NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

IRRIGATION SYSTEM, SPRINKLER

(Ac.)

CODE 442

DEFINITION

An irrigation system in which all necessary equipment and facilities are installed for efficiently applying water by means of nozzles operated under pressure.

PURPOSES

This practice may be applied as part of a conservation management system to achieve one or more of the following:

- Efficient and uniform application of irrigation water to maintain adequate soil water for the desired level of plant growth and production without causing excessive water loss, erosion, or water quality impairment.
- Climate control and/or modification.
- Application of chemicals, nutrients, and/or wastewater.
- Leaching for control or reclamation of saline or sodic soils.
- Reduction in particulate matter emissions to improve air quality.
- Reduction in the use of energy.

CONDITIONS WHERE PRACTICE APPLIES

The sprinkler method of water application is suited to most crops, irrigable lands, and climatic conditions where irrigated agriculture is feasible. Areas must be suitable for irrigation or sprinkler water application and have an adequate supply of suitable quality water available for the intended purposes.

This standard pertains to the planning, functional design, and the overall application of all sprinkler components except for special structures such as permanently installed main and lateral pipelines or pumping plants. Other components shall meet appropriate Natural Resources Conservation Service (NRCS) conservation practice standards.

This standard does not include criteria for mini- or micro-sprinkler systems. These are covered by Conservation Practice Standard (CPS) 441, Irrigation System, Microirrigation.

CRITERIA

General Criteria Applicable to All Purposes

The criteria for the design of components not addressed in conservation practice standards shall be consistent with sound engineering principles.

Each sprinkler discharge system must be designed as an integral part of an overall plan of conservation land use and treatment for the intended purpose(s) based on the capabilities of the land and the needs of the operator. The selected system shall be based on a site evaluation, expected operating conditions, and verification that soils and topography are suitable for the intended purpose(s).

Depth of application. Net depth of application shall meet criteria for the intended purpose(s), not exceeding the available soil water holding capacity (including leaching requirements) for the managed rooting depth of the desired crop(s) and meeting the land user's management plan for the intended purpose.

Capacity. The sprinkler irrigation system shall be designed with adequate capacity to accomplish the primary purpose(s) of the system.

Design application rate. Rates shall be selected such that runoff, translocation, and unplanned deep percolation are minimized.

Additional conservation measures (such as furrow diking, dammer diking, in-furrow chiseling, conservation tillage, or residue management) shall be applied as needed and appropriate.

Distribution patterns, nozzle spacing, and height. A combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and distribution shall be selected.

Coefficient of Uniformity (CU) data or distribution uniformity (DU) shall be used in selecting sprinkler spacing, nozzle size, and operating pressure. Definitions of each of these uniformity values can be found in Chapter 6 in National Engineering Handbook Part 652 (NEH 652), *Irrigation Guide*.

Flood valves or versions thereof shall not be included on any portion of the sprinkler irrigation system.

Pipelines. The design of main lines, submains, and supply lines shall ensure that required water quantities can be conveyed to all operating lateral lines at required pressures. For detailed criteria, see CPS 430, Irrigation Pipeline.

Pump and power unit. Where required, pump and power units shall be adequate to efficiently operate the sprinkler system at design capacity and total dynamic head. For detailed criteria, see CPS 533, Pumping Plant.

Management plan. An irrigation water management plan that meets CPS 449, Irrigation Water Management, shall be developed for this practice unless the purpose of the practice is wastewater application. Where implemented for waste application as a component of a comprehensive nutrient management plan (CNMP), a waste utilization plan and/or nutrient management plan shall be developed that meets the requirements of CPS 633, Waste Recycling, and CPS 590, Nutrient Management, as appropriate.

Additional Criteria Applicable to Center Pivot or Linear-Move Sprinkler Systems

Low energy precision application (LEPA) is a form of surface irrigation that applies water to a limited area. It does not have overlapped wetted areas nor does it wet the entire soil surface. LEPA systems are typically composed of drag socks or bubblers that must travel in the same pattern or path as the row arrangement. The management practice of surface storage (for example, furrow dikes, dammer dikes, or implanted reservoirs) is also required.

Low-pressure in canopy (LPIC) is a form of spray application with sprinklers on drops within the crop canopy. LPIC wets the entire soil surface.

