NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

IRRIGATION WATER CONVEYANCE STEEL PIPELINE

(ft.)
CODE 430FF

DEFINITION

A pipeline and appurtenances installed in an irrigation system.

PURPOSE

To prevent erosion of loss of water quality or damage to land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to the design and installation of buried and permanently installed above ground steel irrigation pipelines. Pipelines greater than 6-inch diameter installed above ground shall be placed on supports. This standard is restricted to pipelines not greater than 48 inches in diameter and does not apply to short pipes used in structures such as siphons, outlets from canals, and culverts under roadways.

The pipeline shall be planned and located to serve as an integral part of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms. All areas served by the pipeline shall be suitable for use as irrigated land.

Water supplies and irrigation deliveries to the area shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

CRITERIA

Working pressure. The pipeline shall be designed to meet all service requirements without the use of a working pressure that will produce tensile stresses in the pipe greater than a design stress equal to 50 percent of yield-point stress. Design stresses for commonly used steel and steel pipe classes are:

Specification and grade of steel	Design stress 50 percent yield point *lb/in.^{2}*
ASTM-A-283	
Grade B	13,500
Grade C	15,000
Grade D	16,500
ASTM-A-570	
Grade A	12,500
Grade B	15,000
Grade C	16,500
Grade D	20,000
Grade E	21,000
AWWA-C-200	
Furnace butt weld	12,500
Grade A	15,000
Grade B	17,500
Grade X42	21,000

In computing tensile stresses in steel pipe, the following items shall be considered:

1. The pressure to be delivered at the end of the pipeline.
2. The friction head loss,
3. The elevation differential between the outlet and the inlet of the pipe, and
4. Any pressure due to water hammer or surge that may be created by the closure of a valve in the pipeline.

Flow capacity. The design capacity shall be based on the greater of:

1. Capacity to deliver sufficient water to meet the weighted peak consumptive use rate of the crops to be grown, or
2. Capacity sufficient to provide an adequate irrigation stream for the methods of irrigation to be used.

Minimum wall thickness. Minimum pipe wall thickness shall be as follows:

Nominal diameter *in.*	Wall thickness
4 - 18	12 gage less 12.5 %
20 - 24	10 gage less 12.5 %
26 - 36	3/16 in. less 12.5 %
38 - 48	1/4 in. less 12.5 %

Friction loss. For design purposes, the pipeline friction loss shall be based on that computed with Manning's Formula with "n" equal to no less than 0.012 for unlined and no less than 0.010 for lined pipe.

Check, pressure-relief, vacuum-release, and air-release valves. If detrimental backflow may occur, a check valve shall be installed between the pump discharge and the pipeline.

A pressure-relief valve shall be installed at the pump location if excessive pressure can build up when all valves are closed. Also, in closed systems where the line is protected from reversal of flow by a check valve and excessive surge pressure can build up, a surge chamber or a pressure-relief valve shall be installed on the discharge side of the check valve.

Pressure-relief valves shall be no smaller than ¼ inch nominal size for each diameter inch of the pipeline and shall be set at a maximum of 5 $lb/in.^2$ above the safe working pressure of the pipeline. A pressure-relief valve or surge chamber shall be installed at the end of the pipeline if needed to relieve surge.

Air-release and vacuum-release valves or combination air-release and vacuum-release valves shall be placed at all summits in the pipeline, at the end of the line, and between the pump and check valve if needed to provide a positive means of air entrance or escape.

Air-release and vacuum-release valve outlets shall be at least ½ inch in nominal diameter when specified for lines 4 inch or less in diameter, at least 1 inch outlets for lines 5 to 8 inch diameter, at least 2 inch outlets for lines 10 to 16 inch diameter, at least 4 inch outlets for lines 18 to 28 inch in diameter, at least 6 inch outlets for lines 30 to 36 inch in diameter, and at least 8 inches outlets for lines 38 to 48 inch in diameter.

For pipelines larger than 16 inch in diameter, 2-inch air-release valves may be used in place of the sizes indicated if they are supplemented with vacuum-release valves that provide a vacuum-release capacity equal to the sizes shown.

Drainage and flushing. Provisions shall be made for completely draining the pipeline if a hazard is imposed by freezing temperatures or if drainage is desired for the project.

If provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets may drain at all low places in the line. If drainage cannot be provided by gravity, provisions shall be made to empty the line by pumping.

