

## NATURAL RESOURCES CONSERVATION SERVICE

### CONSERVATION PRACTICE STANDARD

## IRRIGATION DITCH LINING

(Ft.)

CODE 428

### DEFINITION

A lining of impervious material or chemical treatment, installed in an irrigation ditch, canal, or lateral.

### PURPOSES

- Improve conveyance of irrigation water
- Prevent waterlogging of land
- Maintain water quality
- Prevent erosion
- Reduce water loss

### CONDITIONS WHERE PRACTICE APPLIES

This practice applies to constructed ditches that are subject to erosion or excessive seepage and are integral parts of an irrigation water distribution or conveyance system.

This practice applies where water supplies and irrigation deliveries for the area served are sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

This practice does not apply to natural streams.

### CRITERIA

Lined ditches shall be located where they are not susceptible to damage from side drainage flooding, or they shall be protected from such damage.

Provision shall be made to protect the lining from external water pressures, frost heave, chemical reactions with the soil and water,

animal damage and fire when the lining is subject to damage from excess heat or fire.

Thickness of canal linings must be established on the basis of engineering considerations for each site. Location, canal size, velocity, subgrade conditions, method of construction, operation, lining material, and climate shall be evaluated in establishing thickness to be used.

**Materials.** On sites where sulfate, salts or other strong chemical concentrations exist and may cause damage to the lining, the lining material must be resistant to or otherwise protected from the chemicals most likely to damage the lining.

**Concrete.** Concrete linings installed under this standard shall be limited to ditches with:

- bottom widths not greater than 6 feet,
- flow capacities equal to or less than 100 cubic feet per second, and
- design velocities equal to or less than 15 feet per second.

Fly ash can be used to replace up to 15 percent of the cement by weight, when other pozzolans are not used. Fly ash material shall meet the requirements of ASTM C-618 "Standard Specification for Coal Fly Ash and Raw or Calcined Pozzalon for Use in Concrete".

If air-entrainment admixture is used to improve concrete workability and reduce damage due to freeze-thaw cycles, air content shall not exceed 7 percent of the volume of concrete.

Concrete linings in soils with high sulfate concentrations shall be installed in accordance with those values shown in Table 1.

Conservation practice standards are reviewed periodically and updated if needed. To obtain the current version of this standard, contact your Natural Resources Conservation Service State Office or visit the Field Office Technical Guide.

**NRCS, NHCP**  
**September 2009**

Table 1. Cement Requirements for Concrete Exposed to Sulfates

Water-soluble sulfate (SO <sub>4</sub> ) percent by weight	Sulfate (as SO <sub>4</sub> ) in water parts per million	Cement type ASTM C150 or C595
SO <sub>4</sub> ≥ 0	SO <sub>4</sub> ≥ 0	Any
SO <sub>4</sub> ≥ 0.10	SO <sub>4</sub> ≥ 150	II, IP(MS), IS(MS), P(MS), I(PM)(MS), I(SM)(MS)
SO <sub>4</sub> ≥ 0.2	SO <sub>4</sub> ≥ 1500	V
SO <sub>4</sub> > 2.00	SO <sub>4</sub> ≥ 10000	V plus pozzolan

- Pozzolan known or shown to improve sulfate resistance in concrete with Type V cement

Minimum thickness for plain concrete linings in rectangular sections shall be 3½ inches. For trapezoidal or parabolic sections, minimum thickness shall be in accordance with Table 2.

Table 2. — Minimum required thickness for trapezoidal or parabolic sections, plain concrete ditch and canal linings

Design velocity <sup>1</sup> (ft/s)	Minimum thickness by climatic area <sup>2</sup> (in)	
	Warm	Cold
Less than 9.0	1.5	2.0
9.0–12.0	2.5	2.5
12.0–15.0	2.5	3.0

<sup>1</sup>Velocities in short chute sections shall not be considered design velocity.

<sup>2</sup>Climatic area:

Warm – Average January temperature is 40 °F and above

Cold – Average January temperature is less than 40 °F.

**Steel and Non-Ferrous Metal.** Steel and non-ferrous metals subject to damage from soils or water with high salt or other chemical concentrations shall be protected with coatings, cathodic protection, or other methods specifically designed to protect the liner from these chemicals.

Galvanized lining material shall equal or exceed the requirements of ASTM A-525 "General Requirements for Steel Sheet, Zinc Coated (Galvanized) by the Hot-Dip Process." The minimum thickness of the lining material shall be 24 gauge for individual sheets 84

inches or less in width, and 22 gauge for wider sheets. The minimum thickness of steel sheets used in bulkheads and related structures shall be 20 gauge.