Low-elevation spray application (LESA) is a form of spray application with sprinklers on drops near the ground (typically below the crop foliage) but not beyond 18 inches above the ground. LESA wets the entire soil surface

Mid-elevation spray application (MESA) is a form of spray application with sprinklers on drops, typically positioned below the truss rods, above the mature crop canopy. MESA wets the entire soil surface.

Variable rate irrigation (VRI) is a system of controllers, solenoids, valves, a position location device, and associated equipment that are fitted to an existing center pivot sprinkler, which can be programmed to control the flow from selected nozzles to vary the application of water at different areas within the field.

Design capacity. Sprinkler systems shall be designed to have the capacity to meet the primary purpose. For the purpose of crop irrigation, sprinkler irrigation systems shall have either (1) a design capacity adequate to meet peak water demands of all irrigated crops in the design area or (2) an adequate capacity to meet requirements of selected irrigations during critical crop growth periods when less-than-full irrigation is planned (NEH 652, Section KS652.0408).

In computing capacity requirements, allowance must be made for reasonable application water losses.

Distribution patterns, nozzle spacing, and height. On center pivot systems (using the Heermann-Hein equation) or linear move sprinklers (using the Christensen equation), CU shall not be less than 85 percent (76 percent DU) except as noted in the additional criteria for a specific type system. In lieu of the manufacturer’s CU information, simulation modeling shall use Agricultural Research Service model Center Pivot Evaluation and Design (CPED) or similar modeling software. The manufacturer's information on nozzle packaging that allows exclusion of the end gun and the first 12 percent of pivot length (not to exceed 250 feet) shall be considered acceptable documentation of system CU.

In the absence of CU data, sprinkler performance tables provided by the manufacturer shall be used in selecting nozzle size, operating pressure, and wetted diameter for the required sprinkler discharge. To the extent possible, low-pressure spray nozzles shall be at uniform heights along the length of the lateral with the exception of height adjustment to increase wetted diameter for runoff control. From a point midway between the first and second tower to the distal end of a center pivot, spray nozzle spacing along lateral lines shall not exceed 25 percent of the effective wetted diameter, and impact sprinkler spacing shall not exceed 50 percent of the effective wetted diameter. The effective wetted diameter shall be determined from the manufacturer's information for the nozzle height.

Low-elevation nozzle application systems (typically less than 7 feet from ground surface) that discharge water in the crop canopy for a considerable length of time during the growing season shall also meet the criteria of a LPIC system as defined in this standard.

Additional Criteria Applicable to LEPA and LESA Center Pivot or Linear-Move Sprinkler Systems

Distribution patterns. For center pivot systems, nozzle discharge CU using the Heermann-Hein equation weighted area method shall be used in selecting sprinkler spacing, nozzle size, and operating pressure. Nozzle discharge CU shall not be less than 94 percent of the calculated design flow rate needed at the discharge point. For linear systems, discharge shall be based on equivalent unit areas.

Nozzle spacing. Nozzle spacing shall not be greater than 2 times the row spacing of the crop—not to exceed 80 inches.

Specific Additional Criteria for LEPA

LEPA systems shall meet the criteria shown below. However, systems that utilize bubble pads, shields, or drag hoses for a portion of the crop year and then spray nozzles at uniform heights (not exceeding 18 inches for a portion of the crop year) shall meet LESA criteria.

Discharge height. Water shall discharge through a drag sock or hose on the ground surface or through a nozzle equipped with a bubble shield or pad at a uniform height not to exceed 18 inches above the ground surface.

Row arrangement and storage. LEPA systems are only applicable on crops planted with furrows or beds. LEPA systems shall have row patterns that match the lateral line movement (for example, circular for center pivots). Water shall not be applied in the tower wheel track of a LEPA system. Runoff and translocation under LEPA systems shall be eliminated by providing surface basin storage such as furrow dikes, dammer dikes, or implanted reservoirs.

Slope. The slope for a LEPA system shall not exceed 1 percent on more than 50 percent of the field.

Specific Additional Criteria for LESA

Discharge height. LESA systems shall discharge water through a spray nozzle at uniform heights not to exceed 18 inches above the ground surface. A minimum 1-pound weight shall be added at or below the sprinklers on flexible drops greater than 30 inches in length.

