch which interrupts the ignition circuit.

Care should be taken that the engine is not overloaded if a full life and minimum repair costs are to be obtained.

Automatic Starting Equipment

Some internal combustion engines and electric motors have automatic starting equipment which places the pumping plant into operation. This automatic starting equipment can be removed from operation by turning a switch from automatic to manual operation.

High-Pressure Pipelines:

Starting a system with high-pressure pipelines requires that the pump and motor be brought up to speed before the water output is turned into the high head line. This is to eliminate water hammer.

Similarly, to prevent water hammer when stopping a pump and motor requires that the pump discharge be removed from the pipeline by closing valves slowly before power is turned off. To prevent back-spin of the pump or running engines in reverse direction, a non-slam check valve should be used.

Trouble Check Lists

Trouble-shooting can reduce work and time spent on repairs. Look at the trouble check lists before starting to disassemble any piece of the sprinkler system, as what may appear to be a trouble in one unit may often be located elsewhere.

OFF-SEASON CARE

Preventive maintenance is the simple precaution that can be taken during a period of non-use to make certain that sprinkler irrigation equipment is ready for use the next season. Every sprinkler system, from pump and power plant to the sprinklers, requires a certain amount of care in handling, storage and maintenance. Sand, water, wear, and abuse to equipment take their toll and reduce the efficiency of system operation. Preventive maintenance is an off-season job that will repay the time and effort spent doing it.

When any machinery that has ball or roller bearings is stored, the bearings should be covered with a protective coating of lubricant. As weather changes from warm days to cooler nights, moisture will condense from the air on cold surfaces. If the cold bearing surfaces are covered with lubricant, the moisture won't cause rust and pit the bearings.

Small animals winter in partially enclosed, protected areas. There are many of these areas around stored pump, motor, controls, and pipeline which make excellent living quarters. Tape or otherwise cover the entrance to these enclosed areas in the fall and save many hours of cleaning before the next irrigation.

Pumps

When in doubt, call a qualified pump maintenance man.

(1) Preparation for Storage.

(a) Make sure all oil- or grease-lubricated bearings are well covered with lubricant.

(b) Drain water from pump and connecting pipelines to eliminate damage from freezing.

(c) If a packing gland is used, loosen it.

(d) When pump is stopped, make sure it is free of any material that might be carried in the water.

(e) Cover any exposed metal, such as the shaft, with protective lubricant to eliminate corrosion.

(f) Loosen "V" belt or flat belt drive so belts will be under no

tension and insert piece of grease-proof paper between belts and pulley.

(2) Preparation for Use.

(a) Tighten packing gland to proper setting.

(b) Check discharge head thoroughly for foreign matter.

(c) Replace oil or grease with proper weight of bearing lubricant.

(d) Pump shaft should turn freely without noticeable dragging. A deep well turbine pump might require some vertical adjustment.

(e) If source of water is a well, check the static level and drawdown in case a deeper pump setting might be required.

Power Plants

When in doubt, call a qualified electrician for electric motors or a qualified mechanic for internal combustion engines.

(1) **Electric Motors.** Electric motors and controls require very little maintenance. They often get none. The recommended preparation for storage and annual spring checkup will return their cost many times during the life of your equipment.

(a) Preparation for storage:

1. Make sure all bearings are well lubricated.
2. Cover motor to protect against rodents, insects and dust, but provide ventilation from cover to prevent condensation.
3. Lock control box in "off" position.
4. If control box is exposed to weather, a canvas cover will protect against moisture and dust.

Make these checks and do this maintenance before power is turned on.

(b) Preparation for use:

1. Inspect for rodent and insect invasion over the storage period.
2. Change motor bearing oil. Oil changes are recommended at least once a year. Do not overfill. Overfilling or spilling oil will hasten the need for complete motor cleaning and baking. Remember, motor bearings require a special type of lubricant.

(a) Oil bath bearings - drain oil and replace with proper weight, clean oil.

(b) Grease lube bearings - if grease gun is used, be sure old grease is purged through outlet hole.

3. "Megger" check the control panel, motor, conduits, etc. to determine the condition of current-carrying conductors, motor windings, contactors, etc. Corrosion can cause poor contact, poor grounding, direct or high resistance shorts.

