NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

IRRIGATION WATER CONVEYANCE

FLEXIBLE MEMBRANE DITCH AND CANAL LINING

(ft)
CODE 428B

DEFINITION

A fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch or irrigation canal or lateral.

SCOPE

This standard applies to buried membrane linings made of flexible materials, such as plastic, rubber, or asphalt. It includes design and construction criteria for the ditch section that affects the installation of the lining as well as for the lining itself.

PURPOSE

To prevent waterlogging of land, to maintain water quality, and to reduce water loss.

CONDITIONS WHERE PRACTICE APPLIES

Ditches and canals to be lined shall serve as an integral part of an irrigation water distribution or conveyance system designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

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

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

DESIGN CRITERIA

Capacity. A lined ditch or canal shall have enough capacity to meet its requirement as part of the planned irrigation water distribution system without danger of overtopping. Design capacity shall be based on the following, whichever is greater:

1. The capacity shall be enough to deliver the water needed for irrigation to meet the design peak consumptive use of the crops in the area served.

2. Capacity shall be enough to provide an adequate irrigation stream for all methods of irrigation planned for use in the area served.

Velocity. The velocity in canals or ditches lined with flexible membranes shall not exceed the nonerosive velocity for the soil material used for the protective cover 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, the maximum design velocity shall not exceed those shown in figure 6-2, chapter 6, SCS TR-25, except that the design velocity shall not exceed 3 ft/s (0.9 m/s).

The velocity in ditch reaches from which water is to be delivered onto the field through turnouts, siphon tubes, or similar means shall be less than supercritical and sufficiently low to

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permit operation of the planned takeout structure or device.

Canals and laterals lined with flexible membranes must be designed with enough capacity to carry the required flows at the velocity that will be developed under the maximum probable retardance conditions.

For capacity design, the value *n* shall be selected according to the material in which the canal or lateral is constructed, the alignment, the hydraulic radius, and the potential weed and moss hazard.

For checking designs to see that velocities do not exceed permissible values in erodible soils, a Manning's *n* no greater than 0.025 shall be used.

Freeboard. The required freeboard varies according to the size of the ditch or canal, the velocity of the water, the horizontal and vertical alignment, the amount of storm or waste water 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 in. (76 mm) of lining above the designed water surface. This minimum freeboard requirement is based on the assumption that the finished channel bottom elevations will vary no more than 0.1 ft (30 mm) from the design elevations. If a construction deviation greater than 0.1 ft (30 mm) is permitted, the minimum freeboard shall be increased.

Side slopes. Canals and ditches with buried membrane linings must be constructed with side slopes that will be statically stable. Slope requirements vary according to the type of cover material, but the side slopes shall not be steeper than 3:1.

Protective cover. Membrane linings shall be protected by an earth or an earth and gravel covering not less than 6 in. (152 mm) thick and must extend not less than 6 in. 152 mm) above the top edge of the lining. In areas subject to traffic by livestock, the minimum thickness of the protective cover shall be 9 in. (228 mm). The material on the bottom 3 in. (76 mm) of cover shall not be coarser than silty sand.

Membrane thickness. The required membrane thickness depends on the expected subgrade conditions, the hydrostatic forces that will be acting on the membrane, and the susceptibility of the lining to damage during or after installation. The minimum nominal thickness shall be:

Material	Asphalt	Plastic sheeting	Nonreinforced rubber	Reinforced rubber
	mil	*mil*	*mil*	*mil*
Coarse soils (SM-SSP-SW)	225	8	30	30
Gravel (GC-GM-GP-GW)	—	12	30	30

Water surface elevations. All lined ditches and canals shall be designed so that the 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, the 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 in. (101 mm) shall be provided.

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 conservation irrigation. These structures can be installed before, during, or after the lining placement. They must be constructed or installed in such a way as to not damage or impair the effectiveness of the lining.