Row arrangement and storage. LESA systems are applicable on crops flat planted, drilled, or planted with furrows or beds. LESA systems should employ some method of providing surface storage (such as furrow dikes, dammer dikes, or implanted reservoirs) or farming practices (such as conservation tillage, in-furrow chiseling, and/or residue management) to prevent runoff.

Land slope. The slope for LESA systems shall not exceed 3 percent on more than 50 percent of the field.

Additional Criteria Applicable to LPIC and MESA Center Pivot or Linear-Move Sprinkler Systems

Systems that utilize bubble pads, shields, or drag hoses for a portion of the crop year and spray nozzles for a portion of the crop year (and do not meet all of the LEPA or LESA criteria) shall meet LPIC criteria.

Distribution patterns, nozzle spacing, and height. When nozzles operate within a row crop canopy for 30 percent or more of the growing season, nozzle spacing beyond the inner 20 percent of the lateral shall not exceed every other row nor shall they exceed 80 inches. The inner 20 percent distance shall not exceed the mid-point of the second span from the pivot point. Nozzles within this area may exceed the spacing limit if the inner 20 percent results in improved uniformity for the system.

In-canopy heights shall be such that areas of high leaf concentration are avoided (for example, corn near the ear height [approximately 4 feet]). Local research and Kansas State Research and Extension information with applicable crops may serve as a guide for establishing appropriate nozzle spacing, height, and row arrangement.

CU (as determined by the Heermann-Hein equation for center pivots) shall not be less than 90 percent (84 percent DU) for all LPIC and MESA systems with nozzle heights less than 7 feet above the ground level.

Sprinklers positioned below the truss rods and above the crop canopy shall be installed to clear the planned crops while avoiding sprinkler pattern interference from the center pivot truss rods. A minimum 1-pound weight shall be added at or below sprinklers on flexible drops greater than 30 inches in length.

CU shall not be less than 85 percent (76 percent DU) for MESA systems with nozzle heights 7 feet or greater.

Land slope. The slope for LPIC and MESA systems shall not exceed 3 percent on more than 50 percent of the field for fine-textured soils and shall not exceed 5 percent on more than 50 percent of the field on coarse-textured soils.

Specific Additional Criteria for Low-Pressure Center Pivots and Linear-Move Sprinkler Systems including LPIC, LESA, and MESA Systems (2 to 35 pounds per square inch)

Distribution patterns, nozzle pressure, spacing, height, and position. Overall projected system runoff (water translocation) shall average less than 1 percent. Projected runoff simulation modeling shall use the CPNozzle software program or other approved methods. Sprinkler wetted diameters will be as published by the manufacturer's performance tables. Sprinklers that operate in the crop canopy most of the time shall be evaluated based upon a reduced wetted diameter as compared to the non-canopy wetted diameter. The row grade should be used to calculate runoff rather than land slope when all furrows across the land slope are high enough to direct runoff water.

Pressure regulators are required for each sprinkler—with the exception that is listed below. Regulated working pressure at the nozzle shall be 35 pounds per square inch (psi) or less. The pressures throughout the system shall be 5 psi greater than the regulated working pressure at any sprinkler.

Pressure regulators may be omitted if, from the first to last sprinkler on the center pivot, pressure variation at any sprinkler does not exceed 20 percent of its design operating pressure. Elevation changes in the field have the largest impact on operating pressures. (For example, a sprinkler operating at 20 psi in a field with a 9.2-foot elevation difference can have a 20 percent or 4 psi change in pressure.) Without regulators, operating pressure and pumping cost usually will not increase significantly if the elevation does not change much from the pad to the end of the pivot. Where elevation changes are great, the choice is to increase operating pressure (and probably pumping cost) or to use pressure regulators. This decision is site-specific and should be made by comparing the extra cost of pressure regulators to the increased pumping cost without them. Documentation shall include enough survey information to verify the elevation changes in the field.

For the spray nozzle sprinklers within the inner 20 percent, the spacing and type may be different from the rest of the system if it results in an increase in system uniformity.

Low-pressure impact sprinklers shall have a ≤10° trajectory.