The manufacturer's specific instructions should be followed in preparation for storage and bringing equipment out of storage. If manufacturer's instructions are not available, the following procedures will pay dividends in extending the life of the engine. In addition, it could prevent a breakdown of equipment at a critical time that would cause severe crop damage.

(a) Preparation for storage:

1. Run engine to thoroughly warm up oil in the crankcase.
2. Stop engine and drain crankcase oil.
3. Replace drain plug and refill crankcase with highgrade engine oil.
4. Start engine - and run slowly for two minutes to complete oil distribution on all surfaces.
5. Stop engine - remove all spark plugs.
6. Pour 2 ounces of engine oil into each spark plug hole.
7. With ignition switch off, crank engine for several revolutions to distribute this oil over the cylinder walls and valve mechanism.
8. Replace spark plugs.
9. Drain oil from crankcase.
10. Drain cooling system and close drain cocks (including block, water pump, heat exchanger, oil cooler and radiator).
11. Drain all fuel from tank, lines and carburetor bowl. Replace all plugs and close drain cock. If LP gas is used, drain vaporizer-regulator (both fuel and water lines).
12. Lubricate all accessories. Seal all openings airtight with weatherproof masking tape. This includes air cleaner inlet, exhaust outlet, and crankcase breather tube.
13. Check oil filler cap, gas tank and radiator cap.
14. Spray all accessories and electrical equipment with suitable insulating compound.
15. Insert a strip of grease-proof paper under the "V" belt pulley to prevent fan belt from bonding to pulley.
16. Remove battery and store fully charged.
17. If engine is outside, cover with a waterproof covering.

(b) Preparation for use:

1. Remove all tape from openings that have been sealed.
2. Turn on fuel tank shut-off valve.
3. Shut water drain cocks and add coolant.
4. Check oil drain plug - be sure it is tight. Replace oil filter and add correct amount of oil to engine.
5. Remove spark plugs and spray cylinder walls with a light engine oil.

6. Replace spark plugs and crank engine several revolutions by hand to spread oil in cylinder walls.
7. Fill fuel tank.
8. Lubricate all engine accessories.
9. If a distributor is used, clean cap inside and outside. Inspect cap and rotor for cracks. Lubricate distributor sparingly with suitable lubricant. If magneto is used, inspect breaker points for wear and gap, and lubricate rotor.
10. Check all terminals and electrical connections.
11. If oil bath air cleaner is used, clean and fill with correct grade of oil.
12. Start engine, run slowly for a few minutes. Watch oil pressure and if it fails to come up to correct reading, stop engine at once and investigate cause.
13. Check oil level in crankcase. Bring oil level up to proper mark on dipstick.

Sprinkler Heads

(1) Preparing for Storage.

(a) Inspection of all sprinklers at storage time will eliminate delays in starting time for next irrigation season.

(b) Bearing washers should be replaced if there is indication of serious wear.

(c) If damage has occurred to the oscillating arm, the arm should be replaced. The angle of water-contact of the jet with the arm, if not correct, will change the turning characteristics of the sprinkler.

(d) Do not use any lubricant for either storage or operation of sprinkler heads.

(e) Wear of sprinkler nozzles may be checked with proper size drill bit. Some nozzles may not be drilled to the size marked on the nozzle because the orifice style causes a higher discharge and the nozzle is marked for a size that would give this discharge.

Pipelines

(1) Preparation for storage. Drain all pipelines and completely open all valves.

(a) Aluminum tubing:

1. Inspect pipe ends to make certain that no damage has occurred. Ends should be round for best operation. A slightly tapered wooden plug of proper diameter can be used to round out damaged ends.
2. Inspect pipe for corrosion inside pipe. If any is found, consult suppliers for protection methods.
3. Pipe should be stored on inclined racks well above the ground to permit drainage and air circulation.

4. Pipe left in fields during freezing weather should be completely drained. Side roll laterals should be tied down to prevent wind damage and in extremely cold weather should be broken into short sections to prevent contraction damage.
5. Do not store pipe in the vicinity of acids, caustic or other chemical fumes or dusts.
6. Avoid contact of animal waste on irrigation tubing during storage.
7. Pipe makes an excellent nesting area for small animals and birds. If such nesting occurs, cleaning of the tubing before use is necessary. Keep pipe away from power lines when you raise it in the air for cleaning.

(b) Couplers and gaskets:

1. Remove gaskets; clean off silt, sand or other debris; and store in a dry place.
2. Clean couplers with water after the gaskets have been removed to eliminate any foreign matter that might have collected during operation.