Outlets. Appurtenances for delivering water from a pipe system to the land, to a ditch or to a surface pipe system shall be known, as outlets. Outlets shall have capacity to deliver the required flow:

1. To a point at least 6 inches above the field surface,
2. To the hydraulic gradeline of a pipe or ditch,
3. To an individual sprinkler, lateral line, or other sprinkler line at the design operating pressure of the sprinkler or line.

Pipe supports. Irrigation pipelines placed above ground shall be supported by concrete, steel, or timber saddles shaped to support the pipe throughout the arc of contact, which shall be not less than 90 degrees nor more than 120 degrees as measured at the central angle of the pipe. If needed to prevent overstressing, ring girder-type supports shall be used. Support spacing shall insure that neither the maximum beam stresses in the pipe span or the maximum stress at the saddle exceed the design stress values.

Thrust control. Aboveground pipelines with rubber gasket-type joints shall have the movement of each pipe length restrained by steel hold down straps at the pipe supports or by anchor blocks instead of normal pipe supports.

Expansion joints shall be installed, as needed, to limit stresses in the pipeline to the design values.

Thrust blocks shall be required on both buried and aboveground pipelines at all points of abrupt changes in grade, horizontal alignment, or reduction in size. The blocks must be of sufficient size to withstand the forces tending to move the pipe, including those of momentum and pressure, as well as forces due to expansion and contraction.

Suitable thrust control shall be provided to resist end thrust of rubber gasket pipelines.

$$A = ((98\ HD^2)/B)\sin(a/2)$$

Where:

A = Area of thrust block required
H = Maximum working pressure in ft
D = Inside diameter of pipe in ft
B = Allowable passive pressure of the soil in lb/ft^2
a = Deflection angle of pipe bend

Area of thrust blocks for dead ends and tees shall be 0.7 times the area of block required for a 90º-deflection angle of pipe bend.

If adequate soil tests are not available, the passive soil pressure may be estimated from Table 1.

Table 1 - Allowable Soil Bearing Pressure

Natural soil material	Depth of cover to center of thrust block 2 ft	3 ft	4 ft	5 ft
	-----------------	lb/ft^2	-----------------	
Sound bedrock	8,000	10,000	10,000	10,000
Dense sand and gravel mixture (assumed Ø = 40º)	1,200	1,800	2,400	3,000
Dense fine to coarse sand (assumed Ø = 35º)	800	1,200	1,650	2,100
Silt and clay mixture (assumed Ø = 25º)	500	700	950	1,200
Soft clay and organic soils (assumed Ø = 10º)	200	300	400	500

Joints and connections. All connections shall be designed and constructed to withstand the working pressure of the line without leakage and to leave the inside of the pipeline free of any obstruction that would reduce the line capacity below design requirements. On sloping lines, expansion joints shall be placed adjacent to and downhill from anchors or thrust blocks. If cathodic protection is required, high resistance joints shall be bridged to insure continuous flow of current.

For aboveground pipelines with welded joints, anchor blocks and expansion joints shall be installed at spacings that limit pipe movement due to expansion or contraction to a maximum of 40 percent of the sleeve length of the expansion coupling to be used. The maximum length of pipeline without expansion joints shall be 500 feet. Below ground welded joint pipelines shall have expansion couplers installed at a spacing not to exceed 600 feet. The maximum distance between a coupler and a fixed or anchored location, such as a tee, bend or riser shall be 300 feet. Expansion couplers are not required within reaches of pipe with risers. Expansion couplers shall provide for a minimum of 4 inches of travel distance.

A dielectric connection shall be placed between the pump and the pipeline and between pipes with different coatings.

Corrosion protection. Interior protective coatings shall be provided if the pH of the water to be conveyed is 6.5 or lower. Cement mortar coatings may be used if the water to be conveyed has a pH of 5.5 or higher and a sulfate content of 150 ppm or less.

All pipe exteriors for underground pipelines must be fully protected against corrosion. To meet protection requirements, all pipe must be coated and must be provided with supplementary cathodic protection as specified in Item 2 below:

1. A Class A protection coating shall be provided if the soil-resistivity survey shows that either (a) 20 percent or more of the total surface area of the pipeline will be in soil having a resistivity of 1,500 ohm-cm or less or (b) 10 percent or more of the total surface area of the pipeline will be in soil having a resistivity of 750 ohm-cm or less. Class A protection includes Coal-Tar Enamel and Epoxy Resin Coatings. A Class B coating shall be provided for pipe to be installed in soil having a resistivity greater than 1,500 ohm-cm.
2. Supplementary cathodic protection shall be provided if the soil-resistivity survey shows that any part of the pipeline will be in soil whose resistivity is less than 10,000 ohm-cm unless galvanized pipe is used. Pipe to soil potential shall be not less than is used. Pipe to soil potential shall be not less than 0.85 V negative, referred to as a copper/copper-sulfate reference electrode, with the cathodic protection installed. The initial anode installation shall be sufficient to provide protection for a minimum of 15 years.

