NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

IRRIGATION SYSTEM, SPRINKLER

(no. and 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.

PURPOSE

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

Efficiently and uniformly apply 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.

Applying chemicals, nutrients, and/or waste water.

Leaching for control or reclamation of saline or sodic soils.

Reduction in particulate matter emissions to improve air quality.

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 purpose(s).

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

This standard does not include criteria for mini- or micro-sprinkler systems, which are covered by SD NRCS conservation practice Standard Irrigation System, Microirrigation (441).

CRITERIA

This practice must conform to all federal, state, and local laws and regulations. Laws and regulations of particular concern include those involving water and drainage rights, land use, pollution control, fertilizer and pesticide application, property easements, wetlands, preservation of cultural resources, and endangered species.

Design of components not addressed in SD NRCS 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 needs of the operator. The selected system shall be based on a site evaluation, expected operating conditions, and verification that water, soils, and topography are suitable for the intended purpose(s).

Depth of Application. Net depth of application shall meet the owner/operator's management plan and criteria for the intended purpose, but must not exceed available soil water holding capacity.

Capacity. The sprinkler irrigation system shall be designed with adequate capacity to accomplish the purpose.

Application Rate. Rates must minimize runoff, translocation, and unplanned deep percolation. Additional conservation measures, such as furrow diking, in-furrow chiseling, conservation tillage, or residue management shall be applied as appropriate.

Distribution Patterns, Nozzle Spacing and Height. Select a combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and distribution.

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 the NRCS National Engineering Handbook, Part 652, Irrigation Guide.

Pipelines. Main line, submain, and supply line capacities shall insure that required water quantities can be conveyed to all operating lateral lines at required pressures. For detailed criteria, see SD NRCS conservation practice standard Irrigation Pipeline (430).

Pump and Power Unit. Pump and power units shall be adequate to efficiently operate the sprinkler system at design capacity and pressure. For criteria, see SD NRCS Practice Standard Pumping Plant (533).

Management Plan. An Irrigation Water Management plan, meeting NRCS Conservation Practice Standard Irrigation Water Management (449), shall be developed for this practice, unless the purpose of the practice is waste water application. Where waste application is the purpose, a Comprehensive Nutrient Management Plan (CNMP), waste utilization plan, and/or nutrient management plan shall be developed that meets the requirements of NRCS conservation practice standard Waste Utilization (633), and/or Nutrient Management (590).

ADDITIONAL CRITERIA APPLICABLE TO CENTER PIVOT OR LINEAR-MOVE SPRINKLER SYSTEMS

Design Capacity. For the purpose of crop irrigation, sprinkler irrigation systems shall have either (1) capacity meeting crop peak water demand, or (2) capacity for selected irrigations during critical crop growth periods when less than full irrigation is planned. Capacity allowance must be made for reasonable application water losses.

Distribution Patterns, Nozzle Spacing and Height. Pivot system (Heermann-Hein) or Linear (Christensen) CU shall not be less than 85 percent (76 percent DU), except as noted in criteria for a Low Energy Precision Application (LEPA) 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. Manufacturer's information on nozzle packaging, allowing 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 manufacturer's information for the nozzle height.

Lower elevation nozzle application systems, typically less than seven 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 Low Pressure in Canopy (LPIC) system as defined in this standard.

ADDITIONAL CRITERIA APPLICABLE TO LOW ENERGY PRECISION APPLICATION (LEPA) AND LOW ELEVATION SPRAY APPLICATION (LESA) CENTER PIVOT OR LINEAR-MOVE SPRINKLER SYSTEMS

Distribution Patterns. For center pivot systems, nozzle discharge CU using the Heermann-Hein 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 two times the row spacing of the crop, not to exceed 80 inches.

Discharge Height for LEPA. 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.

Row Arrangement and Storage for LEPA. LEPA systems are only applicable on crops planted with furrows or beds. LEPA systems shall have row patterns that match the lateral line movement (i.e., 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.

Slope for LEPA. The slope for a LEPA system shall not exceed 1.0 percent on more than 50 percent of the field.

LESA. Systems that utilize bubble pads or shields, or drag hoses for a portion of the crop year and then spray nozzles at uniform height not exceeding 18 inches for a portion of the crop year shall meet LESA criteria.

Discharge Height for LESA. LESA systems shall discharge water through a spray nozzle at uniform heights not to exceed 18 inches.

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

Land Slope for LESA. The slope for LESA systems shall not exceed 3.0 percent on more than 50 percent of the field.

ADDITIONAL CRITERIA APPLICABLE TO LOW PRESSURE IN CANOPY (LPIC) AND MID ELEVATION SPRAY APPLICATION (MESA) CENTER PIVOT OR LINEAR-MOVE SPRINKLER SYSTEMS

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

Distribution Patterns, Nozzle Spacing and Height. For row crops, when nozzles operate in canopy for 50 percent or more of the growing season, nozzle spacing shall not exceed every other crop row. In-canopy heights shall be such that areas of high leaf concentration are avoided (i.e., corn near the ear height (approximately four feet)). Local research and Extension service information with applicable crops may serve as a guide for establishing appropriate nozzle spacing, height, and row arrangement.

CU (Heermann–Hein CU for center pivots) shall not be less than 90 percent for all LPIC and MESA Systems with nozzle heights less than 7 feet.

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 3.0 percent on more than 50 percent of the field for fine textured soils and not exceed 5 percent on more than 50 percent of the field on coarse textured soils.

ADDITIONAL CRITERIA APPLICABLE TO FIXED-SOLID-SET, BIG GUN AND PERIODIC MOVE SPRINKLER SYSTEMS

Design Capacity. Sprinkler irrigation systems shall have either (1) capacity meeting crop peak water demand, or (2) capacity for selected irrigations during critical crop growth periods when less than full irrigation is planned. Capacity allowance must be made for reasonable application water losses.

Design Application Rate. The application rate must be above the minimum practical application rate under local climatic conditions, and below the maximum application rate consistent with soil intake rate, slope, and conservation practices used on the land. For variable conditions, the lowest maximum application rate for areas of significant size shall apply.

Lateral Lines. Unless pressure reducers or flow control devices are used, lateral lines shall be designed so that pressure or flow variation at any sprinkler, resulting 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 sprinkler.

Distribution Patterns and Spacing. Use a combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and distribution.

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:

Seventy-five 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.

Eighty-five 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 meet the following:

For 2 to 75 psi pressure sprinkler nozzles, spacing along lateral lines shall not exceed 45 percent of the wetted diameter, as given in manufacturer's performance tables.

For high-pressure and big gun type sprinklers (>75 psi), the maximum distance (diagonal) between two sprinklers on adjacent lateral lines shall not exceed 30 percent of the wetted diameter.

Guidance for towpath spacing of travelers is in Table 11-31 of NEH-15, Irrigation, Chapter 11, Sprinklers.

Sprinkler spacing for orchards:

Triangular pattern. Spacing along lateral lines shall not exceed 50 percent of effective wetted diameter. Spacing of laterals along the main line shall not exceed 55 percent of effective wetted diameter.

Square or rectangular pattern. Nozzle spacing along the lateral and lateral spacing shall not exceed 50 percent of effective wetted diameter at design operating pressure.

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)	**Min. Riser length** (inches)
Less than 10	6
10-25	9
25-50	12
50-120	18
More than 120	36

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

ADDITIONAL CRITERIA APPLICABLE TO TRAVELING SPRINKLER IRRIGATION SYSTEMS

The towpath spacing shall follow the recommendations in Table 11-31, National Engineering Handbook (NEH), Section 15, Irrigation, Chapter 11, Sprinkler Irrigation.

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. NEH, Part 623, Chapter 2 contains guidance.

For frost protection, the system shall apply the necessary uniform rate, based on minimum temperature, maximum anticipated wind speed, and relative humidity. NEH, Part 623, Chapter 2 contains guidance on using sprinkler irrigation systems for frost protection.

ADDITIONAL CRITERIA APPLICABLE TO CHEMICAL, NUTRIENT AND/OR WASTE WATER APPLICATION

These purposes are regulated by federal, state and local laws, rules and regulations. Backflow and anti-siphon prevention measures are covered by applicable regulations. Surface waters must be protected.

Injectors (chemical, fertilizer, or pesticides) and other automatic operating equipment shall be located adjacent to the pump and power unit and installed in accordance with regulations, and manufacturer recommendations. The chemical injection device shall be within one percent of needed maximum injection rates and easily calibrated and adjustable for all chemicals at the required injection rate.

Design sprinkler waste irrigation systems using sprinkler nozzles of sufficient size to prevent clogging. Treatment of wastewater using solid separators, two-stage lagoons, or waste holding ponds, etc., may be needed to reduce solid content.

Application Timing. 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.

Coefficient of Uniformity. 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, use distribution patterns and spacing requirements listed above, as appropriate.

Nutrient and Pest Management. Chemical, fertilizer, and liquid manure application shall meet SD NRCS practice standards: Nutrient Management (590), Pest Management (595), Waste Utilization (633), and/or Manure Transfer (634), as applicable.

NEH, Part 623, Chapter 2, contains guidance on sprinkler chemigation.

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.

Sprinkler systems for dust control shall conform to above criteria except as specified in this section. Provide sprinkler application coverage for dust control on most confined animal pen areas occupied by livestock, except feed bunk aprons. Applied water shall be pathogen free and fit for animal consumption.

Capacity and Application Rate. For dust control, the sprinkler irrigation system shall have capacity and operational flexibility to apply the design application every three days or less.

Design capacity must include 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 waste.

Open-lot management practices shall be applied that include scraping and removal of manure in pens, and shaping of the 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. Select a combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and distribution pattern.

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

For 50 to75 psi pressure 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), maximum distance between two sprinklers on adjacent lateral lines shall not exceed 100 percent of wetted diameter.

Equip the system with timer overrides providing flexibility to operate sprinklers during periods of lesser wind, such as morning, or evening.

Risers. Riser pipes shall be high enough to minimize interference with the distribution pattern. Provide protection from corrosive soils, and equipment and livestock damage. Riser heights shall place the discharge sprinkler at least six feet above 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 diameter. The automated control system shall utilize electro-hydraulic valves facilitating automatic operation. The operating system shall provide flexibility to change sprinkling duration in one-minute increments and have a minimum of six start times per day to adjustment for climate conditions.

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

Manual zone isolation valves shall be incorporated to isolate laterals and allow partial system operation during repair/maintenance.

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

CONSIDERATIONS

Consider, 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.

For low suspended nozzle application systems, row arrangement, nozzle spacing, discharge nozzle type, and configuration, along with height, all impact CU. 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 CU's.

Some aspects of non-uniformity tend to average out throughout 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 one percent for each one 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-crop 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 rates more nearly match the soil infiltration rate 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 possible with some sprinkler irrigation systems.

Management of sprinkler irrigation systems normally include 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, more closely spaced nozzles 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 using pressure regulators on all low pressure systems where elevation differences, pumping depth variations, and end gun or corner arm operation can significantly change nozzle discharge and sprinkler uniformity. Also 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 ground water 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 NEH, Part 623, Chapter 2. 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 assure 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 this practice shall meet this standard and include requirements needed achieve the purpose.

OPERATION AND MAINTENANCE (O&M)

An O&M plan must be prepared and provided to the owner/operator to insure the practice functions properly. It should also provide information regarding periodic inspections and repair or replacement of damage. The plan must include the following:

Periodic inspection and removal of debris and sediment as necessary from nozzles, and checks of all nozzles and spray heads for proper operation and wear.

Regular testing of pressures and flow rates.

Inspection, testing, and repair of all pipeline and pumping plant components and appurtenances, as applicable.

Routine maintenance of all mechanical components in following manufacturer's recommendations.

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