# Irrigation Water Conveyance (ft)

## Aluminum Tubing Pipeline

### Definition

A pipeline and appurtenances installed in an irrigation system.

### Scope

This standard applies only to buried aluminum pipelines coated with plastic tape on the exterior surface.

### Purpose

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

### Conditions where practice applies

All pipelines shall be planned and located to serve as an integral part of an irrigation water distribution system designed to facilitate the conservation of water on a farm or group of farms.

All areas served by the pipelines shall be suitable for irrigation.

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.

### Design criteria

**Working pressure.** The maximum permissible working pressure in the line shall be determined by the following equation:

$$P = \frac{2St}{d}$$

Where:

S = 7,500 lb/in.$^2$

P = Maximum working pressure in lb/in.$^2$

d = Inside diameter of tube in in.

t = Tube nominal wall thickness in in.

**Capacity.** Design capacity shall be based on whichever of the following is greater:

1. The capacity shall be adequate to deliver the volume of water required to meet the peak consumptive use of the crop.
2. The capacity shall be adequate to provide an adequate irrigation stream for all methods of irrigation planned.

For design purposes, the value of *n* in Manning's Formula shall be considered to be 0.01, except where joints, connections, and condition of the pipe indicate that a higher value is required.

**Stands for low-pressure lines 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:

1. Allow a minimum of 1 ft of freeboard. The maximum height of the stand above the centerline of the pipeline must not exceed the maximum working head of the pipe.
2. Have the top of each stand at least 4 ft above the ground surface except for surface gravity inlets, which shall be equipped with trash racks and covers.
3. Have a downward water velocity in stands not in excess of 2 ft/s. 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 ft 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 ft/s 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.

Sand traps, when combined with a stand, shall have a minimum inside dimension of 30 in. and shall be constructed so that the bottom is at least 24 in. below the invert of the outlet pipeline. The

downward velocity of flow of the water in a sand trap shall not exceed 0.25 ft/s. 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 and to dampen surge.

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

**Vents for low-pressure lines open to the atmosphere.** Vents must be designed into the system to provide for the removal of air and prevention of vacuum collapse. They shall:

1. Have a minimum freeboard of 1 ft above the hydraulic gradeline. The maximum height of the vent above the centerline of the pipeline must not exceed the maximum working head of the pipe.
2. Have a cross sectional area at least one-half the cross sectional area of the pipeline (both inside measurements) for a distance of at least one pipeline diameter up from the centerline of the pipeline. Above this elevation, the vent may be reduced to 2 in. in diameter.
3. Vents shall be located:
   a. At the downstream end of each lateral,
   b. At summits in the line,
   c. At points where there are changes in grade in a downward direction of flow of more than 10 degrees,
   d. Immediately below the pump stand if the downward velocity in the stand exceeds 1 ft/s.
4. A combined air-release-vacuum-release valve may be used instead of an open vent. Air-vacuum-release valves shall have a 2-in. minimum diameter. For lines 6 in. or less in diameter, 2-in. valves shall be used; for lines 7 in. through 10 in. in diameter, 3-in. valves shall be used; and for lines 12 in. in diameter, 4-in. valves shall be used.

**Outlets.** Appurtenances to deliver water from a pipe system to the land, a ditch, or any surface pipe system are known as outlets. Outlets shall have a capacity to deliver the required flow to (1) the hydraulic gradeline of a pipe or ditch or (2) a point at least 6 in. above the field surface.

**Drainage.** Provision shall be made to completely drain the pipeline. Drainage outlets should be provided at all low points in the system and may either discharge into a dry well or to a point of lower elevation. If these gravity discharge points are unavailable, provision shall be made to empty the line by pumping.

**Check, pressure-relief, and air-and-vacuum-release valves for high-pressure closed systems.** A check valve shall be installed between the pump discharge and the pipeline if detrimental backflow may occur.

A pressure-relief valve shall be installed at the pump location if excessive pressure can build up when all valves are closed. Also, a surge chamber or a pressure-relief valve shall be installed in closed systems in which a check valve protects the line from reversal of flow and excessive surge pressure may develop. Pressure-relief valves shall be no smaller than 1/4 in. nominal size for each diameter inch of the pipeline and shall be set at a maximum of 5 lb/in.$^2$ above the pressure rating of the pipe. If needed to relieve surge, pressure-relief valves or surge chambers shall be installed at the end of the pipeline.