The edges of the lining sheets shall be rolled or pressed into a shape that will provide added strength at the corners and a firm anchorage into the ditch bank berm at the top of the lining.

Fasteners and anchors used in the assembly of liners shall be zinc plated, cadmium plated, stainless steel or epoxy coated. Joints shall be flexible, watertight, and filled with sealant material capable of withstanding contraction/expansion of the lining material for the temperature variations expected at the site.

**Flexible Membrane and Semi-Rigid Formed Plastic.** Flexible membrane and semi-rigid formed plastic linings shall be protected from animal damage and from excessive heat or fire.

For flexible membrane liners protected by an earth or earth and gravel covering, the covering shall not be less than 6 inches thick and must extend not less than 6 inches above the top edge of the lining, unless recommended by the manufacturer to leave uncovered.

In areas subject to traffic by livestock, the minimum thickness of the protective cover shall be 9 inches and be free of particles larger than 3/8 inch, angular particles, and other sharp objects.

The material in the bottom 3 inches of cover shall be soil free of particles larger than 3/8 inch, angular rock particles, and other sharp objects. Lining in the bottom of the ditch may need to be thicker, as recommended by manufacturer.

Covered linings require cutoffs and anchor trenches to secure the lining to the subgrade.

Exposed linings require cutoffs and anchor trenches to secure the liner from uplift or tearing away from the bottom and sides if the seams release.

Any exposed manufactured lining material shall have sufficient ultraviolet protection to prevent premature deterioration.

Polyurethane/Geotextile composite linings may be exposed when installed according to manufacturer's recommendations.

The required thickness for flexible membrane, chemical treatment, compacted clay, and semi-rigid formed plastic shall be based on sub-grade conditions, the hydrostatic forces that will be acting on the lining and the susceptibility of the lining to damage during or after installation.

Table 3. — Minimum required thickness for flexible membrane, chemical treatment, compacted clay, and semi-rigid formed plastic linings

Material	Minimum thickness (mil unless noted)
PVC*	20
GCL*	0.75 lb/ft <sup>2</sup> sodium bentonite
EPDM	45
EPDM (reinforced)	45
Polyurethane/Geotextile composite	45
HDPE	30
LLDPE	20
PE (reinforced)	24
PP (reinforced)	24
Bituminous	
Geomembrane	120
Chemical Treatment	3 in
Compacted Clay	3 in

\* Cover required (shall not be installed exposed)

Key: PVC – poly-vinyl chloride  
 GCL – geosynthetic clay liner  
 EPDM – ethelene propylene diene monomer (synthetic rubber)  
 HDPE – high-density polyethylene  
 LLDPE – linear low-density polyethylene  
 PE – polyethylene  
 PP – polypropylene

**Chemical Treatment.** Chemical treatment includes application of chemical compounds to the surfaces of earthen ditches and shall require incorporation and compaction of the combined soil/chemical mixture unless other wise noted.

Table 4. — Minimum required application rate for finished compacted lining for chemical treatment of ditches

Material	Minimum application rate/compacted thickness (lb/ft <sup>2</sup> )/(in)
TSPP*	0.0125
STPP*	0.0125
Soda Ash*	0.025
Bentonite*	See Soil Type
Silts	0.375
Silty Sands	0.5
Clean Sands	0.625
Soil Cement	1.25

\* Cover required (shall not be installed exposed)

Key: TSPP – tetrasodium pyrophosphate  
 STPP – sodium tripolyphosphate  
 Soda Ash – sodium carbonate  
 Bentonite – sodium bentonite (min. free swell – 22 ml)  
 Soil Cement – mixture of Portland cement, soil and water

**Capacity.** Lined ditches shall have adequate capacity to meet its requirement as part of the planned irrigation water distribution or conveyance system, without damage or overtopping.

For design purposes, capacity shall be computed using Manning's formula based on maximum probable roughness condition with an "n" value not less than:

Concrete – 0.015

Steel/Non-Ferrous Metal – 0.013

Flexible Membrane/SRFP (covered) – 0.025

Flexible Membrane/SRFP (exposed) – 0.011

Chemical Treatment – 0.025

**Velocity.** In channels with non-covered concrete or metal linings, avoid unstable surge flows by limiting velocities to 1.7 times the critical velocity in straight reaches that discharge into ditch sections or structures designed to reduce the velocity to less than critical velocity. Maximum velocity in these straight reaches shall be 15 feet per second.