Additional Criteria Applicable to Fixed Solid-Set, Big Gun, and Periodic Move Sprinkler Systems

Design capacity. Sprinkler irrigation systems shall have either (1) a design capacity adequate to meet peak water demands of all crops to be irrigated in the design area or (2) an adequate capacity to meet requirements of selected water applications during critical crop growth periods when less-than-full irrigation is planned. In computing capacity requirements, allowance must be made for reasonable application water losses.

Design application rate. The design application rate shall be within a range established by the minimum practical application rate under local climatic conditions and the maximum application rate consistent with soil intake rate, slope, and conservation practices used on the land. If 2 or more sets of conditions exist in the design area, the lowest maximum application rate for areas of larger than 10 percent of the irrigated field shall apply.

Lateral lines. Unless pressure reducers or regulators are installed at each outlet or other pressure-compensating or flow-control devices are used, lateral lines shall be designed so that the pressure variation or flow variation at any sprinkler that results from friction head and elevation differential does not exceed 20 percent of the design operating pressure or 10 percent of the design flow of the sprinklers respectively.

Distribution patterns and spacing. A combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and distribution shall be selected.

If available, CU (or DU) data shall be used in selecting sprinkler spacing, nozzle size, and operating pressure. CU shall not be less than the following:

- 75 percent (60 percent DU) for deep-rooted (4 feet or more) field and forage crops where fertilizers and pesticides are not applied through the system.
- 85 percent (76 percent DU) for high-value or shallow-rooted crops and for any crop where fertilizer or pesticides are applied through the system.

In the absence of CU data, maximum lateral and nozzle spacing shall comply with the following criteria:

- For low-pressure (2 to 35 psi), moderate-pressure (36 to 50 psi), and medium-pressure (51 to 75 psi) sprinkler nozzles, the spacing along lateral lines shall not exceed 50 percent of the wetted diameter as given in the manufacturer's performance tables when the sprinkler is operating at design pressure. The spacing of laterals along the main line shall not exceed 65 percent of this wetted diameter.

  If winds that can affect the distribution pattern are likely during critical crop growth periods, spacing should be reduced to 60 percent for average velocities of 1 to 5 miles per hour (mph), to 50 percent for average velocities of 6 to 10 mph, and to 45 percent for average velocities greater than 10 mph.

- For high-pressure and big gun type sprinklers (> 75 psi), the maximum distance (diagonal) between 2 sprinklers on adjacent lateral lines shall not exceed 2/3 of the wetted diameter under favorable operating conditions.

  If winds that can affect the distribution pattern are likely during critical crop growth periods, the diagonal spacing should be reduced to 50 percent of the wetted diameter for average velocities of 5 to 10 mph and to 30 percent for average velocities greater than 10 mph. Guidance for towpath spacing of travelers is in Table 11-31 in National Engineering Handbook (NEH) Section 15, *Irrigation*.

- Sprinkler spacing requirements for orchards (including subtropical fruits) are as follows:

  1. Triangular pattern–The spacing along lateral lines shall not exceed 65 percent of the effective wetted diameter. The spacing of laterals along the main line shall not exceed 70 percent of the effective wetted diameter.
  2. Square or rectangular pattern–The nozzle spacing along the lateral and the lateral spacing along the main line shall not exceed 65 percent of the effective wetted diameter at the design operating pressure.
  3. Spacing between sprinklers and lateral lines shall be reduced by 2.5 percent for each mph over 3 mph average wind velocity normally occurring during planned hours of operation.

Risers. Except for under-tree operation, riser pipes used on lateral lines shall be high enough to prevent interference with the distribution pattern when the tallest crop is irrigated. Riser heights shall not be less than shown below:

Sprinkler Discharge (gallons/minute)	Riser Length (inches)
Less than 10	6
10-25	9
25-50	12
50-120	18
More than 120	36

Risers over 3 feet in height shall be anchored and stabilized.

Additional Criteria Applicable to Traveling Sprinkler Irrigation Systems

The tow path spacing shall follow the recommendations in Table 11-31 in NEH Section 15.

