NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD
ARIZONA

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

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

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

Reduce energy use.

Develop renewable energy systems (i.e., in-pipe hydropower).

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to water conveyance and distribution pipelines installed above or below ground *restricted to pipelines less than 36 inch in diameter.*

This standard does not apply to multiple outlet irrigation system components (e.g., surface gated pipes, sprinkler lines, or micro irrigation tubing) *short pipes used in structures such as siphons, outlets from canals, outlets from water harvesting catchments and culverts under roadways.*

CRITERIA

Conservation Practices shall be designed on an individual basis to meet site conditions and functional requirements. They shall be part of an approved and overall engineering plan for irrigation, drainage, wildlife, recreation, channel improvement, or similar purposes.

The owner is responsible for securing necessary permits and water rights, complying with all laws and regulations, and meeting legal requirements applicable to the installation, operation, and maintenance of this practice and associated structures.

General Criteria Applicable to All Purposes

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 material type being selected. *Bedding and backfill requirements shall be site specific for the selected material type.*

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

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 *(peak consumptive use)* 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 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 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 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:

<u>Smooth Wall Plastic Pipe.</u> 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.

<u>Corrugated or Profile Wall Plastic Pipe.</u> 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.

<u>Smooth Wall Steel Pipe.</u> 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. *Minimum wall thickness shall meet the following criteria:*

Diameter (inches)	Wall Thickness (gage)
4 through 12	14
14 through 18	12
20 through 24	10
26 through 36	3/16

<u>Corrugated Metal Pipe.</u> 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.

<u>Smooth Wall Aluminum Pipe.</u> 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:

<u>Non-reinforced Concrete Pipe with Mortar Joints.</u> 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

<u>Non-reinforced Concrete Pipe with Rubber Gasket Joints.</u> 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

<u>Cast-in-Place Concrete Pipe.</u> 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 that are capable of being used as the outside form for approximately the bottom half of the conduit.

<u>Reinforced Concrete Pipe with Gasket Joints.</u> The maximum allowable pressure for reinforced concrete pipe with rubber gasket joints shall be 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, the 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. *For protection from freezing, pipe shall be installed below the applicable frost depth. The minimum depth of cover shall be:*

Pipeline Diameter (inches)	*Depth of Cover (inches)*
½ through 2-½	*18*
3 through 5	*24*
6 and greater	*30*

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 the 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. *Extra fill may be placed over the pipe (mounding) to provide the minimum depth of cover. In such cases the top width of the fill shall be no less than 6 feet and the side slopes no steeper than 6:1(horizontal to vertical). The fill material shall be placed and compacted prior to trench excavation.*

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 back flow 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 flow of the water 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 the 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 insure 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 though 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 *or other components* are closed. *Pressure-relief valves shall be installed on the discharge side of the check valve where a reversal of flow may occur and at the end of the pipeline if needed to relieve surge at the end of the line*. 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 give 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 *below* the pressure rating or maximum allowable pressure of the pipe. The valves shall 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 shall be ¼ 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 (*AV-VR*), 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)*, by allowing air to re-enter the pipeline* due to sudden gate or valve closure, pump shutoff, or drainage of the pipeline.

AV-VR (air and vacuum or air-vent and vacuum relief) 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. *AV-VR's are* *not continuous acting as they do not allow further air release once the valve closes.*

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

If needed to provide positive means for air escape during filling and air entry while emptying, an *AV-VR*, 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 *AV-VR* 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. On long pipelines, additional *AV-VR* or COMB valves may be required to adequately vent the pipe during filling.

For air release, the *AV-VR* 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 *AV-VR*, 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 the 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 minimum diameter of 2 inches.

When an *AV-VR* 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 *AV-VR* 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 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 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.
- 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 *or the following formula may be used:*

$$A = \frac{98HD^2}{B} \text{ x } \sin\left(\frac{\alpha}{2}\right)$$

Where:

A = Area of thrust block required (sq.ft.)
H = Maximum working pressure (ft)
D = Inside diameter of pipe (ft)
B = Allowable soil bearing pressure (lb/ft2)
a = Deflection angle of pipe bend

Area of thrust blocks for valves, dead ends and tees shall be 0.65 times the area of block required for a 90° deflection angle of pipe bend.