Air-release and vacuum-release valves shall be placed at all summits in the pipeline and at the end of the line if needed to provide a positive means of air release or escape. Air-release and vacuum-release valve outlets of at least 1/2-in. nominal diameter shall be used in lines 4 in. or less in diameter, at least 1-in. outlets in lines 5 to 8 in. in diameter, and at least 2-in. outlets in lines 10 to 16 in. in diameter.

**Joints and connections.** All connections shall be constructed to withstand the working pressure of the line without leakage and to leave the inside of the line free of any obstructions that can reduce the line capacity below design requirements. All such fittings as risers, ells, tees, and reducers should be of similar metal. If dissimilar metals are used, however, the fittings shall be protected against galvanic corrosion. For example, separate dissimilar metals with a rubber or plastic insulator. The connection between the pump discharge pipe and the aluminum line shall be made of suitable insulating material, such as rubber or plastic.

**Quality of water.** Water-quality tests shall be made for all aluminum pipeline installations. A copper content in excess of 0.02 p/m produces nodular pitting and rapid deterioration of the pipe if water is allowed to remain stagnant.

**Materials.** Pipe and coating materials shall equal or exceed the physical requirements specified under "Materials."

**Plans and specifications**

Plans and specifications for constructing aluminum tubing irrigation pipelines shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

# Irrigation Water Conveyance

## Aluminum Tubing Pipeline Specifications

### Installation

**Corrosion protection.** All aluminum tubing shall be wrapped with plastic tape to protect it against corrosion. The following specifications shall apply:

1. The surface of the tubing to be coated shall be cleaned of all foreign material, such as oil, grease, dirt, and mud. Any knurls, burrs, or other sharp points shall be removed by filing, peening, or wire brushing.

2. The coating material, plastic tape, or a combination of plastic tape and other materials used to protect the tubing and to bond the plastic tape to the tubing shall have the minimum physical and electrical properties specified under "Materials."

3. If possible, fittings shall be coated at the fabricating shop in such a manner as to provide a uniform, intimately bonded coating, allowing no voids or bridging of coating to metal surface. The surface preparation and the coating materials shall conform to the minimums set forth under these specifications.

Contours or offsets in pipe or fittings that can cause "bridging" of the tape coating shall be prepared in the following manner:

a. Clean and prepare metal surface according to these specifications.

b. Prime entire surface to be coated, allowing no skips or voids, and

c. Wrap with molding or filler tape as recommended by the manufacturer of the tape or apply a filler compound to the irregular surface and overwrap with tape. Primer, molding tape, and filler compound shall be compatible and shall be recommended by the manufacturers of the products with which they are used.

4. Clean and prepare the surface of the metal as prescribed in these specifications. Remove sufficient overwrap to allow for a minimum of a 2-in. overlap onto the "inplace" coating. Remove any scuffed or loosely bonded coating material.

Prime entire surface to be coated, including the 2-in. area of the "inplace" coating.

Beginning with a "square" or perpendicular wrap, spirally wrap the entire primed area, maintaining firm tension, and overlap as recommended by the manufacturer. Overlap shall not be less than 1/2 in., ending with a "square" or perpendicular wrap. Tape shall be applied free of voids, folds, or wrinkles.

If irregular contours or offsets are encountered that are conducive to "bridging" of the coating to the metal, thereby preventing an intimate voidfree bond, the techniques set forth under item 3 shall apply.

**Markings.** Each wrapped pipe section shall be plainly identified according to the manufacturer's symbol or name, size of pipe, wall thickness, and working pressure or class.

**Handling plastic-coated tubing.** Tubing shall be handled so as to prevent abrasion to the coating during transportation and placement. It shall not be dropped, dragged, or rolled on the ground. If the pipe must be moved longitudinally on the ground or in the ditch, care shall be taken to insure that the tubing and coating are not damaged. When stockpiled, the coated tubing shall be carefully piled and blocked so as to prevent damage to the coating.

**Placement.** All pipe shall be placed deep enough below the land surface to protect it from hazards imposed by traffic crossings, farm operations, freezing temperatures, or soil cracking. The cover shall be a minimum of 2 ft, but in soils susceptible to deep cracking, the cover shall be a minimum of 3 ft. Extra fill may be placed over the pipeline to provide the minimum depth of cover if the top width of the fill is not less than 10 ft and side slopes are not steeper than 6:1.

The width of the trench shall be at least 6 in. greater than the diameter of the pipe being installed. If trenches are excavated in soils containing rock or other hard materials that might damage the pipe or coating material, they shall be excavated deeper than required and then backfilled to grade with selected fine earth or sand.