When using flexible membrane linings, follow the manufacturer's recommendations for velocity limitations.

In channels with covered linings, the stability of the cover material shall be evaluated by computing the velocity using a Manning's roughness coefficient "n" no greater than 0.025.

When soil material is used as a protective cover over a liner, the velocity in ditches shall not exceed the nonerosive velocity for the soil material or the material through which the canal or ditch passes, whichever is less. Local information on velocity limits for specific soils may be used if available. If such information is not available, stability limits shall be based on the tractive stress design approach in USDA - ARS (Agricultural Research Service) Agriculture Handbook Number 667 - "Stability Design of Grassed-Lined Open Channels" or other comparable channel stability criteria.

The velocity in ditch reaches from which water is to be delivered onto the field through gates, turnouts, siphon tubes or by similar means, shall be less than supercritical and sufficiently low to permit operation of the planned structure or device.

**Freeboard.** The required freeboard varies according to the ditch, velocity of water, horizontal and vertical alignment, the amount of storm or wastewater that may be intercepted, and the change in water surface elevation that may occur when any control structure is operating. The minimum freeboard for any lined ditch or canal shall be 3 inches of lining above the design water surface. If the design velocity is within  $\pm$  30 percent of critical velocity, the freeboard shall be at least 6 inches.

Minimum freeboard requirement is based on assumption that the finished channel bottom elevation will vary no more than 0.1 feet from design elevations. If a construction deviation greater than 0.1 feet is permitted, the minimum freeboard shall be increased.

Additional freeboard shall be provided if required by velocity, depth of flow, alignment, obstruction, curves, and other site conditions.

**Water surface elevations.** All lined ditches shall be designed so that water surface elevations at field takeout points are high enough to provide the required flow onto the field surface. If ditch checks or other control structures are to be used to provide necessary head, backwater effect must be considered in computing freeboard requirements.

The required elevation of the water surface above the field surface varies with the type of takeout structure or device used and the amounts of water to be delivered. A minimum head of 4 inches shall be provided. Where erosion is anticipated at outlets, energy dissipation devices shall be used.

**Ditch side slopes.** For the construction methods and materials shown below, side slopes shall not be steeper than:

- Hand-placed, formed concrete:  
Height of lining less than 1½ ft .....Vertical
- Hand-placed, screeded concrete:  
Height of lining less than 2½ ft ....¾H to 1V\*  
Height of lining more than 2½ ft .....1H to 1V
- Slip form concrete:  
Height of lining less than 3 ft .....1H to 1V  
Height of lining more than 3 ft ....1½H to 1V
- Chemical Treatment:  
Spray/stair-step applications .....1H to 1V  
Incorporation on slope ..... 3H to 1V
- Covered lining:  
Not less than ..... 3H to 1V

\*H – Horizontal, V – Vertical

For materials not listed above, follow the manufacturer's recommendations.

**Ditch banks.** Ditch banks shall be shaped with earth to at least the top edge of the lining and to provide any necessary anchorage for the top edge of the lining. In cut sections, other than in rock, a berm shall be constructed not less than 2 inches above the top of the lining. Banks and berms shall be a wide enough to ensure stability of fills, the lining, and to prevent excessive deposition in cut sections.

When using siphon tubes, minimum berm or bank width of 12 inches shall be provided at the top of the lining on both sides of the finished ditch. All other canals and laterals shall have a minimum berm or bank width of 18 inches at the top of lining.

If the bank or berm is to be used as a roadway, the minimum top width shall be adequate for the purpose. Minimum recommended roadway width for straight sections is 12 feet.

Outside bank slopes and slopes above the berm elevation in cut sections must be flat enough to insure stability. A minimum slope is 2H to 1V is recommended. Where vegetation will be maintained by mowing, the minimum slope shall be 3H to 1V.

**Subgrade.** For flexible membranes, lining material shall be placed on a relatively smooth and firm surface. The top 6 inches of the subgrade shall be free of organic material, particles larger than 3/8-inch in size, angular rock particles, other sharp objects, or anything else that could damage the lining. If the subgrade does not meet these criteria, a 6-inch layer of sand or soil, free of particles larger than 3/8-inch diameter, angular rock particles, and other sharp objects, or an 8-ounce non-woven geotextile material, or a geomembrane composite, shall be used as padding beneath the lining.