Cathodic protection shall be provided for galvanized pipe if the soil-resistivity survey shows that any part of the galvanized pipe will be in soil whose resistivity is less than 4,000 ohm-cm. Galvanized pipe requiring cathodic protection shall have a Class B coating.

The total current required, the kind and number of anodes needed, and the expected life of the protection may be estimated as shown below:

The total cathode current required may be estimated from the formula.

$$I_t = C\ [\ A_i / Re_1 + A_2 / Re_2 + \ldots A_n / R_{en}]$$

Where:

I_t = total current requirement in mA
A = surface area pipe in ft^2
R_e = soil resistivity in ohm-cm
C = a constant for a given pipe coating

For design purposes, this constant shall be considered to be not less than 32 for Class A coatings and not less than 60 for Class B coatings.

The kind of galvanic anode to be used depends on the resistivity of the soils in the anode bed location. If the resistivity of the anode bed is:

a. Less than 2,000 ohm-cm, zinc anodes shall be used;
b. Between 2,000 and 3,000 ohm-cm, either zinc or magnesium anodes shall be used;
c. Between 3,000 and 10,000 ohm-cm, magnesium anodes shall be used.

Anodes shall not be required on pipelines if soil resistivity is greater than 10,000 ohm-cm.

The number of anodes needed to protect the pipeline may be estimated by dividing the total cathode current requirement of the pipeline by the current output per anode.

$$N = I_t / I_m \text{ and } I_m = k / R$$

Where:

N = number of anodes needed
I_t = total current requirement in mA
I_m = maximum anode current output in mA
k = constant for a given anode
R = soil resistivity of the anode bed in ohm-cm.

The expected life of an anode, based on the use of 17 lb/ampere year for magnesium and 26 lb/ampere year for zinc and a utilization factor of 0.80, shall be computed as follows:

Magnesium . . . . . $Y = 47W / I_o$

Zinc . . . . $Y = 31W / I_o$

Where:

Y = expected life in years
W = weight of anode in lb
I_o = design anode current in mA = I_m
Unless resistors are used in anode circuit to reduce output.

If resistors are used to reduce anode current output to increase service life, the number of anodes required shall be based on the regulated output of the anode rather than on the maximum output, I_m.

Preliminary soil-resistivity measurements to determine coating requirements and the approximate amount of cathodic protection needed may be made before the trench is excavated. 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 there is a visible change in soil characteristics. If a reading differs markedly from a preceding one, 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; the lowest depth shall be the strata in which the pipe will be laid. The lowest valve 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 basis for the final design of the 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.

Steel pipelines placed on the ground shall be limited to sites where the soil resistivity along any part of the pipeline is greater than 4,000 ohm-cm. Pipe at anchor or thrust blocks shall be embedded or attached rigidly with a hold down strap.

All pipe installed above ground shall be galvanized or shall be protected with a suitable protective paint coating, including a primer coat and two or more final coating.

Materials. Steel pipe shall meet or exceed the minimum requirements of:

- AWWA C-200, “Steel Water Pipe 6 Inch Diameter and Larger”
- ASTM A 53, “Steel, Black And Hot Dipped, Zinc Coated Welded And Seamless”
- ASTM A 134, Steel, Electric Fusion (ARC) Welded (Sizes NPS 16 and Over)
- ASTM A 135, Electric-Resistance Welded Steel
- ASTM A 139, Electric Fusion (ARC) Welded Steel (NPS 4 and over)

Pipe coatings and linings shall conform to one of the following

- AWWA C203, Standard for Coal-Tar Protective Coatings and Linings for Steel pipelines-Enamel and Tape-Hot Applied
- AWWA C205, Cement-Mortar Protective Lining and Coating for Steel Pipe-4 Inch and Larger-Shop Applied.
- AWWA C209, Standard for Cold Applied Tape Coatings for the Exterior of Special Sections, Connections and Fittings for Steel water Pipelines
- AWWA C214, Standard for Tape Coating Systems for the Exterior of Steel water Pipelines
- Coal Tar Epoxy Paint meeting the requirements of Paint Specification No. 16, Type 1, Class II of the Steel Structures Painting Council
- Epoxy Resin Coating, (Tested for 1000-volts, D.C.
- Urethane primer coat with two coats of semi-gloss or gloss Alkyd enamel paint (For above ground only)