Additional Criteria Applicable to Climate Control and/or Modification

Design capacity. For temperature control, the sprinkler irrigation system shall have sufficient capacity to satisfy the evaporative demand on a minute-by-minute basis throughout the peak use period. Chapter 2 in National Engineering Handbook Part 623 (NEH 623), *Irrigation,* contains guidance on using sprinkler irrigation systems for temperature control.

For frost protection, the system shall be capable of applying in a uniform manner the necessary rate based on the minimum temperature, maximum anticipated wind speed, and relative humidity. The capacity shall be sufficient to supply the demand for the entire crop being protected. Chapter 2 in NEH 623 contains guidance on using sprinkler irrigation systems for frost protection.

Additional Criteria Applicable to Chemical, Nutrient, and/or Wastewater Application

The installation and operation of a sprinkler irrigation system for the purpose of chemical or nutrient application (chemigation) and/or wastewater application shall comply with all federal, state, and local laws, rules, and regulations. This includes backflow and anti-siphon prevention measures. Additionally, surface waters shall also be protected from direct application. Variable rate irrigation can be used to prevent the application of wastewater to surface waters and their associated buffer areas.

Injectors (chemical, fertilizer, or pesticide) and other automatic operating equipment shall be located adjacent to the pump and power unit and installed in accordance with state regulations. When state regulations are absent, these shall be installed in accordance with the manufacturer's recommendations. The chemical injection device shall be within 1 percent of maximum injection rates and easily calibrated and adjustable for all chemicals at the required injection rate.

Sprinkler irrigation systems used to apply waste shall be designed with sprinkler nozzles of sufficient size to prevent clogging. Treatment of the wastewater using solid separators, 2-stage lagoons, 2-stage waste holding ponds, etc., may be needed to reduce the percentage of solids.

Design application rate and timing. Application rates shall meet the levels specified in "General Criteria Applicable to All Purposes" and shall not exceed the minimum intake rate for any soil within the irrigated field (except as modified using Form KS-ENG-22, Irrigation System, Sprinkler - 442, Center Pivot Sprinkler Design, and called the maximum allowable application rate)**.**

Timing of chemical applications shall be the minimum length of time it takes to deliver the chemicals and flush the pipelines at rates specified by the label.

CU. If available, CU (or DU) data shall be used in selecting sprinkler spacing, nozzle size, and operating pressure. The CU shall not be less than 70 percent for wastewater and not less than 85 percent (76 percent DU) for chemigation or fertigation. If CU data is not available, distribution patterns and spacing requirements shall be in keeping with the appropriate specific criteria of this standard.

Nutrient and pest management. Chemicals, fertilizers, and liquid manure shall be applied in accordance with appropriate CPS 590, Nutrient Management; CPS 595, Integrated Pest Management; CPS 633, Waste Recycling; and CPS 634, Waste Transfer. Chemical or nutrient application amounts shall not exceed these standards.

Chapter 2 in NEH 623 contains guidance on using sprinkler irrigation systems for chemigation.

Additional Criteria Applicable to Leaching

Design application rate and depth. Application rates shall meet the levels specified in "General Criteria Applicable to All Purposes." Design depth shall be determined as defined in Chapter 2 in NEH 623 and Chapter 4 in NEH 652**.**

Management or reclamation plan. A plan shall be developed conforming to the requirements contained in CPS 610, Salinity and Sodic Soil Management.

Additional Criteria Applicable to Reduction in Particulate Matter Emissions to Improve Air Quality

These criteria pertain to sprinkler systems used to improve air quality by controlling dust emissions from confined animal pen areas and other critical areas such as unpaved roads, staging areas, and equipment storage yards.

Installation of fixed solid-set sprinklers or periodic move sprinkler systems for dust control shall conform to the criteria stated above, unless described by criteria in this section. The installation and operation of sprinkler systems for dust control on confined animal pen areas shall provide application coverage on the majority of pen areas occupied by livestock (except for feed bunk aprons). The quality of discharge water shall be pathogen-free and fit for animal consumption.

Capacity and application rate. For dust control, the sprinkler irrigation system shall have sufficient capacity and operational flexibility to apply the design application depth every 3 days or less. When determining capacity requirements, allowance shall be made for reasonable water losses during application.