If adequate soil tests are not available, the allowable soil bearing pressure (lb/ft2) may be estimated as shown below:

Natural Soil Material	*Depth of Cover to center of thrust block*		
	2 to 3ft.	*3 to 4ft.*	*4 to 5ft.*
Sound Bedrock	*10,000*	*10,000*	*10,000*
Dense Sand, Gravel (Φ=40°)	*1,800*	*2,400*	*3,000*
Dense/Course Sand (Φ=35°)	*1,200*	*1,650*	*2,100*
Silt and Clay mixture (Φ=25°)	*700*	*950*	*1,200*
Soft Clay and Organic(Φ=25°)	*300*	*400*	*500*

Longitudinal Bending. For plastic pipe, the allowable longitudinal bending for the pipeline shall be based on material type, *diameter* and the pressure rating, and shall be in accordance with industry standards*, manufacturer's recommendation* 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*, as shown below:*

Temperature (°F)	*PVC*	*PE*
73.4	*1.00*	*1.00*
80	*0.88*	*0.92*
90	*0.75*	*0.81*
100	*0.62*	*0.70*
110	*0.50*	*-*
120	*0.40*	*-*
130	*0.30*	*-*
140	*0.22*	*-*

Note: To obtain the pipe's reduced pressure rating because of a water temperature greater than 73.4ºF, multiply the normal pressure rating by the appropriate factor from table.

Values and procedures for pressure rating reduction shall follow information described in the NEH Part 636, Chapter 52 *or as specified by the manufacturer.*

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. *The outlet, inlet or other portions (i.e., risers, vents) of PVC materials installed in above ground applications and subjected to long or short term exposure to ultraviolet (UV) radiation from sunlight shall be protected to prevent UV degradation.*

Regardless of the method selected, manufacturer documentation or protection measures taken shall be clearly documented (i.e., manufacturer warranty/guarantee, construction notes/details, As-Built verification/certification) in the project file. Ultraviolet (UV) protection shall be by one or more of the following methods:

1. *Pipe specially formulated with an UV stabilizer that will protect against solar degradation for a minimum of 10 years.*
2. *Apply Alkyd Enamel Paint, containing minimum 50-percent solids by volume, on approved pipe surfaces. The paint should provide 4-5 years protection against UV.*
3. *Apply a two-component, high gloss industrial type Acrylic Polyurethane Coating having a minimum of 50% solids by weight. This coating should provide greater than a 5-year protection.*
4. *Reflective swimming pool paint or water based latex paint will be used on approved pipe surface.*

Surface preparation and application shall be per manufacturer recommendations.

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, the 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 CaCO3), the calcium hardness (mg/l Ca+2 as CaCO3), 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:

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

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

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

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

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

Hot-dipped asphalt or polymeric-coated, galvanized steel pipe shall 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 shall 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 shall be electrically bridged to ensure continuous flow of current. A dielectric connection shall 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 shall be designed in accordance with NRCS Design Note 12, Control of Underground Corrosion.

The following types of coatings shall be applied to pipes, threaded connections, fittings or other materials where water quality or corrosion is known:

- *Coal Tar paint meeting the requirements of AWWA C203, "Coal Tar Protective Coatings and Linings for Steel Water Pipeline – Enamel and Tape – Hot Applied" (Kippers-Bitumastic No. 300-M is an approved off the shelf product);*
- *Epoxy Paint meeting the requirements of AWWA C210, "Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines" or AWWA C213, "Fusion-Bonded Epoxy Coating for Interior and Exterior of Steel Water Pipelines". The coating shall have a*

minimum thickness of 10 mils (minimum 2 coats);

- *Locally available product (Rust-oleum, High Performance, W9200 Potable Water Coating or equivalent) suitable for use in potable water.*

Surface preparation and application shall be per manufacturer recommendations.

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 the 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 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.

Testing. *The pipeline shall be tested for pressure strength, leakage and proper functioning while the maximum working pressure is maintained. Underground pipelines shall be tested prior to placement of the final backfill, but partial backfill (shading) is necessary to stabilize the pipe, to protect the material from UV degradation (where applicable), and to minimize expansion and contraction variations due to temperature changes. Aboveground steel pipelines may be tested at any time after they are ready for operation.*

The pipeline shall be filled with water, taking care to bleed air and prevent water hammer. When the line is full, all valves shall be closed and the line shall be brought up to full design working pressure. All joints shall then be carefully inspected for leakage and any visible leaks shall be repaired.

Testing shall demonstrate that the pipeline will function properly at design capacity, with no objectionable flow conditions (i.e. water hammer, surges, unsteady delivery of water, and damage to the pipeline, or detrimental discharge from control valves).

Additional Criteria Applicable to Reduce Energy Use

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

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

Additional Criteria Applicable to Develop Renewable Energy Systems

Renewable energy systems shall meet applicable design criteria in NRCS and/or industry standards, and shall be in accordance with manufacturer's recommendations. Hydropower systems shall be designed, operated, and maintained in accordance with the Microhydropower Handbook, Sections 4 and 5, as appropriate.