Materials. Flexible membrane liners shall equal or exceed the physical requirements indicated for materials under "Specifications".

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.

IRRIGATION WATER CONVEYANCE

FLEXIBLE MEMBRANE DITCH AND CANAL LINING SPECIFICATIONS

INSTALLATION

Preparing subgrades. Subgrades on which flexible membranes will be placed shall be raked to remove all large clods, roots, brush, sod, or rocks that might endanger the membrane. Rolling the subgrade is recommended to provide an extra measure of safety against punctures. In rocky areas, a cushion layer of fine soil shall be provided as a protection against irregularities that cannot be removed by rolling.

Placing membranes. Plastic and rubber membranes shall be carefully spread in a relaxed condition over the raked and smoothed subgrade. Rubber sheets may be pulled out smooth, but all liners shall be installed in a relaxed state. For polyethylene film, care shall be taken to insure that at least 5 percent slack is provided. Prefabricated asphalt membranes shall be pulled out so that they lay flat on the subgrade.

If the width or length of the lining specified requires placing sheets together, all joints shall be watertight, and the strength of the bonded seam in any direction shall not be less than 80 percent of breaking strength (ultimate tensile strength) of the membrane when the specimen is pulled in shear.

Anchoring membranes. Small anchor trenches about 10 in. (254 mm) wide and 12 in. (304 mm) deep shall be used to anchor the sides of the membrane. These trenches shall be located along the berm on both sides of the canal. They shall be a minimum of 4 in. (101 mm) back on the berm from the top of the side slope and at the elevation required to maintain the specified freeboard. The membrane shall conform to the trench shape and shall extend a minimum of 8 in. (203 mm) up the side opposite the canal. The trenches shall be carefully backfilled and compacted after the membrane is in place.

The upstream end of each section of plastic or rubber membrane shall be anchored in a trench dug across the canal. This trench shall be about 10 in. (254 mm) wide and 12 in. (304 mm) deep and shall connect with the two side anchor trenches. The upstream end of the membrane section shall lap down a minimum of 12 in. (304 mm) into this transverse trench. After the membrane is in place, the trench shall be carefully backfilled with selected compacted material. Prefabricated asphalt membranes shall be anchored at the upstream end of the lining section and at such intermediate points as are specified for individual jobs.

No anchors shall be required at the downstream end of membrane sections. The downstream end of the membrane shall be lapped a minimum of 3 ft (0.9 m) over the anchored upstream end of the next section. Placement of the protective cover material will secure the joint.

Placing protective cover. Material to be used as protective cover on membrane linings shall be free of large clods and sharp rocks and shall be carefully placed to the specified depth without damaging the membrane.

Construction operations. 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 workmanlike and present a good appearance.

MATERIALS

The flexible sheets or films to be used as buried membrane linings in irrigation ditches or canals shall be suitably constructed of high-quality ingredients and shall be certified by the manufacturer to be suitable for this intended use. Pigmented polyvinyl or polyethylene plastic, rubber, asphalt, or similar materials that are highly resistant to bacteriological deterioration shall be acceptable base materials for buried membrane linings.

The fabricated membranes shall be uniform throughout and shall be free from dirt, oil, foreign matter, pits, tears, holes, or other defects that can affect their serviceability. They shall be packaged so as to prevent damage from rough handling during shipment and so as to facilitate placement at the job site. Each package shall be marked with the name of the material, the manufacturer's name or symbol, the quantity contained therein, and the thickness or unit weight of the material.

Flexible membrane liners of the materials shown shall equal or exceed the physical requirements listed in table 1 (polyethylene and ethylene copolymer plastic film); table 2 (reinforced rubber sheeting); and table 3 (unreinforced rubber sheeting). Polyvinyl chloride plastic sheeting shall meet the requirements indicated in ASTM-D-3083, table 4, table 5 (unreinforced chlorisulfonated polyethylene), and table 6 (reinforced chlorisulfonated polyethylene).