Buried pipe installations. Trench width at any point below the top of the pipe should 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 sides of the pipe. The minimum trench width shall be not less than two pipe diameters, unless the trench is precision excavated with a semicircular bottom that closely fits the pipe. Trench banks that are more than 5 feet high shall be shored or sloped.

Power transmission lines shall not be placed in the same trench as the pipe.

Where rock, hardpan, cobbles or other hard material which might prevent the pipe from being uniformly supported is encountered in the bottom of the trench, the trench shall be undercut a minimum of four inches below final grade. The over cut area of the trench will then be filled with sand or fine-grained soil.

The pipe shall be firmly and uniformly bedded throughout its entire length. Bedding material shall be placed and spread in uniform layers and in such a manner as to fill the trench so there are no unfilled spaces below the pipe. For pipe with bell joints, holes shall be dug in the bedding at the bells to permit the body of the pipe to be in contact with the bedding along its entire length. Blocking or mounding shall not be used to bring the pipe up to final grade.

The initial backfill material shall be soil or sand that is free from rocks, gravels, frozen materials larger than 1 inch or earth clods greater than 2 inch in diameter. This may be the on site trench excavated materials as long as any unsuitable materials are removed. The initial backfill materials shall be placed in a manner as not to displace, deform or damage the pipe.

Hand, mechanical or water packing are optional methods for placing and compacting pipe backfill.

When backfilling is done by hand or mechanical means the initial fill shall be compacted firmly around and above the pipe to achieve a soil density equal or greater than the density of the undisturbed side walls of the trench. The thickness of individual lifts prior to compaction shall not exceed 6 inches.

When water packing is used, the pipe shall be filled with water. The initial backfill, before wetting, shall be of sufficient depth to ensure complete coverage of the pipe with backfill after consolidation has taken place. Water packing shall be accomplished by adding water to diked reaches of the trench in such quantity as to thoroughly saturate the initial backfill. After the backfill is saturated, the fill shall be consolidated by rodding or with a vibrator. The wetted fill shall be allowed to dry until firm before completing the final backfill.

The final backfill material shall be free of rocks, frozen clods or other debris larger than 1inch in diameter within 6 inches of the pipe and 6 inches in particle size for the remaining portion of the final backfill unless otherwise specified on the drawings. The material shall be placed and spread in approximately uniform layers so there are no unfilled spaces in the backfill. Rolling equipment shall not be used until a minimum of 18 inches of compacted backfill material has been placed over the top of the pipe. Final backfill may be mounded over the top of the trench above ground level, but in no case shall the final backfill be lower than the natural ground along the top of the trench.

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

CONSIDERATIONS

In soils subject to cracking and/or sloughing or the trench depth is 5 feet or greater include provisions for shoring or sloping sides of the trench.

Where differential settlement can create a concentrated loading on the pipe, as at the connection of a buried pipe to a rigid structure consider a flexible joint in the pipe adjacent to the structure.

Consider effects on the water budget, especially on volumes and rates of runoff to downstream water users.

Consider the effects on wetlands and water related wildlife.

Consider effects on water flows and aquifers and the affect to other water uses and users.

Consider the potential effect on irrigation water management.

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared to show site specifics. The drawings and specifications shall show pipe location, pipe type and sizes, wall thickness and coatings, details for appurtenances including type, pressure class (settings) size and locations, thrust block locations and sizes, cathodic protection requirements and trench/backfill requirements as applicable.

OPERATION AND MAINTENANCE

The operation and maintenance of the system shall include typical items of flushing pipe, cleaning and repairing appurtenances, reading anode output, replacing anodes, repainting above ground pipe etc.

REFERENCES

- Engineering Field Manual
    - Chapter 3, Hydraulics
    - Chapter 15, Irrigation
- NRCS Conservation Practices
    - Structure for Water Control, Code 587
    - Irrigation System, Trickle, Code 441
    - Irrigation System, Sprinkler, Code 442
    - Irrigation System, Surface and Subsurface, Code 443
    - Irrigation System, Tailwater Recovery, Code 447