Investigations, Surveys and Design Criteria*.* *Documentation requirements will be as outlined below, in additional to the documentation requirements of the practice components used in the system.*

Make a preliminary site assessment, investigation or reconnaissance to determine the complexity of the problem and/or site (see NEH Part 652 – Irrigation Guide, Chapter 6, Irrigation System Design and Chapter 7, Farm Distribution Components) and shall include the following:

1. *Water source and pressure (if applicable), quality (debris and/or sediment load) and quantity.*
2. *Soil or geological investigation to determine soil conditions, properties (physical and chemical), depths and topography along proposed alignment to determine trench and bedding requirements, as needed. Documentation shall include the following, at a minimum:*
   a. *Classification by the Unified Soil Classification System (SM, CL, etc.) and texture (silty sand, lean clay, etc.);*
   b. *Locate borrow materials and/or disposal areas, if necessary.*
   c. *Corrosion potential or conditions (metal pipe), resistivity readings or published data, if applicable.*
3. *Planned location, length, distribution, and type and size of outlets or turnouts.*
4. *Verify appropriate state or local laws for permitting and approval requirements and notify landowner of his/her responsibilities.*
5. *Verification or certification of used materials (if any).*

To adequately plan and layout this practice, a detailed topographic survey is required, that adequately details:

1. *Site topography, as needed to show the physical features of the site, including existing features/practices, ground elevations, location of any utilities or markers, etc.*
2. *Profile along the proposed centerline, including all control points, such as structure elevations, summits and low points, and critical field elevations which impact the function and operation of the system, road crossings, drain points, etc.*
3. *Topographic map, as needed, to determine pipeline location, outlet/turnout locations, irrigation methods, etc.*
4. *All pertinent water surface elevations, including the water supply ditch/reservoir/ well, check structures, high water marks, etc.*
5. *If applicable, a permanent benchmark(s) shall be set and described. Preferably, the elevations and coordinates should be based on a local (assumed) or coordinate system (State or grid) and clearly stated on the plan. Datum may be in the form of Northing and Easting coordinates or Longitude and Latitude.*

The design of a practice is the application of Field Office Technical Guide practice standards, practical experience and judgment in the development of a solution to the problem or the objective. All computations and decisions made during the design of a practice are to be checked by another qualified individual and appropriate notations made. Design computations, calculations or analysis shall meet the following criteria:

1. *Determine design capacity or flow based on peak consumptive crop use, irrigation application efficiency or method requirements, irrigation water quantity or availability.*
2. *Hydraulic data computations/analysis to determine system performance (friction/head loss; maximum, minimum and actual operating pressures; hydraulic and static grade lines; flow ranges; hydraulic transients, etc.).*
3. *Record all pipe sizing (material, number, diameter, pressure rating or wall thickness, location and quantities, depth of cover, markings) calculations with applicable references.*
4. *Irrigation appurtenance designs (location, size, pressure settings, capacity, head loss, published performance data, etc.)*
5. *Water measurement and/or structural design requirements, if any.*
6. *Prepare material and cost estimates, including pipe quantities, vegetative components, etc.*
7. *Subsidiary and applicable components shall be designed in accordance with applicable conservation practice standards (i.e., structures shall meet the requirements of*

Conservation Practice 587, Structure for Water Control, etc.).

***Installation and Basis of Acceptance**. For construction that does not meet State, OSHA, or Tribal criteria or requirements where deficient construction materials were used, NRCS may consider a waiver request for approval of construction after it has received a signed and sealed construction and/or material exemption from a licensed engineer. Required exemption shall be for installation of materials that do not meet minimum quality criteria as found in applicable Standards, Specifications, ASTM's, AWWA standards, etc.*

Contractors performing work under this practice shall abide by all Federal, State or Tribal laws or criteria, and must be licensed by the state board of technical registers where the work is being implemented.

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.

Consider hydropower applications as alternatives to use of pressure reduction valves or reduced pipe diameter to induce friction loss.

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.