The line may be assembled above ground or in the ditch, taking care to aline the joints at time of placement. At each joint, which shall be observed during testing for leakage, scoop out sufficient dirt to allow for final coating and taping. Care shall be taken to prevent impact or scuffing against the sides of the trench.

Depending on the type of joint used between lengths of tubing, it may be necessary to partly backfill the ditch to hold the tubing in place during testing. If this is done, the backfill shall be on the

body of the tubing but not at the joints. Thrust blocks or anchors shall be used at line ends or bends in the line if necessary.

**Installation of minimum-wall-thickness tubing.** If the aluminum tubing is 6 in. or more in diameter and has a wall thickness less than that specified in column A of table 1, the installer shall take additional precautions to prevent negative pressures from causing the tube to collapse under initial filling, testing, and normal service conditions.

Table 1.—Specifications for aluminum tubing

| Tube diameter | *(Column A)* Nominal wall thickness acceptable for all installations having a working pressure not exceeding 150 lb/in.² | *(Column B)* Minimum permissible wall thickness and associated maximum working pressure | |
|---|---|---|---|
| *in.* | *in.* | *in.* | *lb/in.²* |
| 2 | 0.050 | 0.05 | 150 |
| 3 | .050 | .05 | 150 |
| 4 | .050 | .05 | 150 |
| 5 | .052 | .05 | 150 |
| 6 | .058 | .05 | 125 |
| 7 | .064 | .05 | 108 |
| 8 | .072 | .05 | 94 |
| 9 | .082 | .058 | 97 |
| 10 | .094 | .058 | 87 |
| 12 | .110 | .058 | 73 |

**Testing.** The pipe shall be tested before backfilling. The pipe shall be filled with water; care shall be taken to bleed the air and slowly build up the pressure to the maximum working pressure. The pipeline shall be walked and all leaks repaired before proceeding with backfill. Pipelines shall be tested at the working pressure.

It shall be demonstrated that all pipelines function properly at design capacity. At or below design capacity there shall be no objectionable surge or water hammer. Objectionable flow conditions shall include (1) continuing, unsteady delivery of water, (2) damage to the system, and (3) detrimental overflow from vents, stands, or valves.

**Backfilling.** The initial backfill shall be of selected material, free from rocks, stones, or hard clods. This initial fill shall be compacted firmly around the pipe. Care must be taken to avoid deformation or displacement of the pipe during this phase of the operation.

If water packing is used, the pipeline shall be filled with water. The initial backfill, before wetting, shall be of sufficient depth to insure complete coverage of the pipe after consolidation takes place.

Water packing is accomplished by adding enough water to thoroughly saturate the initial backfill without inundation. After the backfill is saturated, the valves shall be closed, and the pipeline shall remain full until final backfill is made.

The wetted fill must be allowed to dry until firm before beginning the final backfill.

Final backfill material shall be free of large rocks or boulders and shall be added to the trench in a manner that will leave the fill at ground level after settling.

Any special requirements of the pipe manufacturer or the installer shall be strictly observed.

**Inspection.** After final assembly of the line and taping of the joints and connections, the entire system shall be visually inspected for breaks or ruptures in the plastic coating. All breaks or ruptures shall be marked and repaired in the following manner:

1. Remove overwrap (if necessary) from the area adjacent to the damage.
2. Trim off scuffed or broken material and brush a thin film of primer over the damaged area and about 2 in. beyond onto the undamaged tape. Apply a patch cut to fit the entire primed area and smooth it into place without wrinkles.

The continuity of the plastic coating shall be of such quality that after assembly all tubing, joints, and fittings are capable of passing an inspection test conducted with a spark discharge holiday detector at 1,500 V.

**Certification and guarantee.** The installing contractor shall certify that the installation complies with requirements of this standard. He shall furnish a guarantee against defective workmanship and materials for 1 year from date of installation.

## Materials

**Aluminum tubing.** The tubing shall be rigid and shall be made of aluminum alloys having properties and characteristics recommended to be suitable for irrigation service by the Sprinkler Irrigation Association (SIA) and the American Society of Agricultural Engineers (ASAE), "Minimum Standards for Aluminum Irrigation Tubing."

All alloys used for buried irrigation lines shall be covered on the inside of the tubing with an alloy that is anodic to the base alloy to a thickness of at least 5 percent of the nominal wall thickness of the tubing.

Tubing having the nominal wall thickness listed in column A of table 1 shall be acceptable for all installations where the operating pressure does not exceed 150 lb/in.$^2$ The minimum permissible wall thickness of the tubing and the associated maximum permissible working pressures are given in column B of table 1. For tubing having a wall thickness between the range listed for the pipe size, the maximum working pressure shall not exceed that obtained by the equation specified for working pressure under "Design Criteria."