Table 1. Requirements for polyethylene and ethylene copolymer plastic film.

Test description		Requirements		Test method
		Type I polyethylene	Type II copolymer	
Tensile strength				
Each direction, minimum average	*lb/in.*^{2}	1,800	2,000	ASTM-D-882, Method "A"
Ultimate elongation				
Each direction, minimum average	*pct*	500	500	ASTM-D-882, Method "A"
Impact resistance				
Minimum average	*g/mil*	45	65	ASTM-D-1709, Method "B"
Water vapor permeability	*perm-mil*	0.7	1.5	ASTM-E-96
Tear resistance (Elmendorf)				
Each direction, minimum	*g/mil*	80	80	ASTM-D-1922
Soil burial				
Tensile retained, each direction, minimum	*pct*	95	95	ASTM-D-3083
Elongation retained, each direction, minimum	*pct*	80	80	
Luminous transmittance, maximum	*pct*	1.0	1.0	National Bureau of Standards Publication PS-17

Table 2. Requirements for reinforced rubber sheeting

Test description		Requirements		Test method
		As much as 20 mils thick	20 mils thick and greater	
Breaking strength, minimum				
Warp direction	*lb/in.*	75	100	ASTM-D-751
Fill direction	*lb/in.*	75	100	ASTM-D-751
Ultimate elongation, maximum				
Warp direction	pct	30	30	ASTM-D-751
Fill direction	pct	30	30	ASTM-D-751
Ozone resistance, procedure "B"				
50 pphm, 100 ^{o}F	*days*	7	7	ASTM-D-1149 and ASTM-D-518
Hydrostatic strength retained after				
ozone exposure, 7 days (Mullen)	*pct*	100	100	Federal Specification CCC 191 b, Method 5512
Heat aging, 7 days at 212 ^{o}F				
Tensile strength retained	*pct*	90	90	ASTM-D-573
Elongation retained	*pct*	90	90	ASTM-D-573
Tear resistance, minimum, warp or				
fill direction	*lb*	8	8	ASTM-D-751 (tongue)
Hydrostatic burst (Mullen), minimum	*lb/in.*^{2}	100	175	ASTM-D-751
Dimensional stability, 7 days at 212 ^{o}F,				
change in length or width	*pct*	± 1.0	± 1.0	([1])
Low temperature flexibility (optional)				
No cracking or flaking		- 40 ^{o}F	- 40 ^{o}F	Federal Specification CCC 191 b, Method 5874
Commercial field splice strength				
Shear force, minimum tensile	*pct*	75	75	Commercial field splice 1-inch wide strip, pulled in shear at 10 in./min, after 7 days cure room temperature

[1]A 1-ft2 sample, 10 in. bench marks in warp and fill direction, placed on aluminum or stainless plate in changing air over.

Table 3. Requirements for unreinforced rubber sheeting

Test description		Requirements		Test method
		Type A	Type B	
Tensile strength, minimum	*lb/in.*^{2}	1,200	1,200	ASTM-D-412
Modulus at 300% elongation, minimum	*lb/in.*^{2}	600	600	ASTM-D-412
Ultimate elongation, minimum	*pct*	300	300	ASTM-D-412
Shore "A" hardness		60 ± 10	60 ± 10	ASTM-D-2240
Ozone resistance, procedure A				ASTM-D-1149
No cracks, 50 pphm at 100 °F, 20% elongation	*days*	7	—	ASTM-D-518
No cracks, 100 pphm at 100 °F, 50% elongation	*days*	—	7	ASTM-D-518
Heat aging, 7 days at 212 °F				ASTM-D-573
Tensile strength retained	*pct*	75	75	
Elongation retained	*pct*	75	75	
Water vapor permeability at 80 °F	*perm mil*	0.002	0.05	ASTM-E-96 (procedure BW)
Tear resistance, minimum	*lb/in.*^{2}	150	150	ASTM-D-624 Die "B"
Dimensional stability, 7 days at 212 °F,				
change in length or width	*pct*	± 0.5	± 0.5	
Commercial field splice strength shear force, minimum tensile	*pct*	60	60	Commercial field splice, 1-inch-wide strip pulled in shear at 10 in./min, after a 7-day cure at room temperature.