(2) Preparation for Use.

(a) Reassemble all couplers, installing gaskets, risers and sprinklers.
(b) Treat corroded pipe.
(c) Check and lubricate all valves according to manufacturer's instructions.

SAFETY

Safe operating procedures should be practiced in all undertakings. The operation of a sprinkler irrigation system has caused fatalities among operation personnel. Many of these fatalities have resulted from contact with electricity—either powering the pumping plant or from transmission lines in or associated with the area being irrigated.

Moving of portable sprinkler lateral pipelines has been the worst offender. Raising a pipeline into the air to dislodge a small animal or debris and contacting overhead electrical transmission lines has resulted in severe electrical shock or death to the person holding the pipe.

A sprinkler throwing a stream of water into a power line has shorted the power to ground through the sprinkler system and resulted in severe electrical injuries to anyone touching the sprinkler system parts.

Always have the electric motor well bonded to a good ground with suitable size conductors. Injuries have occurred from touching ungrounded motor or pump frame having shorted electrical windings in electrical powered pumping plants.

Electrical shocks from faulty starting equipment and from working on energized circuits have occurred. Always pull the line disconnect

switch when making repairs or checks on electrical equipment of any kind.

Look over each sprinkler system and mark the potential hazards to safety, then avoid the hazard.

EVALUATION OF OPERATING SYSTEMS

An existing sprinkler system can be evaluated for adequacy of design and operation with a relatively few pieces of equipment and observations of pressures, application rate, depth of water penetration, and crop damage.

Equipment Needed

The following items are generally required:

(1) Pressure gage (0 to 100 pounds) with pitot tube attachment to measure pressure at the sprinkler nozzle

(2) Soil auger, shovel or probe

(3) Spray gage cans (quart oil cans or equivalent)

(4) Graduate to measure water caught in spray gage cans (500 cc capacity graduated to 1 cc)

(5) Tape (100 foot)

(6) Forms for recording data.

General Sprinkler Performance Requirements

In any sprinkler system there are five main factors that should be checked to determine adequacy of design and operation, and as a basis for possible adjustments in operation.

(1) **Application Rate.** Water should not be applied at a rate faster than the soil will absorb it. However, it should be applied fast enough to prevent excessive evaporation losses.

(2) **Depth of Application.** The amount of water applied during an irrigation should not be greater at the point of lightest application than can be held by the soil within the root zone of the crop. Greater amounts should be applied only when leaching to remove harmful salts is necessary.

(3) **System Capacity.** The equipment should be able to replenish the soil moisture at a rate equal to the peak use rate of water by the crop.

(4) **Uniformity of Application.** Water should be applied as uniformly as practical over the field.

(5) **Crop Damage.** Water must be applied in a way that will not damage the crop physically.

Evaluation Method

(1) Take pressure measurements on main and lateral pipelines

(2) Make field observation of application rate

(3) Take water distribution pattern in area being sprinkled
(4) Determine if irrigation is filling root zone of crop
(5) Determine if sufficient sprinkler equipment is available
(6) Check operating procedure used with sprinkler system
(7) Analyze the data obtained
(8) Make recommendations for revision of the system or changes in operating procedures, if necessary.

System Operating Characteristics

(1) **Pressure Measurements.** With the sprinkler system in operation, measure lateral and main line pressures at various points in the system. If a pitot tube attachment is used, pressure may be measured at the nozzle of rotating-head sprinklers. Otherwise, pressure gages should be connected into the pipelines before the water is turned on. Pressure on lateral pipelines should be measured at the first sprinkler from the main line outlet, the high point in the lateral line, and the end sprinkler. Pressures at sprinklers should be close to the manufacturer's recommended operating pressures for the sprinkler used. The pressure should not vary more than 20% below the highest pressure read on the lateral.

Main line pressures should be measured at the pump, at the highest point on the line, and at the point farthest from the pump. Differences in pressures measured on main lines between the pump or source of water pressure and various points along the main line result from elevation difference between the two measurement points and friction loss in the main pipeline. Allowable friction loss in the main line should not exceed an economically practical value.

(2) **Application Rates.** Observe the rate at which water enters the soil, especially near the end of the longest sprinkler operating period. There should be no movement of water over the surface and the slightest ponding is generally unsatisfactory. If there is water movement over the soil surface, the application rate is too high and sprinkler nozzle size or operating pressure needs reducing.