**Tape and bonding agent.** The coating applied to the tubing shall be of plastic, a rubber-type material, or both. It shall be capable of withstanding the moisture and soil conditions to which it will be subjected on buried aluminum tubing. See table 2.

Table 2.—Minimum physical properties for the applied thickness of plastic corrosion-prevention tape

| Test description | Test method |
|---|---|
| Minimum plastic or plastic and bonding adhesive agent, applied thickness, in.—0.010 | ASTM–D–1000 |
| Breaking strength, lb/in. width—20 | ASTM–D–1000 |
| Elongation of plastic coating at break, pct—50–300 | ASTM–D–1000 |
| Adhesion to aluminum, oz/in.—22 | ASTM–D–1000 |
| Tear test | ASTM–D–1004 |
| Machine direction, lb—4 | |
| Cross direction, lb—4 | |
| Dielectric breakdown | ASTM–D–1000 |
| After standard conditions, V—7,000 | |
| After water immersion, V—6,000 | |
| Resistance to impact, mm—600 | (See "Test Methods," Resistance to Impact.) |
| Puncture resistance, lb—8.0 | (See "Test Methods," Puncture Resistance.) |
| Salt water resistivity, ohm/ft—$2 \times 10^{11}$ | (See "Test Methods," Salt Water Resistivity.) |
| Resistance to abrasion, maximum, mg—300 | (See "Test Methods," Resistance to Abrasion.) |

### Resistance to impact test

**Apparatus.** The following apparatus shall be required:

1. A steel ball bearing with a diameter of 1-3/8 in. and weighing 173.5 ± 1.0 g.
2. A suitable device to release the ball in free fall,
3. A solid steel plate at least 2 in. by 2 in. by 1/2 in. on which the specimen is placed
4. A steel roller (see ASTM-D-1000, Section 35(c) ),
5. An ohmmeter, and
6. An electrolytic (saturated) solution of cupric chloride in butylcellosolve.

**Test procedure and results.** A 2-in. by 2-in. specimen shall be placed adhesive side down on the steel plate and the roller passed over it once in each direction at a rate of about 2 in./s. The steel ball shall be dropped from 600 mm on the 10-mil specimens and from 1450 mm on the 20-mil specimens. A few drops of the electrolytic solution shall be applied to the indentation, and one of the probes of the ohmmeter shall be placed in the solution and the other probe on the steel plate. A puncture occurs if the ohmmeter reads 50 megohms or less. Six of 10 ball drops must not puncture at specified drop heights.

### Puncture-resistance test

**Apparatus.** The following apparatus shall be required:

1. A crosshead-type testing machine, conforming to the specifications in Section 35(a) of ASTM-D-1000, that is capable of a speed of 2 in./min.
2. A test fixture as shown in figure 1.

**Test procedure and results.** Five 1-in. by 3-in. specimens shall be prepared from each 1-in. roll. The testing machine shall be zeroed to compensate for the weight and frictional drag of the test fixture. The specimen shall be placed adhesive side down over the hole in the lower part of the fixture and tightly secured with the clamping device. The driven jaw shall move at a rate of 2 in./min. The force required to puncture the specimen shall be recorded in pounds. An average of five determinations shall be reported as the puncture resistance.

### Salt water resistivity test

**Apparatus.** The following apparatus shall be required:

1. A 10-in. by 13-in. sheet of No. 20-gage sheet metal,
2. Six pint cans with covers—L.D., about 3.25 in,
3. Four 1-1/2-V No. 6 dry cells,
4. A short circuit jack box containing six short circuit jacks,
5. 1-1/2 pints saturated NaCl solution,
6. An electrometer with appropriate shunt to measure $10^{-3}$ to $10^{-14}$ A, and