***Flow Measurement**. A water measurement device or structure (flow meter, ramp flume, weir, etc.) may be installed to manage water applications and for on-going evaluation of system performance. Manufacturer's recommendations or sound engineering guidance must be followed regarding size, placement, orientation, etc.*

PLANS AND SPECIFICATIONS

Prepare plans and specifications for irrigation pipelines that describe the requirements for applying the practice *will be guided by the National Engineering Handbook, Part 650, shall be in accordance with the National Engineering Manual, Parts 541 and 542, and shall be in keeping with and* according to this standard. As a minimum the plans and specifications shall *be prepared for each specific site and* include *the requirements for applying the practice to achieve its intended purpose*. *As a minimum this shall include the following:*

- *Project location map, including section, township and range, North arrow, cooperator/owner acknowledgement and certification signature blocks, engineering job class (cover sheet);*
- *References that the owner/cooperator are responsible for all permits, rights-of-way, easements and the contact, coordination and location determination of any existing utilities or clearances (buried utility disclaimer);*
- *If applicable, a map showing the location of the practice(s) or system in reference to a known or established benchmark or reference point with the location, description and elevation clearly shown. Topographical features and/or controls shall be shown, showing tie in with existing or other planned practices;*
- *Field surveys and notes, soil investigations or geologic soil boring locations and soil classifications, earthwork or material estimates/quantities (backfill material);*
- A plan *or system over*view of the layout *(water source, alignment, stationing, topographical features, reference to existing or proposed features or facilities, appurtenances, etc.)* of the *proposed* pipeline, *including* pipe material, *rating (pressure class),* sizes *(diameters), and flow rates; all system components, construction and installation criteria, including State and Federal [OSHA] safety requirements [safety features for trenches, if applicable];*
- *Plan and* profile *views* of the *proposed* irrigation pipeline *system and components (i.e., original ground surface; outlet, turnouts, and appurtenances; pipeline invert elevations and grades [slope], hydraulic grade lines; maximum static pressure/head; changes in pipe size and ratings; etc.);*
- *Location, size, type and pressure class for all system fittings and appurtenances (drains, vents, valves, outlets, pressure relief, thrust blocks), including* pipe joint requirements, depth of cover *for each pipe diameter* and *pipe trench/*backfill requirements*, as required for proper system functionality;*
- *Structural details, as needed to show construction details*
- Site specific construction *notes, details or* specifications that describe, in writing, the installation of the irrigation pipeline *and components*. Include the specification for pressure testing of the irrigation pipeline.
- *Use Arizona Construction and Material Specifications for each item of work and material, as applicable and available. Additional specifications may need to be written to provide full material and installation instructions. Fill in blanks and add or delete items from the specifications to make them fit the job as needed.*
- Disposal requirements for excess soil material, *if applicable; and*
- Vegetative establishment requirements, *if any.*

All designs completed by non-NRCS personal shall meet minimum State licensing board requirements and NRCS requirements and criteria as outlined in the General Manual, the National Engineering Manual (including Arizona Supplements), and the National Engineering Handbook.

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 that practices perform adequately throughout their expected life. *These actions include normal repetitive activities in the application and use of the practice (operation), and the repair and upkeep of the practice (maintenance). The pipeline will be inspected periodically, protected and restored as needed.*

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, which details allowable flow rates and appurtenance operation at the 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 the 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.

The Operation and Management Plan *shall also address the following:*

- *Prevent surface ponding by grading to remove depressions.*
- *Limit livestock usage to periods that permit use without damage.*
- *If fences are installed, they shall be maintained to provide warning and/or prevent unauthorized human or livestock entry.*
- *Check to make sure all valves and air vents are set at the proper operating condition so they may provide protection to the pipeline.*
- *Maintain the design depth of cover over the pipeline and avoid any sub-soiling operation that may disturb the pipeline.*
- *Limit traffic over the pipeline to designated sections that were designed for traffic loads and avoid travel over pipelines by tillage equipment when the soil is saturated.*
- *Remove all foreign debris that hinders system operation.*
- *Drain the system and components in areas that are subject to freezing. If parts of the system cannot be drained, an anti-freeze solution shall be added.*
- *Allow the pipe to fill gradually when being put into use after shut down or draining.*
- *Periodically check and repair all valves, gates and regulators to the system requirements following the manufacturer's recommendations.*
- *Checking coatings on fiberglass and plastic tanks and re-coating as needed to maintain effective ultraviolet resistance;*
- *Maintaining appurtenance features (valves, piping, floats, drains, fences, etc.) in functional and protected conditions;*
- *Eradicate or otherwise remove all rodents or burrowing animals that have or may potentially damage any part of the delivery or application facilities. Immediately repair any damage caused by their activity;*
- *Immediately repair any damage resulting from vandalism, vehicles, livestock or wildlife;*

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.

McKinney, J.D., et al. Microhydropower Handbook, IDO-10107, Volumes 1 & 2. U.S. Department of Energy, Idaho Operations Office.

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

USDA-NRCS, Engineering Design Note 12, Control of Underground Corrosion.