

**NATURAL RESOURCES CONSERVATION SERVICE**  
**CONSERVATION PRACTICE STANDARD**  
**IRRIGATION PIPELINE**

(Feet)

**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**

**General Criteria Applicable to All Purposes**

Use of this standard will comply with all applicable federal, state, and local laws and regulations.

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

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

Pipelines will 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.

**Capacity.** Capacity will 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 will 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 the 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 will be computed using one of the following equations: Manning's, Hazen-Williams, or Darcy-Weisbach. Equation selection will be based on the given flow conditions and the 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 will be evaluated as appropriate. For closed, pressurized systems, the hydraulic grade line for all pipelines will be maintained above the top of

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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, will 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 will 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 will 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 will 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 will 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 will 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 will 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 will be designed using the following criteria:

Non-reinforced Concrete Pipe with Mortar Joints. The maximum allowable pressure for pipe with mortar joints will not exceed one-fourth of the certified hydrostatic test pressure as determined by the test procedure described in ASTM C118. Nor will 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 will not exceed one-third the certified hydrostatic test pressure as determined by the test procedure described in ASTM C505. Nor will 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 will be 15 feet above the centerline of pipe. Cast-in-place concrete pipe will be used only in stable soils that are 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 will be not

exceed the rated hydrostatic pressure for the specified pipe according to appropriate ASTM or AWWA standards.

**Reinforced Plastic Mortar Pipe.** The pipeline will 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 will include free board. The minimum acceptable pipe pressure rating will be 50 psi.

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

**Joints and Connections.** All connections will 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 will be obtained from the manufacturer for the joint type and pipe material used.

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

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

For suspended pipelines, joints will 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 will be of similar materials whenever possible. If dissimilar materials are used, the joints or connections will be protected against galvanic corrosion.

**Depth of Cover.** Buried pipe will 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 will have sufficient strength to withstand all external loads on the pipe for the given installation conditions. Appropriate live loads will be used for the anticipated traffic conditions.

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

**Pressure Reduction.** Pressure reduction will 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 will be of adequate size for the type of entrance condition to ensure design flow capacity without excessive head losses.

Provision will 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 will 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 will 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) will 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 back flow may contaminate the source water supply or groundwater.

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

**Stands Open to the Atmosphere.** Stands will 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 will 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 will 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 will 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 will 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 will 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 will 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, will have a minimum inside dimension of 30 inches and will be constructed so the bottom is at least 24 inches below the invert of the outlet pipeline. The downward velocity of flow of the water in a sand trap will not exceed 0.25 feet per second. Suitable provisions will be made for cleaning sand traps.

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

The size of float valve stands will 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 will 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" will apply except as modified below.

The inside diameter of the closed stand will 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 will 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 will 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) will 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 will 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 will 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 will 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 will be installed downstream of pressure reducing valves.

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

PR valves will 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 will have sufficient flow capacity to reduce the excessive pressures in the pipeline. In lieu of a detailed surge/pressure analysis, the minimum size of PR valve will be  $\frac{1}{4}$  inch nominal valve size per inch of the nominal pipeline diameter.

The pressure at which the valves start to open will be marked on each PR valve. Adjustable PR valves will 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 will 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 will 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 will also be used to release air from the pipeline on filling prior to the pipe being pressurized. They will 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 will 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 will be located at changes of grade in downward direction of flow in excess of 10 degrees to ensure adequate air release during filling. On long pipelines, additional AVR or COMB valves may be required to adequately vent the pipe during filling.

For air release, the AVR or COMB valve will 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 will be limited to 2 psi.

For vacuum relief, the AVR, VR, or COMB valves will 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 will 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 will be used as needed to permit air to escape while the line is at working pressure. Small orifices of these valve types will be sized according to the design working pressure and venting requirements recommended by the valve manufacturer.

The location of the CAV or COMB valves will 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 will be given to installing vent chambers for CAV or COMB valves. The vent chamber will 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 will be used:

For Plastic  $\leq$  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 will provide dimensional data or a capacity table based on performance tests, which will be the basis for selection and acceptance of these valves.