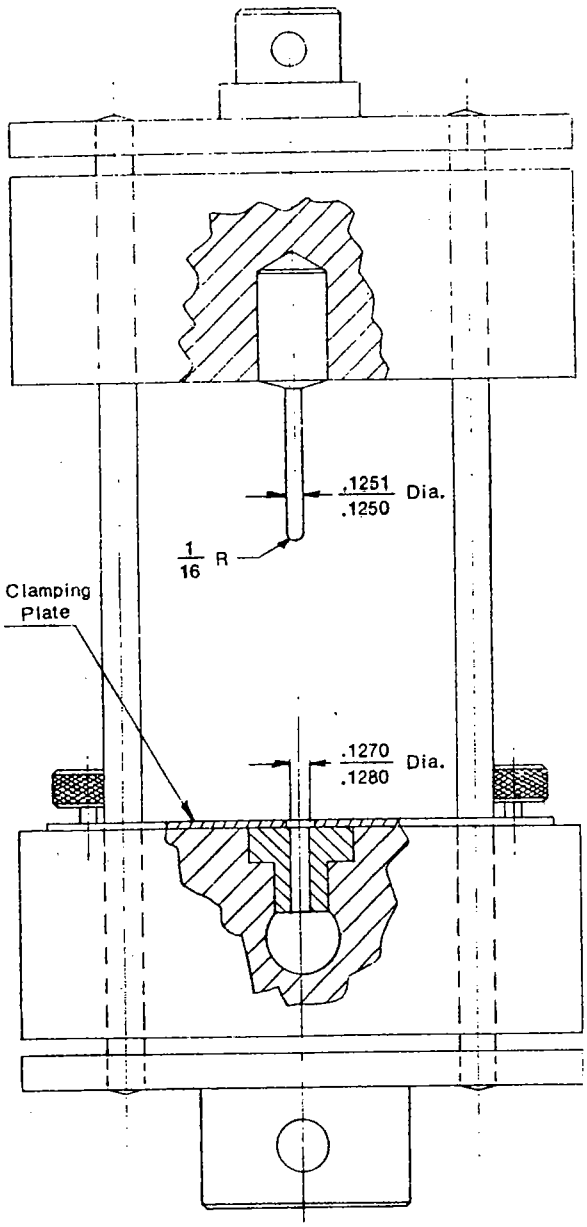


Figure 1.—Puncture-resistant test unit.

7. Roller, sealing material, miscellaneous wire and solder.

**Test procedure and results.** Two 4-in. by 13-in. specimens shall be placed adhesive side down on the 10-in. by 13-in. sheet. A roller shall be passed over the specimens until all air is excluded. The bottoms shall be removed from the pint cans. Three cans shall be evenly spaced bottom side down on each specimen and sealed to the surface of the specimen. The four dry cells shall be connected in series. The 10-in. by 13-in. sheet shall be connected to the negative terminal of the battery bank. Each pint can shall be connected to the positive terminal of the battery bank through a short circuit jack so that an ammeter can be inserted into each individual circuit without interrupting the current flow. Each can shall then be filled one-fourth full with saturated salt solution and the can cover placed on the can to prevent evaporation. The resistivity of the coating, in ohm-ft, shall be determined after 15 weeks by measuring the current flowing to each can. The current shall be measured by inserting the electrometer and the shunt into the circuit for each can by using the short circuit jacks. The resistivity of each sample shall be calculated according to the following formula:

$$\text{Resistivity (ohm-ft)} = \frac{(\text{voltage applied in V})\ (\text{area in ft}^2)}{(\text{current in A})\ (\text{thickness in ft})}$$

An average of six determinations shall be reported as the salt water resistivity.

**Resistance to abrasion test**

**Apparatus.** The following apparatus shall be required:

1. A Taber abraser, Model 140, and parts or equivalent.
2. An analytical balance, and
3. A steel roller (see ASTM-D-1000, Section 35(c) ).

**Test procedure and results.** An approximate 4-in. by 4-in. two-ply specimen shall be placed adhesive side down to cover the flat specimen plate and the steel roller passed over it once in each direction at a rate of about 2 in./s. The specimen plate with the attached two-ply specimen shall be weighed on an analytical balance to the nearest milligram and then placed in the Taber abraser. The abraser wheels, covered with fresh NEMA sandpaper strips and loaded at 1,000 g/wheel, shall abrade the specimen for 400 cycles. The specimen plate shall be reweighed to the nearest milligram. The weight loss, in milligrams, shall be reported as abrasion resistance.

# Irrigation Water Conveyance Aluminum Tubing Pipeline (ft)

**Planning considerations for water quantity and quality**

*Quantity*

1. Effects on the components of the water budget, especially infiltration and evaporation.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential use for irrigation water management.
4. Effects of installing a pipeline on vegetation that may have been located next to the original conveyance.

*Quality*

1. Effects of installing the pipeline (replacing other types of conveyances) on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.
2. Effects on the movement of dissolved substances into the soil and on percolation below the root zone or to ground water recharge.
3. Effects of controlled water delivery on the temperatures of water resources that could cause undesireable effects on aquatic and wildlife communities.
4. Effects on wetlands or water-related wildlife habitats.
5. Effects on the visual quality of water resources.