NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

IRRIGATION PIPELINE

(Ft.)

CODE 430

DEFINITION

A pipeline and appurtenances installed to convey water for storage or application, as part of an irrigation water system.

PURPOSE

Conveyance of water from a source of supply to an irrigation system or storage reservoir.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to water conveyance and distribution pipelines installed above or below ground.

This standard does not apply to multiple outlet irrigation system components (e.g., surface gated pipes, sprinkler lines, or micro-irrigation tubing).

CRITERIA

The water supply, quality, and rate of irrigation delivery for the area served by the pipeline shall be sufficient to make irrigation practical and feasible, for the crops to be grown and the irrigation water application methods to be used.

Pipelines shall be placed only in soils and environmental conditions suitable for the pipe material being selected.

Pipelines shall be designed to meet all service requirements such that internal pressure, including hydraulic transients or static pressure at any point is less than the pressure rating of the pipe.

Utilities and Permits. The landowner and/or contractor shall be responsible for locating all buried utilities in the project area, including drainage tile and other structural measures.

The landowner shall obtain all necessary permissions from regulatory agencies, including the Illinois Department of Agriculture, US Army Corps of Engineers, US Environmental Protection Agency, Illinois Environmental Protection Agency and Illinois Department of Natural Resources – Office of Water Resources, or document that no permits are required.

Capacity. Capacity shall be sufficient to convey the design delivery flow rate for the planned conservation practices.

Design capacity of the pipeline conveyance or distribution system for irrigation systems shall be sufficient to meet the requirements for efficient application based on one of the following:

- Adequate to meet the moisture demands of all crops to be irrigated in the design area.
- Sufficient to meet requirements of selected irrigation events during critical crop growth periods when less than full irrigation is planned.
- For special-purpose irrigation systems, sufficient to apply a specified amount of water to the design area in a specified operating period.

In computing the above capacity requirements, allowance must be made for reasonable water losses during application or use.

Friction and Other Losses. For design purposes, head loss for hydraulic grade line computations shall be computed using one of the following equations: Manning's, Hazen-Williams, or Darcy-Weisbach. Equation selection shall be based on the given flow conditions and pipe materials used. Other head losses (also called minor losses) from change in velocity and direction of flow due to inlet type, valves, bends, enlargements or contractions can be significant and shall be evaluated as appropriate. For closed, pressurized systems, the hydraulic grade line for all pipelines shall be maintained above the top of the pipeline at all locations for all flows unless specifically designed for negative internal pressures.

Flexible Conduit Design. Flexible conduits, such as plastic pipe, steel pipe, aluminum pipe, corrugated metal pipe, or ductile iron pipe, shall be designed using NRCS National Engineering Handbook (NEH) Part 636, Chapter 52, Structural Design of Flexible Conduits, and the following criteria:

Smooth Wall Plastic Pipe. When operating at design capacity, the full-pipe flow velocity should not exceed 5 feet per second in pipelines with valves or some other flow control appurtenances placed within the pipeline or at the downstream end. As a safety factor against surge, the working pressure at any point should not exceed 72 percent of the pressure rating of the pipe. If either of these limits is exceeded, special design consideration must be given to the flow conditions, and measures must be taken to adequately protect the pipeline against transient pressures.

Corrugated or Profile Wall Plastic Pipe. When operating at design capacity, the full-pipe flow velocity should not exceed 5 feet per second in pipelines with valves or some other flow control appurtenance placed within the pipeline or at the downstream end. As a safety factor against surge, the working pressure at any point should not exceed 72 percent of the pressure rating of the pipe. If the pipe is not pressure rated, the maximum allowable pressure shall be 25 feet of head, or the maximum pressure as specified by the manufacturer for the pipe and connecting joints used.

Smooth Wall Steel Pipe. The specified maximum allowable pressure shall be determined using the hoop stress formula, limiting the allowable tensile stress to 50 percent of the yield-point stress for the material selected. Design stresses for commonly used steel and steel pipe are shown in the NEH Part 636, Chapter 52.

Corrugated Metal Pipe. Maximum allowable pressure for the pipe shall be:

- 20 feet of head for annular and helical pipe with sealed seams and watertight coupling bands.
- 30 feet of head for helical pipe with welded seams, annular ends, and watertight couplings.

Smooth Wall Aluminum Pipe. The maximum allowable pressure of the pipe shall be determined using the hoop stress formula limiting the allowed tensile stress to 7,500 psi.

Rigid Conduit Design. Rigid conduits, such as concrete pipe or plastic mortar pipe shall, be designed using the following criteria:

Non-reinforced Concrete Pipe with Mortar Joints. The maximum allowable pressure for pipe with mortar joints shall not exceed one-fourth of the certified hydrostatic test pressure as determined by the test procedure described in ASTM C118. Nor shall they exceed the following:

Diameter (inches)	Maximum Allowable Pressure (feet)
6 through 8	40
10 and greater	35

Non-reinforced Concrete Pipe with Rubber Gasket Joints. The maximum allowable pressure for non-reinforced concrete pipe with rubber gasket joints shall not exceed one-third the certified hydrostatic test pressure as determined by the test procedure described in ASTM C505. Nor shall they exceed the following:

Diameter (inches)	Maximum Allowable Pressure (feet)
6 through 12	50
15 through 18	40
21 and greater	30

Cast-in-Place Concrete Pipe. Maximum working pressure for cast-in-place concrete pipe shall be 15 feet above the centerline of pipe. Cast–in-place concrete pipe shall be used only in stable soils capable of being used as the outside form for approximately the bottom half of the conduit.