The minimum design application rate shall meet the maximum total daily wet soil evaporation rate with allowances for moisture input to pen areas from animal manure and urine.

Open-lot management practices shall be applied that include scraping and removal of manure in pens between occupations and shaping of the holding areas to prevent water ponding and chronic wet areas.

Over-application and excessive sprinkler overlap shall be avoided to minimize runoff and reduce odor and fly problems.

Water amendments. Appropriately labeled chemicals for pest control or dust suppression may be applied through the sprinkler system when designed, installed, and operated with appropriate backflow prevention and anti-siphon devices. When chemicals are applied through the sprinkler system, surface waters and livestock watering facilities shall be protected from direct application unless chemical labels indicate that direct application will not negatively impact animal health or water quality.

Distribution patterns and spacing. A combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and distribution pattern shall be selected.

Maximum spacing of sprinklers along laterals shall not be greater than 75 percent and no closer than 50 percent of the wetted diameter listed in the manufacturer's performance tables. Spacing between laterals shall comply with the following criteria:

- For medium-pressure (51 to 75 psi) sprinkler nozzles, the spacing of laterals along the main line shall be no more than 90 percent and no closer than 70 percent of wetted diameter.
- For high-pressure sprinklers (> 75 psi), the maximum distance between 2 sprinklers on adjacent lateral lines shall not exceed 100 percent of the wetted diameter.

If winds impact distribution patterns during critical dust-emission periods, the system shall be equipped with timer overrides and have the flexibility to be operated manually during periods of lesser wind (such as late evening and early morning).

Risers. Riser pipes used in lateral lines shall be high enough to minimize interference with the distribution pattern. The risers shall be constructed in a manner that provides protection from corrosive soils, equipment damage, and livestock damage. Riser heights shall place the discharge sprinkler not less than 6 feet above the ground surface. Risers shall be anchored and stabilized.

System valves and controllers. Due to high application rates inherent with large sprinkler nozzle diameters, an automatic irrigation control system shall be utilized for all nozzles greater than 0.5 inch in diameter. The automated control system shall utilize electro-hydraulic valves that facilitate automatic operation. The valves shall be of a size and quality consistent with standard engineering practice. The operating system shall provide the flexibility to change sprinkling duration in 1-minute increments and have a minimum of 6 start times per day to provide for adjustment for climate conditions.

Systems shall be equipped with a rain sensor connected to the control valve network set to prohibit system operation during rainfall events.

Manual zone isolation valves shall be incorporated to isolate laterals, allowing partial system operation during periods of maintenance and repair.

In areas of uneven or sloping terrain, a control valve or low-head drainage device shall be incorporated at each sprinkler to ensure that line drainage to the lowest sprinkler is minimized.

Additional Criteria Applicable to Reduce Energy Use

Provide analysis to demonstrate reduction of energy use from practice implementation.

Reduction of energy use is calculated as average annual or seasonal energy reduction compared to previous operating conditions.

CONSIDERATIONS

When planning this practice, the following items should be considered where applicable:

- Application rates near the end of a center pivot may exceed soil intake rate. Light, frequent applications can reduce runoff problems but may increase soil surface evaporation. Nozzle offsets or booms can be used to reduce peak application rates.
- In lieu of sprinklers positioned at or below the truss rods, consider placing sprinklers on the span pipe to minimize projected average system runoff to less than 1 percent.
- Row arrangement, nozzle spacing, discharge nozzle type and configuration, and height all affect CU for low suspended nozzle application systems. System design and field management should complement each other to yield the highest CU. In general, circular rows for center pivot systems and straight rows for linear move systems provide higher CUs.
- Some aspects of non-uniformity tend to average out through the irrigation season while others tend to accumulate. Factors that tend to average out during the irrigation season are climatic conditions and uneven travel speed for systems that start and stop. Factors that tend to accumulate during the irrigation season are nozzle discharge variances due to pressure or elevation differences, surface movement of water, and poor water distribution around field boundaries.
- Consider the effects of a center pivot end gun operation on CU. A large end gun may reduce the average CU by 1 percent for each 1 percent of the area covered past the main system hardware.
- Consider the on and off effects of center pivot corner arm units and end guns on overall sprinkler performance. Discharges reduce flow in the main tower, significantly lowering the CU.
- Beneficial effects of conservation practices applied to limit surface redistribution of water and runoff may diminish over the irrigation season.
- The velocity of prevailing winds and the timing of occurrence should be considered when planning a sprinkler system. Systems designed to operate in varied time increments aid in balancing the effects of day and night wind patterns.
- Consider filtering or screening the irrigation water before it enters the system if it contains particulate matter, algae, or other material that could plug the sprinkler nozzles.
- Drop tubes should be installed alternately on both sides of the mainline; and when used in the crop canopy, they should have a flexible joint between the gooseneck pipes and the application device. Drops should be weighted or secured in windy areas.
- Consider different sprinkler application depths and application rates with hand move and center pivot systems. With hand move systems, the application rate more nearly matches the soil infiltration rates so that large irrigations can be applied and the number of hand moves reduced. With an automated system (such as a center pivot), hand labor is not a major consideration, and small applications at high rates are normal.
- Fertilizer and chemical application amounts may vary from prior application methods and rates due to precise applications that are possible with some sprinkler irrigation systems.