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

- Vents will 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 will be constructed to intercept and/or capture air within the pipeline. The chamber will 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 will extend vertically at least one pipeline diameter up from the centerline of the pipeline. Above this elevation, the vent chamber may be reduced to minimum diameter of 2 inches.
- When an AVR or COMB valve is used instead of a vent, the above requirements will apply except that the reduced section will 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 will apply to the reduced section.
- Vent chambers will 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 will 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 will 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 will be designed to minimize erosion, physical damage, or deterioration due to exposure.

**Filling.** The pipe system will 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 will be open to the atmosphere (outlets open) prior to pressurizing. The valves to the irrigation system components (gated pipe, wheel line, pivot, etc.) will be opened to release entrapped air and minimize transient pressures in the system. The system will 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 will have adequate velocity to ensure that sediment is moved through and flushed out of the pipeline.

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

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

- Freezing temperatures are a hazard.
- Draining is required by the pipe manufacturer.
- Draining of the pipeline is otherwise specified.

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

**Safe Discharge of Water.** Provisions will be made for water being discharged from valves, especially air valves and pressure relief valves. Such valves will 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 will be followed. In absence of manufacturer's data, thrust blocks will be designed using NEH Part 636, Chapter 52.

**Longitudinal Bending.** For plastic pipe, the allowable longitudinal bending for the pipeline will be based on material type and the pressure rating, and will 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 73.4°F. When operating temperature is higher the effective pressure rating of the pipe will be reduced accordingly.

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

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

Plastic pipe installed above ground will 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 will be protected from hazards presented by traffic loads, farm operations, freezing temperatures, fire, thermal expansion, and contraction. Reasonable measures will 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, the fittings will be protected against galvanic corrosion (e.g., separate dissimilar metals with rubber or plastic insulator).

Bolts used to join galvanized steel will 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 will 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 with very pure water (e.g., snow melt). If the Langelier Saturation Index (LSI) is a greater negative number than -1, corrosion protection will be provided.

To calculate the LSI, it is necessary to know the alkalinity (mg/l as CaCO<sub>3</sub>), the calcium hardness (mg/l Ca+2 as CaCO<sub>3</sub>), the total dissolved solids (mg/l TDS), the actual pH, and the 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:

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

$$B = -13.12 \times \text{Log}_{10} (^\circ\text{C} + 273) + 34.55$$

$$C = \text{Log}_{10} [\text{Ca}^{+2} \text{ as CaCO}_3] - 0.4$$

$$D = \text{Log}_{10} [\text{alkalinity as CaCO}_3]$$

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

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

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

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

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

The total current required, kind, and number of anodes needed, and life expectancy for the cathodic protection will 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 will be conducted to determine corrosion protection requirements. For this purpose, field resistivity measurements will be made or samples for laboratory analysis will 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 will be taken to locate the point of change. Resistivity determinations will 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 will be used as the design value for that station.

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

**Environmental Constraints for Aluminum Pipe.**

Water quality will 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 the copper content exceeds this limit, the pipeline will be designed to allow draining after each use.

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

**Environmental Constraints for Concrete Pipe.**

Concrete pipelines will not be installed on sites where the sulfate-salt concentration in the soil or soil water exceeds 1.0 percent. On sites where the 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 the existence or non-existence of underground utilities 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 the movement of dissolved substances into the soil and on percolation below the root zone or to ground water recharge,
- Of controlled water delivery on the temperatures of water resources that could cause undesirable effects on aquatic and wildlife communities,
- On wetlands or water-related wildlife habitats, and
- On the 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 will include:

- A plan view of the layout of the pipeline.
- Profile of the irrigation pipeline.
- Pipe material and sizes.
- Pipe joint requirements.
- Site specific construction specifications that describe in writing the installation of the irrigation pipeline. Include the specification 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 will be developed for each pipeline system installed. The plan will document needed actions to ensure that practices perform adequately throughout their expected life.

O&M requirements will 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, will be described as needed within the O&M Plan.

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

A filling procedure which details allowable flow rates and appurtenance operation at the various phases of the filling process will be developed as 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) will be used to determine the rate of flow into the pipeline system. This information will be provided to the operator, and will 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.