**Related structures.** Plans for ditch lining installations shall provide for adequate inlets, outlets, turnouts, checks, crossings, and other related structures needed for the successful management of irrigation water.

Structures shall be constructed or installed such that the capacity or the freeboard of the ditch is not reduced and the effectiveness of the lining is not impaired.

Bulkheads, formed to fit the lining and of sufficient size to extend at least 12 inches into the earthen ditch pad for the entire width of the ditch lining, shall be installed at the beginning and end of the lining section and at intervening points, as needed, to provide adequate anchorage.

## CONSIDERATIONS

- The addition of fiber reinforcement to increase durability and reduce the potential for minor cracking in concrete
- Effects of downstream flows or aquifers that would affect other water uses or users
- Potential changes in growth and transpiration of vegetation located next to the conveyance because of elimination of leakage from the system
- Effects on the movement of dissolved substances into the groundwater
- Effects on wetlands or water-related wildlife habitats
- Effects on the visual quality of water resources
- Energy savings resulting from less water loss and improved irrigation water management
- Short-term and construction-related effects on air quality

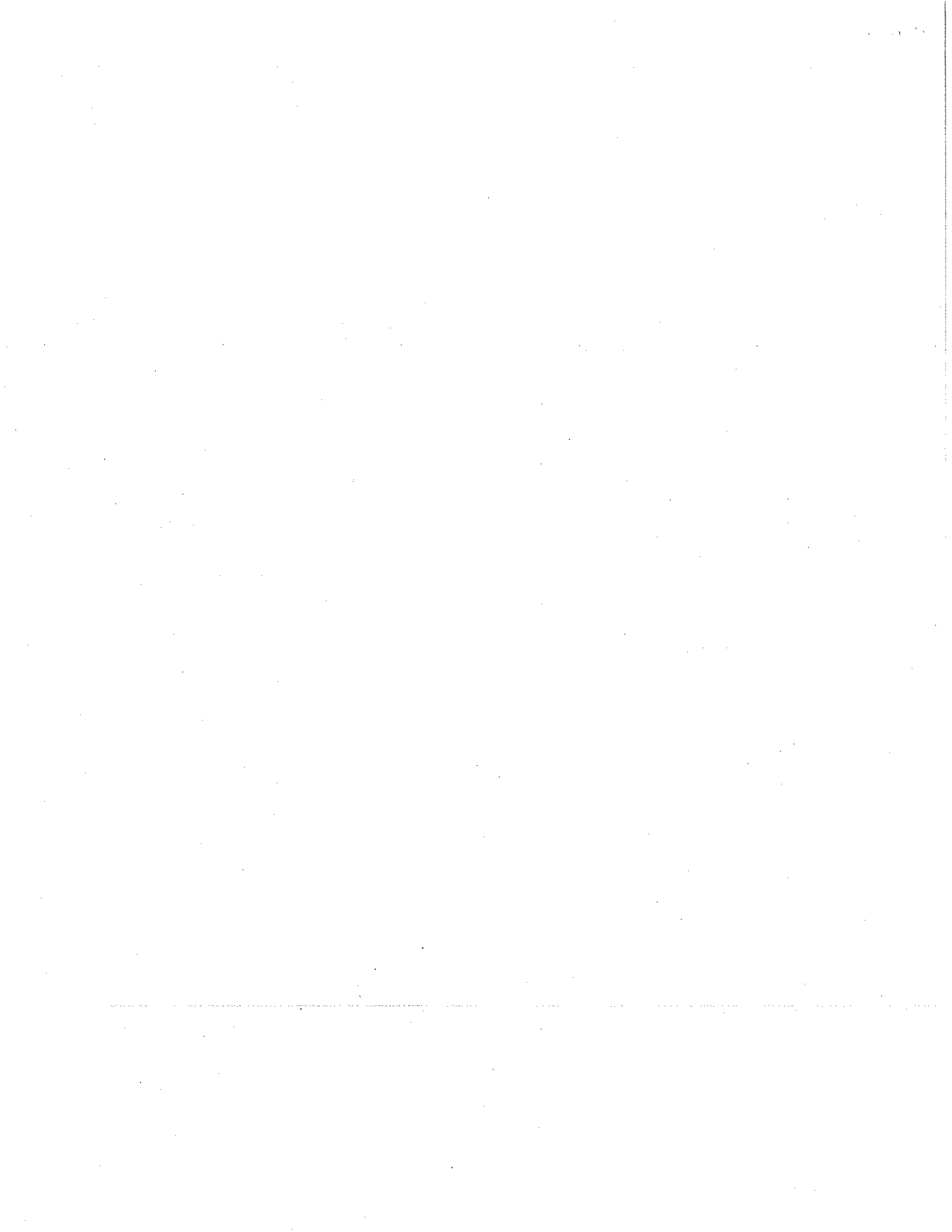
## PLANS AND SPECIFICATIONS

Plans and specifications for installing irrigation ditch and canal linings shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## OPERATION AND MAINTENANCE