- Management of sprinkler irrigation systems normally includes utilizing soil water stored in the root zone, especially during critical crop growth stages.
- Deflection of spans on center pivots and linear move systems is common when the lateral is loaded (filled with water). This should be considered when determining nozzle heights. Wheel track depth will also affect nozzle height.
- Water distribution is greatly affected by nozzle spacing and height for LPIC and MESA systems. In general, smaller nozzles that are more closely spaced will yield a higher uniformity than larger, more widely spaced nozzles.
- On center pivot or linear move systems, nozzles should be diverted away from wheel tracks to avoid rutting.
- Low-pressure systems (35 psi or less) are sensitive to small changes in nozzle pressure.
- Consider installing a pressure gauge at both ends of the sprinkler system to monitor system pressure.
- Consider system effects on the water budget, especially the volume and rate of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.
- Consider system effects on erosion and movement of sediment and soluble and sediment-attached substances carried by runoff.
- Consider system effects on soil salinity, soil water, or downstream water quality including subsurface drains. Crops may be more sensitive to salts applied to plant foliage during sprinkling than to similar water salinities applied by surface irrigation, subirrigation, and microirrigation. Information on foliar injury from saline water applied by sprinkler irrigation is contained in Chapter 2 in NEH 623. If the salt content of the irrigation water is high, other irrigation methods should be considered.
- Where wastewater is used for irrigation, timing of irrigation based on prevailing winds should be considered to reduce odor. In areas of high visibility, irrigating at night should be considered. The use of wastewater may reduce the life of the system due to corrosion or abrasion.
- When utilized for particulate matter reduction, check to ensure that adequate animal feeding operation water supplies are available to meet other operating needs during sprinkler system operation.
- Irregularly shaped pen areas that are impractical to treat with a sprinkler system (and where potential dust sources may occur) should be treated for dust control with tanker water trucks equipped with hoses or nozzles designed to apply water at rates similar to an equivalent sprinkler system.
- Open feedlot management practices that minimize thickness of loose manure will reduce water demands for dust control as well as reduce wet areas and ponding that could increase ammonia emissions.

PLANS AND SPECIFICATIONS

Plans and specifications for constructing irrigation sprinkler systems shall be in keeping with this standard and shall describe the requirements for properly installing the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

An operation and maintenance plan must provide specific instructions for operating and maintaining the system to ensure that it functions properly. It should also provide information regarding periodic inspections and prompt repair or replacement of damaged components. The plan, at a minimum, shall include provisions to address the following:

- Periodic checks and removal of debris and sediment as necessary from nozzles to ensure proper operation.
- Inspection or testing of all pipeline and pumping plant components and appurtenances as applicable.
- Regular testing of pressures and flow rates to ensure proper operation.
- Periodic checks of all nozzles and spray heads for proper operation and wear.

- Routine maintenance of all mechanical components in accordance with the manufacturer’s recommendations.

- Prior to retrofitting any electrically powered irrigation equipment, electrical service must be disconnected and the absence of stray electrical current verified.

REFERENCES

USDA-NRCS, National Engineering Handbook, Part 623, Chapter 2, Irrigation Water Requirements.