(3) **Water Distribution Pattern.** Set out spray gage cans in a symmetrical pattern across the area to be sprinkled, between four sprinkler heads in a solid set system, or in the area between two settings of a portable lateral. The gage cans should be on a 5 × 5 foot spacing where the sprinkler spacing is 60 feet apart, and on a 10 × 10 foot rectangular spacing where the sprinklers are over 60 feet apart. The area selected for pattern tests should be typical of the sprinkler area and conducted with several wind conditions.

Run the sprinkler system for the normal length of time for an irrigation. Shut off the system and measure the depth of water

caught in the cans. The depth of water caught can be determined by measuring with a thin ruler, or more accurately by use of a graduate-cylinder.

The distribution pattern is made by plotting the depth of water caught in each spray gage can on a scale map of the area. It will be necessary to add the water caught from the two or more settings of a portable lateral system to get the full pattern depth in the irrigated area.

(4) **Depth of Wetting.** Examine the depth of water penetration at several locations in the sprinkler pattern area, using a shovel, probe, or soil auger. Normally this examination should be made one day after irrigation. Water should penetrate a few inches below the root zone depth of the crop. Excess depth of penetration is a waste of irrigation water unless leaching is desired. (See section on root zone depth.)

(5) **Operating Procedure.** Determine from the operator the length of time sprinklers operate at each setting and the number of lateral settings per day.

(6) **Adequacy of Sprinkler Equipment.** Make an inventory of the number of sprinkler lateral settings needed to cover the area to be sprinkled. Also, inventory the number of laterals operating at the same time. By dividing the number of lateral settings by the product of the number of laterals operating at one time and the number of times a lateral is moved each day, the length of time between irrigations can be determined in days.

Analysis of Data and Recommendations

By analyzing the data obtained, the correctness of design and operation of a sprinkler system can be estimated.

If the pressure at the sprinkler nozzles is not within the operating range recommended by the sprinkler manufacturer, water distribution usually is poor. A check with the system designer will determine if the system was originally designed to operate at this pressure. If not designed to operate at the pressure measured, then check the equipment trouble lists and the equipment for trouble in the system components.

If the pressure varies more than 20 percent from the maximum pressure measured along a lateral pipeline, the result will be poor water distribution.

To remedy a large loss in pressure without changing pipe size will require a reduction in length of lateral pipeline, or a reduction in the volume of water flowing in the pipe. This is accomplished by removing a number of sprinklers from the lateral, reducing spacing of sprinklers along the lateral, reducing the pressure at the head of the lateral, or reducing nozzle sizes in the sprinkler head. Also, a larger lateral pipeline might bring the pressure along the sprinkler lateral within the 20% maximum allowable.

Reduce the nozzle size or nozzle pressure to reduce the application rate. Sometimes the sprinkler spacing on the lateral can be increased to reduce the application rate.

Poor water distribution patterns may be improved by the following methods:

(1) Use proper sprinkler nozzle pressure as recommended by the manufacturer.

(2) Change lateral spacing. Lateral spacing should not exceed 65 percent of the diameter of the pattern under no-wind conditions. For 0- to 5-mile/hour wind, lateral spacing should be limited to 60 percent of the wetted diameter, and with 5- to 10-mile/hour wind the spacing should be reduced to 50 percent of the wetted diameter or less.

If the time in days for coverage of the sprinkler design area exceeds the allowable irrigation period during the peak use period, then more laterals will be needed to provide for an adequate irrigation of the crop. This may involve a complete revision of the sprinkler system from pump to sprinkler laterals because of the increased water needed.

If an examination of the depth of water penetration shows *too much water* being applied, the remedy may be to:

(1) Shorten the operating time of the sprinkler lateral, or

(2) Install smaller nozzles in the sprinklers.

If the depth of water penetration shows *too little water* being applied, the remedy may be to:

(1) Increase the operating time of the sprinkler lateral, or

(2) Install larger nozzles in the sprinklers.

Step 1 may cause further troubles with shortage of laterals preventing a complete coverage of the area to be irrigated in the time allowed by the crop needs and the soil. Step 2 may cause low sprinkler pressure at the nozzles by overloading the pump and motor which wasn't designed to deliver as much water.