An operation and maintenance (O&M) plan shall be developed for irrigation ditch and canal linings. The plan should document needed actions to ensure that practices perform adequately throughout their expected life.

O&M requirements shall be determined as part of the design. Any requirements should be documented as brief statements in the plans, the specifications, or the conservation plan narrative, or as a separate O&M plan. Typical O&M may include sediment/debris removal, patching of cracked concrete, and replacement of deteriorated linings.



**NATURAL RESOURCES CONSERVATION SERVICE  
CONSERVATION PRACTICE CONSTRUCTION SPECIFICATION  
IRRIGATION DITCH LINING, SEMI-RIGID FORMED PLASTIC  
CODE 428**

**1. SCOPE**

The work shall consist of installing approved semi-rigid formed plastic liners including all preparation, earthfill, excavation; and furnishing and installing all necessary mechanical attachments, connectors, seals, anchors, and/or bonding to the alignment, grades, and dimensions as shown on the drawings or as staked in the field.

**2. MATERIALS**

All materials shall be constructed of high quality ingredients and shall be certified by the manufacturer to be suitable for its intended use.

All materials shall be uniform throughout and shall be free from dirt, oil, foreign matter, holes, or other defects that can affect material serviceability. Material shall be packaged to prevent damage from rough handling during shipment and to facilitate placement at the job site. Each package delivered to the job site shall be marked with the manufacturer's name or symbol; the name of the material; and the quantity, thickness, weight, and physical properties of the material.

Formed modular plastic liners shall equal or exceed the physical requirements listed in **Table 1** at the end of this specification.

Fittings and appurtenances fabricated from steel shall be coated with a coating suitable for burial such as coal tar, epoxy paint, or tape wrap.

Liner shall be manufactured from virgin material and shall be suitable for use in either exposed or buried conditions.

Liner material shall be delivered, handled, and stored in accordance with recommendations of the manufacturer. Material shall be protected from puncture, dirt, grease, excessive heat, exposure to ultraviolet radiation, and shall not be dropped or allowed to roll freely down skids.

**3. CONSTRUCTION REQUIREMENTS**

**Site preparation.** Site preparation (mobilization and demobilization, clearing and grubbing, structure removal, pollution control, and water for construction) shall be in accordance with Construction Specification 587.

**Earthwork.** Foundation work (diverting surface water, dewatering the construction site, dewatering borrow areas, and foundation preparation) and earthwork (common excavation and earthfill) shall be in accordance with Construction Specification 587. Prior to compacting the subgrade, all visible roots, rocks, and unsuitable material shall be removed.

The area to be lined shall be compacted to provide a dry, firm unyielding subgrade. All banks and fills within the area to be lined must be shaped to the slopes and elevations as shown in the construction drawings.

The supporting surface slopes and foundation to accept the liner shall be stable and free from deviations of more than 3 inches. Subgrade compaction must be sufficient to maintain a stable foundation for the liner for the expected life of the practice.

The foundation area shall be very smooth and free of foreign and organic material, rocks larger than  $\frac{3}{8}$  inch, any angular rocks, sharp objects, or any other projections that might damage the lining. Coverage by equipment tracks or roller shall provide a smooth surface prior to liner installation. Surface deformations shall not exceed 1 inch. The foundation area shall also be wide enough to permit the liner to be easily placed and joined and to allow backfill material to be uniformly placed and compacted under the haunches and along the sides of the liner.

## Construction Specification 428C-2

If the design requires a soil sterilant, it shall be applied to the subgrade at the rate recommended by the manufacturer.

**Liner Placement.** Installation shall be conducted in a safe manner and in such a way that erosion and air and water pollution are minimized.

Liner shall be installed in accordance with manufacturer's recommendations.

Modules shall be connected together using connectors and seals/gaskets supplied by the manufacturer. An approved watertight flexible sealant, such as silicon, shall be applied to the female and male ends of the module joint prior to installation of the seal and securing of the joint.