NOTE: Type A sheeting is recommended for general-purpose outdoor use. Type B sheeting is suggested if an extreme outdoor environment makes a highly wearable lining necessary.

Table 4. Requirements of polyvinyl chloride plastic sheeting

Test description		Requirements	Test method
Tensile strength, each direction, minimum average	*lb/in.*^{2}	2,000	ASTM-D-882
Elongation at break, minimum	*pct*	250	ASTM-D-882, Method A
Volatile loss, maximum	*pct*	0.7	ASTM-D-1203, Method A
Water extraction, maximum weight loss	*pct*	0.5	ASTM-D-1239
Tear resistance, each direction, minimum	*g/mil*	160	ASTM-D-1922
Resistance to soil burial (percent change max. in original value)			(120-day soil burial)
Breaking factor	*pct*	-5	
Elongation at break	*pct*	-20	
Modulus at 100% elongation	*pct*	± 10	
Bonded seam strength, percent breaking factor	*pct*	80	ASTM-D-3083 Para. 9.3

(1-inch width)

Table 5. Unreinforced chlorisulfonated polyethylene

Test description		Requirements	Test method
Tensile strength, minimum psi	*pct*	1,000	ASTM-D-412
Ultimate elongation, minimum	*pct*	250	ASTM-D-412
Ozone resistance, 50 pphm, 20% strain, 100 °F, 8,000 hrs	*pct*	± 0	ASTM-D-1149
Heat aging, 14 days at 212 °F			
Tensile strength, minimum psi	*pct*	1,000	
Elongation at break	*pct*	150	
Tear resistance, minimum	*lb/in*	250	ASTM-D-624 Die B
Commercial field splice			ASTM-D-882, Method A
Strength, shear force, minimum tensile	*pct*	60	(7 days cure)
Weight change after 7 days at 70 °C in water, maximum	*pct*	5	ASTM-D-471

Table 6. Reinforced chlorisulfonated polyethylene

Test description		Minimum requirements 30 mil thick and greater	Test method
Breaking strength, minimum			ASTM-D-751
Rubber	*lb/in*	100	
Fabric	*lb/in*	75	
Ultimate elongation, maximum			
Rubber	*pct*	150	
Fabric	*pct*	20	
Ozone resistance, 50 pphm, 20% strain at 100 °F, 8,000 hrs	*pct*	± 0	ASTM-D-1149
Hydrostatic strength after ozone exposure, 7 days (Mullen), % retained	*pct*	100	Fed. Spec. CCC 191b Method 5512, ASTM-D-518
Heat aging, 14 days at 212 °F of original			
Tensile strength	*pct*	90	
Elongation % retained of original	*pct*	90	
Tear resistance, lbs minimum			ASTM-D-751
Warp or fill direction	*pct*	10	(tongue)
Puncture resistance, lbs minimum	*pct*	120	FTMS-101B, Method 2031
Commercial field splice Strength—shear force, % of minimum break	*pct*	75	ASTM-D-882, 7 days cure

PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY

Quantity

1. Effects on the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.

2. Effects on downstream flows or aquifers that would affect other water uses or users.

3. Potential uses for irrigation water management.

4. Potential changes in growth and transpiration of vegetation located next to the conveyance because of the elimination of leakage from the system.

Quality

1. Effects of installing the lining on the erosion of the earth conveyance and the movement of sediment and soluble and sediment-attached substances carried by water.

2. Effects of the practice on the movement of dissolved substances to ground water.

3. Effects of wetlands or water-related wildlife habitats.

4. Effects on the visual quality of water resources.