Reinforced Concrete Pipe with Gasket Joints. The maximum allowable pressure for reinforced concrete pipe with rubber gasket joints shall not exceed the rated hydrostatic pressure for the specified pipe according to appropriate ASTM or AWWA standards.

Reinforced Plastic Mortar Pipe. The pipeline shall be designed to meet all service requirements without a static or working pressure at any point greater than the maximum allowable working pressure of the pipe used. The static or working pressure of pipelines open to the atmosphere shall include free board. The minimum acceptable pipe pressure rating shall be 50 psi.

Support of Pipe. Irrigation pipelines both below and above ground shall be supported, where needed, to provide stability against external and internal forces. Pipe support shall be designed using NEH Part 636, Chapter 52.

Joints and Connections. All connections shall be designed and constructed to withstand the pipeline working pressure without leakage and leave the inside of the pipeline free of any obstruction that would reduce capacity.

Permissible joint deflection shall be obtained from the manufacturer for the joint type and pipe material used.

For sloping steel pipe, expansion joints shall be placed adjacent to and downhill from anchors or thrust blocks.

For welded pipe joints, expansion joints shall be installed, as needed, to limit pipeline stresses to the allowable values.

For suspended pipelines, joints shall be designed for pipe loading, including the water in the pipe, wind, ice, and the effects of thermal expansion and contraction.

Joints and connections for metal pipes should be of similar materials whenever possible. If dissimilar materials are used, joints or connections shall be protected against galvanic corrosion.

Depth of Cover. Buried pipe shall be installed at sufficient depth below the ground surface to provide protection from hazards imposed by traffic loads, farming operations, freezing temperatures, or soil cracking, as applicable.

Pipelines shall have sufficient strength to withstand all external loads on the pipe for the given installation conditions. Appropriate live loads shall be used for anticipated traffic conditions.

Where it is not possible to achieve sufficient cover or sufficient strength, a carrier (encasement) pipe or other mechanical measures shall be used.

Pressure Reduction. Pressure reduction shall be incorporated in circumstances such as head gain exceeding pressure loss by a significant amount, excessive line pressured for the type of irrigation system, or excessive static pressures.

Inlets. Inlets shall be of adequate size for the type of entrance condition to ensure design flow capacity without excessive head losses.

Provision shall be made to prevent the inflow of trash or other materials into the pipeline if these materials would be detrimental to the pipe capacity or performance of the irrigation application system.

For gravity flow inlets with square-edged or gated orifices, the nappe created by inflow at the orifice entrance shall be vented.

Water control structures, stands, Z-pipes and dog-legs are all acceptable inlet devices. Water control structures are commonly used for gravity flow pipelines, but do not account for removal of entrained air. Therefore, pipelines using these inlets must also meet the requirements listed under Vents.

Check Valves and Backflow Prevention. A check valve shall be installed between the pump discharge and the pipeline if detrimental backflow may occur. Check valves can cause extreme internal pressures, due to water hammer; if they close too fast as flow reversal occurs. "Non slam" type check valves or solenoid-operated valves may be required.

Approved backflow prevention devices (chemigation valves) shall be used on all pipelines in which fertilizer, liquid manure, waste water, pesticides, acids, or other chemicals are added to the water supply and where backflow may contaminate the source water supply or groundwater.

Valves and Other Appurtenances. Pressure ratings of valves and other appurtenances shall equal or exceed the pipeline working pressure. When lever operated valves are used, an analysis shall be performed to evaluate potential surge/water hammer assuming an instantaneous valve closure.

Stands Open to the Atmosphere. Stands shall be used when water enters the pipeline to avoid entrapment of air; to prevent surge pressures and collapse because of vacuum failure; and to prevent pressure from exceeding the design working stress of the pipe. The stand shall be designed to:

- Allow a minimum of 1 foot of freeboard. The maximum height of the stand above the centerline of the mainline pipeline must not exceed the maximum working head of the pipe.
- Have the top of each stand at least 4 feet above the ground surface except for surface gravity inlets or where visibility is not a factor. Gravity inlets and stands shall be equipped with trash racks and covers.
- Have a downward water velocity in stands not in excess of 2 feet per second. The inside diameter of the stand shall not be less than the inside diameter of the pipeline.

The cross sectional area of stands may be reduced above a point 1 foot above the top of the upper inlet, but the reduced cross section shall not be such that it would produce an average velocity of more than 10 feet per second if the entire flow were discharging through it.

If the water velocity of an inlet pipe exceeds three times the velocity of the outlet, the centerline of the inlet shall have a minimum vertical offset from the centerline of the outlet at least equal to the sum of the diameters of the inlet and outlet pipes.

Stands shall be constructed of steel pipe or other approved material and be supported on a base adequate to support the stand and prevent movement or undue stress on the pipeline.

Sand traps, when combined with a stand, shall have a minimum inside dimension of 30 inches and shall be constructed so the bottom is at least 24 inches below the invert of the outlet pipeline. The downward velocity of the water flow in a sand trap shall not exceed 0.25 feet per second. Suitable provisions shall be made for cleaning sand traps.