The liner shall be uniformly and continuously supported over its entire length on firm stable material. Blocking and/or mounding are prohibited when bringing liner to final grade. Where bells, fittings, or connections extend below grade, holes shall be excavated in the trench bottom to allow for unobstructed assembly of the joint and to permit the body of the liner to be in contact with the trench bottom throughout its entire length.

Anchoring of modular liners shall be completed as recommended by the manufacturer. In the absence of manufacturer guidance, anchoring shall be completed as follows:

- Two anchor stakes (#6 rebar) 42 inches long shall be installed at each end of every module or jointed connection. Prior to anchoring, ensure liner is level and pulled tight. Once stretching is complete, install anchoring. Install stakes by drilling a 3/4 inch hole in each corner (4 per module) and pounding the stake with a sledge hammer until end of stake is flush with module; then install connector saddle. If a connector saddle is not used, pre-bend rebar to form an "L" prior to installing. Anchors shall be installed vertically and in a manner to provide lateral support and prevent floating.

Hand or mechanical compaction methods shall be used to compact initial backfill. Backfill material shall be soil or sand, free of hard earth clods and stones greater than 1 1/2 inch. Backfill material shall be compacted in 4-6 inch lifts. Each lift shall be shoveled, spread evenly in uniform layers, and tamped between the liner and side of trench to provide satisfactory support. Care shall be taken to assure all voids are filled. Final grade of the backfill shall be natural ground or as specified in design.

The following shall apply unless a certified installer directs otherwise:

- NRCS must inspect and approve the subgrade prior to the placement of the liner.
- The liner shall not be placed during precipitation or in the presence of excessive winds, or in temperatures less than 50 °F or more than 100 °F.
- The liner shall be secured by the end of each workday.
- Construction equipment shall not be allowed to operate directly on the liner.
- Any opening in the liner through which a pipe or other fixture protrudes shall be sealed in accordance with the manufacturer's recommendation.

**Repairs.** All tears, punctures, and material defects in the liner shall be repaired by installing a patch over the defective area. Surfaces of the liner to be patched shall be cleaned before the repair. All patches shall be of the same liner material and extend a minimum of 6 inches beyond the edges of the defect area. All patches shall have rounded corners and shall be seamed to the liner. Holes that are less than 0.25 inch in diameter shall be repaired by a bead of extrudent.

**Mechanical Attachments.** The liner shall be mechanically attached to pipe, concrete, or steel structures as shown in the drawings and according to the liner manufacturer's specification.

Pipe boots shall be fabricated in the field from the same liner as that shown in the drawings. HDPE boots shall be welded and clamped to polyethylene pipe. Pipe boots shall be clamped to other types of pipe as shown in the drawing, or as recommended by the manufacturer, to provide a leak-free attachment.

**Concrete.** Concrete shall be in accordance with Construction Specification 587C.

## 4. CERTIFICATION

Construction operations shall be done in such a manner that erosion and air and water pollution are minimized and held within legal limits. The completed job shall be workman-like and present a good appearance.



**Construction Specification 428C-3**

Channel bottom grade shall not vary by 0.1ft above and 0.2ft below design grade. Embankments shall not vary by 0.2ft above and 0.1ft below design grade. Cross-sectional dimensions shall meet or exceed design cross section.

Upon completion of liner installation, the contractor shall provide documentation to the owner and NRCS certifying the liner meets or exceeds the material specifications and that it was installed in accordance with the manufacturer's recommendations.

**Table 1.**  
**Minimum requirements for semi-rigid HDPE modular liner**

<b>Physical Properties</b>	<b>Method</b>	<b>Requirement</b>
Cell classification	ASTM D3350	345430C
Density, g/cc	ASTM D1505	.950
Tensile properties yield strength, psi break elongation, %	ASTM D638, type IV	3000 500
Melt index, g/10min	ASTM D1238	0.11
Flexural modulus, psi	ASTM D790	110000
Environmental Stress Crack Resistance condition A, hr condition B, hr	ASTM D1692	250 100
Low temperature brittleness, deg F	ASTM D746	-50
Impact resistance, lb-ft	ASTM D5420	2000
Coefficient of linear thermal expansion, in/in/deg F	ASTM D696	0.00007
Carbon black content, %	ASTM D1603	2-3

**Construction Specification 428C-4**

Project Name:

Date:

**5. ITEMS OF WORK AND CONSTRUCTION DETAILS**

Items of work to be prepared in conformance with this specification and the construction details are: