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.

PURPOSE

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

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to constructed ditches and canals 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

General Criteria Applicable to All Purposes

Comply with all Federal, state, and local laws, rules, and regulations. Evaluate and avoid or minimize impact to cultural resources, wetlands and Federal and state protected species to the extent practicable during planning, design and implementation of this conservation practice in accordance with established National and Florida policy, General Manual (GM) Title 420-Part 401; Title 450-Part 401, Title 190-Parts 410.22 and 410.26, National Planning Procedures Handbook (NPPH) Florida Supplements to Parts 600.1 and 600.6, National Cultural Resources Procedures Handbook (NCRPH), National Food Security Act Manual (NFSAM), and the National Environmental Compliance Handbook (NECH).

Locate lined ditches and canals where they are not susceptible to damage from side drainage flooding or they shall be protected from such damage, e.g., flooding.

Make provisions to protect the liner from external water pressures, chemical reactions with the soil and water, animal damge 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. Evaluate location, canal size, velocity, subgrade conditions, method of construction, operation, lining material, and climate to establish thickness to be used.

Capacity. Lined ditches or canals 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

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.

Table 1 - Cement Requirements for Concrete Exposed to Sulfates

Water-soluble sulfate (SO_4) percent by weight	Sulfate (as SO_4) in water parts per million	Cement type ASTM C150 or C595
$SO_4 \geq 0$	$SO_4 \geq 0$	Any
$SO_4 \geq 0.10$	$SO_4 \geq 150$	II, IP(MS), IS(MS), P(MS), I(PM)(MS), I(SM)(MS)
$SO_4 \geq 0.2$	$SO_4 \geq 1500$	V
$SO_4 > 2.00$	$SO_4 \geq 10000$	V plus pozzolan* 1/

1/ 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[1] velocity 1/ (ft/s)	Minimum thickness (in)
Less than 9.0	1.5
9.0– – 12.0	2.5
12.0– – 15.0	2.5

[1]Velocities1/ Velocities in short chute sections shall not be considered design velocity.

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* [1]/	20
GCL* [1/]	0.75 lb/ft^2 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

[1/]* Cover required (shall not be installed exposed)
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 otherwise noted.

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

Material	Minimum application rate/compacted thickness $(lb/ft^2)/(in)$
TSPP*	0.0125
STPP*	0.0125
Soda Ash* [1]/	0.025
Bentonite*	See Soil Type
Silts	0.375
Silty Sands	0.5
Clean Sands	0.625
Soil Cement	1.25

*1/ Cover required (shall not be installed exposed)
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

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 the critical velocity. Maximum velocity in these straight reaches shall be 15 feet per second.

When using flexible membrane linings, follow the manufactures 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 canals or ditches shall not exceed the non-erosive 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 as discussed 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 turnouts, siphon tubes, or similar means shall be sufficiently low to permit operation of the planned takeout structure or device.

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

Minimum freeboard requirement is based on the assumption that the finished channel bottom elevations 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 and canals 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 provide the necessary head, backwater effect must be considered in computing freeboard requirements.

The required elevation of the water surface above the field surface varies according to the type of takeout structure or device used and the amount 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. Ditch side slopes will not be steeper than shown in Table 5 for the construction methods used.

Table 5 – Ditch Side Slopes for Methods and Materials

Construction Method	Side Slope
Hand-placed, formed concrete	
Height of lining < 1 ½ ft	Vertical
Hand-placed, screeded concrete	-----
Height of lining < 2 ½ ft..	3/4H to 1V [1/]
Height of lining ≥ 2 ½ ft.	1H to 1V
Slip form concrete	-----
Height of lining < 3ft	1H to 1V
Height of lining > 3ft	3H to 1V
Chemical Treatment	----
Spray/stair-step application	1H to 1V
Incorporation on slope	1H to 1V
Covered lining	3H to 1V

[1/] 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 no less than 2 inches above the top of the lining. Banks and berms shall be 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 the 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, place lining material 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 liner. If the subgrade does not meet these criteria, use a 6 inch layer of sand or soil free of particles larger than 3/8-inch, angular rock particles, and other sharp objects or 8 ounce (oz.) non-woven geotextile material, or a geomembrane composite as padding beneath the lining.

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

Structures shall be installed such that the capacity or 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 ditch lining, shall be installed at the beginning and end of the lining section and at intervening points, as needed, to provide adequate anchorage.

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.

CONSIDERATIONS

- The addition of fiber reinforcement to increase durability and reduce the potential for minor cracking in concrete.
- Effects on the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
- Effects on 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 the elimination of leakage from the system.
- Abrasive effects of sediment on the liner itself or the erosive effects on the protective cover over the liner.
- Effects on the movement of dissolved substances into the ground water.

- Effects of 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.
- Protect liner from external water pressures.
- Short-term and construction-related effects on air quality.
- Plans and specifications

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

The plans shall include as a minimum, but not limited to, the following items:

- Location of the canals or laterals.
- Profile of canals or laterals
- Type of material, thickness and quantity of lining.
- Typical cross-section of canal or lateral showing top elevation of lining.
- Cross-section and details of all structures.
- Disposal requirements of excavated material.
- Type, quantity, and quality of all materials used for structures.
- Any special provisions needed for the installation of the lining material.
- Vegetative requirements.
- Location of underground utilities.

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, specifications, the conservation plan narrative, or as a separate O&M plan. The plan shall include, but not limited to, the following provisions:

- Inspect lining after major storm events or other major activities (e.g. pumping operations, etc.). If the liner is damaged, immediately repair in accordance with the manufactures recommendation.
- Inspect lining for tears and repair any tears in the lining material.
- Inspect lining material for deterioration; replace deteriorated lining material.
- Inspect concrete for cracks and patch cracked concrete immediately.
- Inspect lining material to ensure it is properly anchored, immediately re-anchor the lining material.
- Inspect seams of lining material, immediately reseal seams.

REFERENCES

ASTM A-525 General Requirements for Steel Sheet, Zinc Coated (Galvanized) by the Hot-Dip Process

ASTM C-618 Standard Specification for Coal Fly Ash and Raw or Calcined Pozzalon for Use in Concrete

General Manual
Title 420-Part 401
Title 450-Part 401
Title 190-Parts 410.22 and 410.26

National Cultural Resources Procedures Handbook

National Environmental Compliance Handbook

National Food Security Act Manual

National Planning Procedures Handbook Florida Supplements to Parts 600.1 and 600.6

NEH, Part 652, Irrigation Guide

USDA-ARS Agriculture Handbook 667- “Stability Design of Grassed-Lined Open Channels”