The dimensions of gate stands shall be adequate to accommodate the gate or gates required, and shall be large enough to make gates accessible for repair.

The size of float valve stands shall be adequate to provide accessibility for maintenance.

Stands must be constructed in a manner to ensure vibration from the pump discharge pipe is not carried to the stand.

Pressure-relief valves can be used as an alternative to stands open to the atmosphere. A pressure-relief valve shall serve the pressure-relief function of the open stand or vent for which it is an alternative.

Stands Closed to the Atmosphere. If pressure-relief valves and air-and-vacuum valves are used instead of open stands, all requirements detailed in “Stands Open to the Atmosphere” shall apply except as modified below.

The inside diameter of the closed stand shall be equal to or greater than that of the pipeline for at least 1 foot above the top of the uppermost inlet of outlet pipe. To facilitate attaching the pressure-relief valve and the air-and-vacuum valve, the stand may be capped at this point, or if additional height is required, the stand may be extended to the desired elevation by using the same inside diameter or a reduced cross section. If a reduced section is used, the cross-sectional area shall be such that it would produce an average velocity of no more than 10 feet per second if the entire flow were discharged through it. If no vertical offset is required between the pump discharge pipe and the outlet pipeline and the discharge pipe is “dog-legged” below ground, the stand shall extend at least 1 foot above the highest part of the pump discharge pipe.

An acceptable alternative design for stands requiring no vertical inlet offset (when inlet velocity is less than three times that of the outletting pipeline) shall be:

- Construct the dog-leg section of the pump discharge pipe with the same nominal pipe diameter as that of the pipeline.
- Install the pressure-relief valve and the air-and-vacuum valve on top of the upper horizontal section of the dog-leg.

Pressure-relief and air-and-vacuum valves shall be installed on stands with the nominal size pipe required to fit the valves’ threaded inlets.

Surge Tanks and Air Chambers. If surge tanks and/or air chambers are required for control of hydraulic transients or water column separation, they shall have adequate size to ensure the water volume needs of the pipeline are met without the tank/chamber being emptied, and that the required flow into the pipeline for the calculated pressure drop is met.

Pressure Relief Valves. A pressure relief (PR) valve shall be installed between the pump discharge and the pipeline if excessive pressure can build up when all valves are closed. If needed to protect the pipeline against pressure-reducing valve malfunction or failure, PR valves shall be installed downstream of pressure-reducing valves.

Manufacturers of PR valves marketed for use under this standard shall provide capacity tables that provide the discharge capacities of the valves at the maximum permissible pressure and differential pressure settings. These tables shall be based on performance tests and shall be the basis for acceptance of these valves and selection of the design pressure setting.

PR valves shall be set to open at a pressure as low as practical, but no greater than 5 psi above the pressure rating or maximum allowable pressure of the pipe. The valves shall have sufficient flow capacity to reduce excessive pressures in the pipeline. In lieu of a detailed surge/pressure analysis, the minimum size of PR valve shall be 1/4 inch nominal valve size per inch of the nominal pipeline diameter.

The pressure at which the valves start to open shall be marked on each PR valve. Adjustable PR valves shall be sealed or otherwise altered to prevent changing the adjustment from that marked on the valve.

Air Release Valves. Five types of air vents/valves commonly used on irrigation pipelines are continuous acting air release valves (CAV), vacuum-relief valves (VR), air release and vacuum relief valves (AVR), combination air valves (COMB), and open vents. Open vents are described in the “Vents” section of this standard.

If accumulation of air during operation may occur CAV shall be used to release air from the filled pipeline while under pressure. Normal orifice venting diameter is 1/16 to 3/8 inch.

VR valves shall be used for relief of vacuum pressures (i.e., negative pressures) due to sudden gate or valve closure, pump shutoff, or drainage of the pipeline.

AVR valves may be used for the same requirements described for VR valves. These valves shall also be used to release air from the pipeline on filling prior to the pipe being pressurized. They shall be used to alleviate flow restrictions, air locks, and water surging due to the presence of air within pipelines.

COMB valves have the combined function of all three valves (CAV, VR, and AVR) in one body. COMB valves may be used for any of the conditions in which a CAV, VR, or AVR is required.

If needed to provide positive means for air escape during filling and air entry while emptying, an AVR, VR, or COMB valve shall be installed at all summits, upstream and downstream of all in line valves as needed, at the entrance, and at the end(s) of the pipelines. Such valves are needed at these locations if the pipeline is closed to the atmosphere. However, they may not be needed if other features of the pipe system, such as permanently located sprinkler nozzles or other unclosed service outlets, adequately vent the particular location during filling and emptying operations. The use of these system features must be analyzed for air flow rate and the proper use of such features described in the Operation and Maintenance plan. High points in the pipeline require a CAV unless an outlet is located at that point.

In addition to the locations described above, an AVR or COMB valve shall be located at changes of grade in downward direction of flow in excess of 10 degrees, to ensure adequate air release during filling. For pipelines longer than 1/4 mile (1320’),additional AVR or COMB valves may be required to adequately vent the pipe during filling.

For air release, the AVR or COMB valve shall be sized to exhaust air from the pipeline at the rate needed to prevent operational problems with the pipeline, while maintaining the proper operation of the valve. For design purposes, the exhaust pressure differential shall be limited to 2 psi.

For vacuum relief, the AVR, VR, or COMB valves shall be sized for air entry into the pipeline, ensuring the pipeline does not collapse due to vacuum created during drainage of the pipeline. For design purposes, the vacuum pressure differential shall be limited to 5 psi.

If the required vacuum relief orifice diameter is significantly larger than the required air release orifice diameter, separate valves may be required to help eliminate excessive water hammer caused when the air is released too fast from the pipeline.

CAV or COMB valves shall be used as needed to permit air to escape while the line is at working pressure. Small orifices of these valve types shall be sized according to the design working pressure and venting requirements recommended by the valve manufacturer.

The location of the CAV or COMB valves shall be sufficient distance downstream from the introduction of air into the system (under pressure conditions) to allow the air to be collected at the top of the pipe. Under some circumstances (e.g., pumped system with low pressure or velocity), consideration should be given to installing vent chambers for CAV or COMB valves. The vent chamber should be constructed according to the requirements under the second criteria in the "Vents" section of this standard.

In lieu of a detailed design for the corresponding pipe material below, the following size air valves shall be used:

For Plastic ≤ 50 psi - 0.22 x pipe diameter

For Plastic > 50 psi - 0.10 x pipe diameter

For Metal - 0.125 x pipe diameter

For Concrete - 0.125 x pipe diameter

Manufacturers of air valves marketed for use under this standard shall provide dimensional data or a capacity table based on performance tests, which shall be the basis for selection and acceptance of these valves.

Vents. Venting must be designed into systems open to the atmosphere to provide for removal and entry of air and protection from surge. The following criteria shall apply:

- Vents shall have a minimum freeboard of 1 foot above the hydraulic gradeline at design capacity. The maximum height of the vent above the centerline of the pipeline must not exceed the maximum allowable working pressure of the pipe.
- A vent chamber shall be constructed to intercept and/or capture air within the pipeline. The chamber shall intercept the circumference arc of 75 degrees at the top of the pipe (i.e., a vent chamber diameter of 2/3 the diameter of the pipeline). The chamber shall extend vertically at least one pipeline diameter up from the centerline of the pipeline. Above this elevation, the vent chamber may be reduced to a minimum diameter of 2 inches.
- When an AVR or COMB valve is used instead of a vent, the above requirements shall apply except that the reduced section shall be sized to meet the nominal pipe size required to fit the valve's threaded inlet. An acceptable alternative is to install the valve(s) in the side of a service outlet, provided that the service outlet riser is properly located and adequately sized. If both AVR and PR valves are required at the location, the 10 feet per second velocity criteria given under the "Stands Open to the Atmosphere" section of this standard, shall apply to the reduced section.
- Vent chambers shall be installed on all open vents and closed vents with air valves, when the normal operating pressure of the pipe is 10 psi or less.
- A vent shall be located at the downstream end of laterals, at summits in the line, and at points where the grade changes more than 10 degrees in a downward direction of flow.

Outlets. Appurtenances to deliver water from the pipe system to the field, ditch, reservoir, or surface pipe system, are known as outlets. Outlets shall have adequate capacity to deliver the required flow to:

- The hydraulic gradeline of a pipe or ditch,
- A point at least 6 inches above the field surface,
- The design surface elevation in a reservoir, or
- An individual sprinkler, lateral line, hydrant, or other device at the required operating pressure.

Outlets shall be designed to minimize erosion, physical damage, or deterioration due to exposure.

Filling. The pipe system shall have a means of controlling the filling of the pipeline to prevent entrapped air and excessive transient pressures.

Filling velocities greater than 1 foot per second in a closed to the atmosphere pipe system (i.e., all outlets closed) requires special evaluation and provisions to remove entrapped air and prevent transient pressures.

If filling at a low flow rate is not possible, the system shall be open to the atmosphere (outlets open) prior to pressurizing. The valves to the irrigation system components (gated pipe, wheel line, pivot, etc.) should be opened to release entrapped air and minimize transient pressures in the system. The system shall be designed for air removal and excessive transient pressures that may develop at higher filling rate.

Flushing. If the sediment load in the water is significant, the pipeline shall have adequate velocity to ensure sediment is moved through and flushed out of the pipeline.

If provisions are needed for flushing sediment or other foreign material, a suitable valve shall be installed at the distant end or low point of the pipeline.

Draining. Provisions shall be made for the complete removal of water from the pipeline by gravity or other means when:

- Freezing temperatures are a hazard (typically where pipeline is not buried below frost depth).
- Draining is required by the pipe manufacturer.
- Draining of the pipeline is otherwise specified.

The water drained from pipelines shall not cause water quality, soil erosion, or safety problems upon release.

Safe Discharge of Water. Provisions shall be made for water being discharged from valves, especially air valves and pressure relief valves. Such valves shall be located such that flows are directed away from system operators, livestock, electrical equipment, and other control valves or hook-ups.

Thrust Control. Abrupt changes in pipeline grade, horizontal alignment, tees, or reduction in pipe size, normally require an anchor or thrust blocks to absorb pipeline axial thrust. Thrust control is typically needed at the end of the pipeline, and at in-line control valves.

The pipe manufacturer's recommendations for thrust control shall be followed. In absence of manufacturer's data, thrust blocks shall be designed using NEH Part 636, Chapter 52.

Longitudinal Bending. For plastic pipe, the allowable longitudinal bending for the pipeline shall be based on material type and the pressure rating, and shall be in accordance with industry standards, or as described in NEH Part 636 Chapter 52.

Thermal Effects. For plastic pipe, thermal effects must be properly factored into system design. Pressure ratings for pipes are normally based on a pipe temperature of 73.4ºF. When operating temperature is higher, the effective pressure rating of the pipe shall be reduced accordingly.

Values and procedures for pressure rating reduction shall follow information described in the NEH Part 636, Chapter 52.

Physical Protection. Steel pipe installed above ground shall be galvanized or shall be protected with a suitable protective paint coating, including a primer coat and a minimum of two final coats.

Plastic pipe installed above ground shall be resistant to ultraviolet light throughout the intended life of the pipe or measures taken to protect the pipe from damage due to ultraviolet light.

All pipes shall be protected from hazards presented by traffic loads, farm operations, freezing temperatures, fire, thermal expansion and contraction. Reasonable measures shall be taken to protect the pipe from potential vandalism.

Corrosion Protection. All metal to metal fittings, such as risers, bends, tees, and reducers, should be of similar metals. If dissimilar metals are used, fittings shall be protected against galvanic corrosion (e.g., separate dissimilar metals with rubber or plastic insulator).

Bolts used to join galvanized steel shall be galvanized, plastic coated, stainless steel, or otherwise protected to prevent galvanic corrosion. Bolts used to join aluminum, other than aluminum alloy bolts, must be plastic coated or otherwise protected to prevent galvanic corrosion.

Interior protective coatings shall be provided when the pH of the water falls outside the ranges shown in the following table.

Material	Water pH
Aluminized Steel	Less than 5 or greater than 9
Galvanized Steel	Less than 6 or greater than 10
Aluminum Alloy	Less than 4 or greater than 10

Unlined steel pipelines can experience corrosion from very pure water (e.g., snow melt). If the Langelier Saturation Index (LSI) is a greater negative number than -1, corrosion protection shall be provided.

To calculate the LSI, it is necessary to know the alkalinity (mg/l as $CaCO_3$), calcium hardness (mg/l Ca+2 as $CaCO_3$), total dissolved solids (mg/l TDS), actual pH, and temperature of the water (°C). These values are used in the following equations:

$$LSI = pH - pH_s$$

$$pH_s = (9.3 + A + B) - (C + D)$$

Where:

$$A = (\text{Log10 [TDS]} - 1) / 10$$

$$B = -13.12 \times \text{Log10 } (°C + 273) + 34.55$$

$$C = \text{Log10 } [Ca^{+2} \text{ as } CaCO_3] - 0.4$$

$$D = \text{Log10 [alkalinity as } CaCO_3]$$

Galvanized steel pipe may be used when soil resistivity is greater than 4000 ohm-cm.

Hot-dipped asphalt or polymeric-coated, galvanized steel pipe shall be provided if soil resistivity along any part of the pipeline is between 3000 and 4000 ohm-cm. In addition to the above coatings, cathodic protection shall be provided for galvanized steel pipe if the soil resistivity is less than 3000 ohm-cm.

Aluminized steel pipe may be used when soil resistivity is greater than 1500 ohm-cm and soil pH is between 5 and 9.

Aluminum alloy pipe may be used when soil resistivity is greater than 500 ohm-cm and soil pH is between 4 and 10.

When cathodic protection is required, joints and connecting bands shall be electrically bridged to ensure continuous flow of current. A dielectric connection shall be placed between the pump and pipeline and between pipes with different coatings.

The total current required, kind and number of anodes needed, and life expectancy for the cathodic protection shall be designed in accordance with NRCS Design Note 12, Control of Underground Corrosion.

Resistivity Measurement Requirements for Metal Pipe. If risk of corrosion is “high” based on the Cooperative Soil Survey’s Soil Features Report, soil-resistivity measurements shall be conducted to determine corrosion protection requirements. For this purpose, field resistivity measurements shall be made or samples for laboratory analysis shall be taken at least every 400 feet along the proposed pipeline and at points where a visible change in soil characteristics occurs. If adjacent readings differ markedly, additional measurements shall be taken to locate the point of change. Resistivity determinations shall be made at two or more depths in the soil profile at each sampling station; with the lowest depth at the stratum in which the pipe will be laid. The lowest value of soil resistivity found at each sampling station shall be used as the design value for that station.

After the pipe trench is excavated, a detailed soil resistivity survey shall be made as a verification of the final required cathodic protection. At this time, resistivity measurements shall be made in each exposed soil horizon at intervals not exceeding 200 feet. The lowest value of soil resistivity found at each sampling station shall be used as the design value for that station. If design values for adjacent stations differ significantly, additional intermediate measurements shall be made.

Electric Fields. An electric field can develop where a metal pipeline is installed adjacent to an existing metal pipeline. This situation can adversely affect the new pipeline. The new pipeline shall be adequately protected from this condition.

Environmental Constraints for Aluminum Pipe. Water quality shall be considered for aluminum pipeline installations. A copper content in excess of 0.02 ppm produces nodular pitting and rapid deterioration of the pipe if water is allowed to become stagnant. When copper content exceeds this limit, the pipeline shall be designed to allow draining after each use.

Protection from corrosion shall be provided for aluminum pipe installed in contact with concrete.

Environmental Constraints for Concrete Pipe. Concrete pipelines shall not be installed on sites where sulfate-salt concentration in the soil or soil water exceeds 1.0 percent. On sites where sulfate concentration is more than 0.1 percent but not more than 1.0 percent, concrete pipe may be used only if the pipe is made with Type V or Type II cement, with tricalcium aluminate content not exceeding 5.5 percent.

CONSIDERATIONS

Safety. Pipelines may present a threat to the safety of people, during both installation and operation. Consider safety as follows:

- Address trench safety in design and during construction.
- Provide protection for people from inlets of pipelines and open stands.
- Provide protection for people from water blowing from pressure-relief, air-release, and other valves.
- Determine if underground utilities are present prior to construction.

Economic. Economics can be a major factor in pipeline design, as follows:

- Select pipe based on lifetime energy requirements, as well as initial costs of materials.
- Select pipe material based upon expected life of practice.

Water Quality and Quantity. The effects of an irrigation pipeline on water quality and quantity should be considered when designing an irrigation pipeline. Consider the effects:

- On the water budget, especially on infiltration and evaporation,
- On downstream flows or aquifers that would affect other water uses or users,
- On potential use for irrigation management,
- Of installing a pipeline in vegetation that may have been located next to the original conveyance,
- Of installing the pipeline (replacing other types of conveyance) on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water,
- On movement of dissolved substances into soil and on percolation below the root zone or to ground water recharge,
- Of controlled water delivery on temperatures of water resources that could cause undesirable effects on aquatic and wildlife communities,
- On wetlands or water-related wildlife habitats, and
- On visual quality of water resources.

Environment. Base pipe material selection on exposure considerations (such as soil resistivity, pH, sunlight, and traffic). Soil texture, resistivity, pH, moisture content, redox potential and depth are important soil properties to be aware of for pipelines and in reducing soil limitations related to corrosivity, or packing of soil material. Refer to soil survey information of the area and on-site soil investigations should be considered during planning.

The Langelier Saturation Index and related indices may be a factor in determining type of material to use for a pipeline.

Pipelines installed below the ground surface should have a soil plan describing soil reconstruction of disturbed soil during and after pipeline installation so original soil productivity is restored after pipeline installation. Appropriate vegetation should be established to stabilize disturbed areas that will not be cropped.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for irrigation pipelines that describe the requirements for applying the practice according to this standard. As a minimum, the plans and specifications shall include:

- A plan view of the layout of the pipeline.
- Profile of the irrigation pipeline.

- Pipe material and sizes.
- Pipe joint, valve, and thrust block requirements.
- Site specific construction specifications that describe in writing the installation of the irrigation pipeline. Include specifications for pressure testing of the irrigation pipeline.
- Depth of cover and backfill requirements.
- Disposal requirements for excess soil material.
- Vegetative establishment requirements.

OPERATION AND MAINTENANCE

An Operation and Maintenance (O&M) Plan shall be developed for each pipeline system installed. The plan should document needed actions to ensure practices perform adequately throughout their expected life.

O&M requirements shall be included as an identifiable part of the design. Depending on the scope of the project, this may be accomplished by brief statements in the plans and specifications, the conservation plan narrative, or as a separate O&M Plan.

Other aspects of O&M, such as draining procedures, marking crossing locations, valve operation to prevent pipe or appurtenant damage, appurtenance or pipe maintenance, and recommended operating procedures, should be described as needed within the O&M Plan.

Monitoring of any cathodic protection systems shall be performed as specified in the O&M Plan.

A filling procedure shall be developed as appropriate, which details allowable flow rates and appurtenance operation at various phases of the filling process, required to assure safe filling of the pipeline. Flow measuring appurtenances such as flow meters or weirs, or other means (e.g., number of turns of a gate valve) should be used to determine rate of flow into the pipeline system. This information shall be provided to the operator, and shall be incorporated into the Operation and Management Plan as appropriate.

REFERENCES

ASTM C118, Standard Specification for Irrigation Pipe for Irrigation or Drainage.

ASTM C505, Standard Specification for Nonreinforced Concrete Irrigation Pipe with Rubber Gasket Joints.

NRCS Engineering Design Note 12, Control of Underground Corrosion.

NRCS National Engineering Handbook, Part 636, Chapter 52, Structural Design of Flexible Conduits.

NATURAL RESOURCES CONSERVATION SERVICE

ILLINOIS CONSTRUCTION SPECIFICATION

UNDERGROUND, PLASTIC IRRIGATION PIPELINE

General

Construction operations shall be carried out in a manner and sequence that erosion and air and water pollution are minimized and held within legal limits.

The completed job shall present a workmanlike appearance and shall conform to the line, grades, and elevations shown on the drawings or as staked in the field.

All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used. Contractor shall be assured that all state laws concerning buried utilities have been met.

All trees, stumps, roots, brush, weeds, and other objectionable materials shall be removed from designated work area.

Minimum Depth of Cover

Pipe shall be installed at sufficient depth below the ground surface to provide protection from hazards imposed by traffic crossing, farming operations, freezing temperatures, or soil cracking. Unless otherwise specified, plastic pipe shall be buried at least 24 inches for ordinary field traffic. When crossing under a road, the pipeline shall be buried deeper or protected from collapsing by placing in a steel or concrete conduit.

Other means of protection must be provided if the depth required for protection is impractical because of shallow soils over rock or for other reasons. Abrupt changes in grade must be avoided to prevent damage to pipe.

Pipelines shall be buried below frost line or otherwise be protected from freezing.

At low places on the ground surface, extra fill may be placed over the pipeline to provide the minimum depth of cover. The top width of the fill shall then be no less than 10 feet and the side slopes no steeper than 6:1.

Trench Construction

The trench at any point below the top of the pipe shall be only wide enough to permit the pipe to be easily placed and joined and to allow the initial backfill material to be uniformly placed under the haunches and along the sides of the pipe. The maximum trench width shall be 36 inches. If the trench is precision excavated and has a semicircular bottom that closely fits the pipe, the width shall not exceed the outside diameter of the pipe by more than 10%.

The trench bottom shall be uniform so that the pipe lies on the bottom without bridging. Clods, rocks and uneven spots that can damage the pipe or cause non-uniform support shall be removed.

If rocks, boulders, or any other material that can damage the pipe are encountered, the trench bottom shall be undercut a minimum of 4 inches below final grade and filled with bedding material consisting of sand or compacted fine-grained soils.

Pipelines having a diameter of 1/2 to 2 1/2 inches that are to be placed in areas not subject to vehicular loads and in soils that do not crack appreciably when dry may be placed by using "plow in" equipment instead of conventional trenching.

Provisions shall be made to ensure safe working conditions where unstable soil, trench depth, or other conditions can be hazardous to personnel working in the trench.

Placement

Care shall be taken to prevent permanent distortion and damage when handling the pipe during unusually warm or cold weather. The pipe shall be allowed to come within a few degrees of the temperature it will have after it is completely covered before placing the backfill, other than that needed for shading, or before connecting the pipe to other facilities. The pipe shall be uniformly and continuously supported over its entire length on firm stable material. Blocking or mounding shall not be used to bring the pipe to final grade.

For pipe with bell joints, bell holes shall be excavated in the bedding material, as needed, to allow for unobstructed assembly of the joint and to permit the body of the pipe to be in contact with bedding material throughout its length.

Materials

The compound used in manufacturing the pipe shall meet the requirements of one of the following materials:

1. Polyvinyl chloride (PVC) as specified in ASTM-D1784.

Material	Classification
Type I, Grade 1	12454-B
Type I, Grade 2	12454-C
Type II, Grade 1	14333-D

2. Acrylonitrile-butadiene-styrene (ABS) as specified in ASTM-D-1788.

Material	Classification
Type I, Grade 2	5-2-2
Type 1, Grade 3	3-5-5
Type II Grade 1	4-4-5

3. Polyethylene (PE) as specified in ASTM-D-1248.

Material	Classification
Grade P14, Class C	IC-P14
Grade P23, Class C	IIC-P23
Grade P33, Class C	IIIC-P33
Grade P34, Class C	IVC-P34

The pipe shall be homogeneous throughout and free from visible cracks, holes, foreign matter, or other defects. The pipe shall be as uniform in color, opacity, density, and other physical properties as is commercially practicable.

All pipe installed under this standard shall be pressure rated for water.

Iron pipe size (IPS) (outside diameter same as that for iron pipe sizes) and I.D. controlled PE pipe manufactured, tested, and marked to meet one of the following ASTM specifications shall be acceptable under this standard.

ASTM Standard Specification for Pipe	
D-1785	PVC, Schedules 40, 80 and 120
D-2241	PVC, SDR-PR
D-2672	Bell-End PVC
D-2740	PVC Plastic Tubing
D-1527	ABS, Schedules 40 and 80
D-2282	ABS, SDR-PR
D-2104	PE, Schedule 40
D-2239	PE, SDR-PR
D-2447	PE, Schedules 40 and 80, O.D.
D-2737	PE Plastic Tubing
D-3035	PE, SDR-PR, O.D.
F-771	PE Irrigation Pipeline Systems

Plastic irrigation pipe (PIP) shall meet the requirements of ASTM-D-2241 or ASTM-D-2282.

Joints and Connections

All joints and connections shall be designed and constructed to withstand the design maximum working pressure for the pipeline without leakage and to leave the inside of the line free of any obstruction that may tend to reduce its capacity below design requirements.

All fittings, such as couplings, reducers, bends, tees, and crosses, shall be installed according to recommendations of the pipe manufacturer.

All fittings and couplers shall meet or exceed the same strength requirements as those of the pipe and shall be made of material recommended for use with the pipe. Listed below are the ASTM standard specifications for fittings covered by this standard.

ASTM Standard Specification for Fittings	
D-2466	Socket-type PVC, Schedule 40
D-2467	Socket-type PVC, Schedule 80
D-2468	Socket-type ABS, Schedule 40
D-2609	PE Plastic Insert Fittings
D-2683	Socket-type PE, SDR 11.0
D-3139	Flexible Elastomeric Seals
D-3261	PE Butt Heat Fusion Fittings

Plastic irrigation pipe (PIP) shall have belled ends or separate couplers and fittings that are suitable for joining the pipe and appurtenances by solvent cement, rubber gaskets, or other methods recommended by the pipe manufacturer. Such fittings and joints shall be capable of withstanding a working pressure equal to or greater than that for the pipe.

Solvent for solvent cement joints shall conform to ASTM Specification D-2564 for PVC pipe and fittings and to D-2235 for ABS pipe and fittings. Solvent cement joints shall be used and constructed according to recommendations of the pipe manufacturer.

Rubber gasket joints shall conform to ASTM Specification D-3139.

Thrust Blocks

Thrust blocks must be formed against a solid hand-excavated trench wall undamaged by mechanical equipment. They shall be constructed of concrete, and the space between the pipe and trench wall shall be filled to the height of the outside diameter of the pipe or as specified on the construction plans.

Testing

The pipeline shall be tested for pressure strength, leakage, and proper functioning. Tests may be performed before backfilling or anytime after the pipeline is ready for service.

Tests for pressure strength and leaks shall be accomplished by inspecting the pipeline and appurtenances while the maximum working pressure is maintained and all joints and connections are uncovered, or by observing normal operation of the pipeline after it is put into service. Partial backfills needed to hold the pipe in place during testing shall be placed as specified in "Initial Backfill." Any leaks shall be repaired and the system retested.

The pipeline shall be tested to ensure that it functions properly at design capacity. At or below design capacity there shall be no objectionable flow conditions. Objectionable flow conditions shall include water hammer, continuing unsteady delivery of water, damage to the pipeline, or detrimental discharge from control valves.

Initial Backfill

Hand, mechanical, or water packing methods may be used.

The initial backfill material shall be soil or sand that is free from rocks or stones larger than 1 inch in diameter. At the time of placement, the moisture content of the material shall be such that the required degree of compaction can be obtained with the backfill method to be used. The initial backfill material shall be placed so that the pipe will not be displaced, excessively deformed, or damaged.

If backfilling is done by hand or mechanical means, the initial fill shall be compacted firmly around and above the pipe as required to provide adequate lateral support to the pipe.

If the water packing method is used, the pipeline first shall be filled with water. The initial backfill before wetting shall be of sufficient depth to ensure complete coverage of the pipe after consolidation. Water packing is accomplished by adding enough water to diked reaches of the trench to thoroughly saturate the initial backfill without excessive pooling. After the backfill is saturated, the pipeline shall remain full until after the final backfill is made. The wetted fill shall be allowed to dry until firm before beginning the final backfill.

Final Backfill

Final backfill material shall be free of large rocks, frozen clods, and other debris greater than 3 inches in diameter. The material shall be placed and spread in approximately uniform layers so that there will be no unfilled spaces in the backfill and the backfill will be level with the natural ground or at the design grade required to provide the minimum depth of cover after settlement. Rolling equipment shall not be used to consolidate the final backfill until the specified minimum depth of cover has been placed.

Mound soil over pipe to allow for settlement. Provisions shall be provided for stabilizing disturbed areas and controlling erosion, as necessary.

All special backfilling requirements of the pipe manufacturer shall be met.

Vegetation

Topsoil shall be added, if needed to establish vegetation. Refer to Conservation Practice Standard (342), Critical Area Treatment, for seeding and mulching recommendations or equivalent.

NATURAL RESOURCES CONSERVATION SERVICE

ILLINOIS OPERATION AND MAINTENANCE

UNDERGROUND, PLASTIC IRRIGATION PIPELINE

Follow the operation and maintenance plan below to keep your pipeline system functioning as intended:

- Pipeline shall be operated at a maximum of ________ gallons per minute. Monitor delivery rate using flow meter on application device or as described below.
- The maximum operating pressure for the pipeline system is _________ psi. Maintain all pressure relief valves installed as a part of the system at the design pressure setting.

  System relief valve: Located at pump, Pressure setting __________ psi

  Supplementary relief valve: Location _______________, Pressure setting __________psi

  Supplementary relief valve: Location _______________, Pressure setting __________psi

  Supplementary relief valve: Location _______________, Pressure setting __________psi
- Frequent operation of the pressure relief valve indicates potential system problems. If the relief valves show sign of frequent use, inspect mechanical components of pipeline, clean out the pipeline, and/or reduce the operating flow delivery rate.
- Perform routine maintenance of all mechanical components in accordance with manufacturer's recommendations. Inspect and test valves, pressure regulators, pumps, agitators, switches, and other appurtenances.
- Inspect system after significant storm events and at least annually to identify repair and maintenance needs. Check for leaks and improper operation. Check for debris, minerals, algae, and other materials that may restrict system flow. Repair any damage as soon as possible after it is noted.
- Slowly open and close valves to prevent excessive water hammer.
- When quick connects are used, ensure proper operation and adequate designed delivery rate.
- Drain and/or provide for cold weather operation of the system.
- Protect pipeline from damage by farm equipment, vehicles, and livestock. Mark pipeline locations in areas where potential damage could occur.
- Repair any eroded areas that are hazardous to the pipeline. Reestablish vegetative cover immediately where erosion has occurred.
- Record on a map the location of the pipeline and approximate depth.

Additional Details:

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