

NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD
IRRIGATION WATER CONVEYANCE
DITCH AND CANAL LINING, PLAIN CONCRETE
(Ft.)
CODE 428A

DEFINITION

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

PURPOSE

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

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to concrete linings made of nonreinforced Portland cement concrete.

Ditches and canals to be lined shall serve as integral parts 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 be located where they are not susceptible to damage from side drainage flooding, or they shall be protected from such damage.

Plain concrete linings shall be installed only in well-drained soils or on sites where subgrade drainage facilities are installed with or before

the lining. These linings shall not be installed on sites susceptible to severe frost heave or on sites where experience has indicated that the sulfate salt concentration in the soil causes rapid deterioration of concrete.

CRITERIA

General. All irrigation systems shall be operated in accordance with an Irrigation Water Management (IWM) Plan. IWM plans shall be in accordance with the South Dakota Standard for Irrigation Water Management – Code 449.

Plain concrete linings installed under the practice standard shall be limited to ditches or canals with:

a bottom width not greater than six feet,
 flow capacity equal to or less than 100 cubic feet per second, and
 design velocity equal to or less than 15 feet per second.

Materials. On sites where sulfate concentrations exist, concrete linings may be used only if they are made using special sulfate-resistant cement in accordance with those shown in Table 1.

Fly ash can be used to replace up to 15 percent of the cement, by weight when other pozzolans are not used.

Air-entrainment admixture is recommended to improve workability and reduce damage due to freeze-thaw cycles. In-place, air content shall not exceed seven percent of the volume of concrete.

Consider the addition of fiber reinforcement to increase durability and reduce the potential for minor cracking.

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 ≥ 0	SO ₄ ≥ 0	Any
SO ₄ ≥ 0.10	SO ₄ ≥ 150	II, IP(MS), IS(MS), P(MS), I(PM)(MS), I(SM)(MS)
SO ₄ ≥ 0.2	SO ₄ ≥ 1500	V
SO ₄ > 2.00	SO ₄ ≥ 10000	V plus pozzolan*

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

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

The capacity shall be enough to deliver water needed for irrigation to meet design peak consumptive use of crops.

The capacity shall be enough to provide an adequate irrigation system for all methods of irrigation planned.

For design purposes, the capacity shall be considered to be equal to the capacity as computed by Manning's Formula, using a coefficient of roughness, "n," of not less than 0.015.

Velocity. To avoid unstable surge flows, restrict design velocities in excess of 1.7 times the critical velocity to 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 ft./s.

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 takeout structure or device.

Freeboard. The required freeboard varies according to the ditch or canal, 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 three inches (in.) of lining above the design water surface.

Minimum freeboard requirement is based on assumption that the finished channel bottom elevation will vary no more than 0.1 ft. from design elevations. If a construction deviation greater than 0.1 ft. 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 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 four in. shall be provided (six inches is recommended).

Where head is greater than six in. and on erosive soils, exit velocities at gates, turnouts or siphon tubes may need to be reduced by energy reduction devices.

Lining thickness. Thickness of canal linings must be established on the basis of engineering consideration on each job. Location, canal size, velocity, subgrade conditions, method of construction, operation,

and climate shall be evaluated in establishing thickness to be used. Minimum thickness for plain concrete linings in rectangular sections shall be 3½ in. For trapezoidal or parabolic sections, minimum thickness shall be in accordance with Table 2.

Table 2. — Minimum required thickness for plain concrete ditch and canal linings

Design velocity ¹ (ft/s)	Minimum thickness by climatic area ² (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

¹Velocities in short chute sections shall not be considered design velocity.

²Climatic area:

Warm – Average January temperature is 40 °F and above

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

Ditch or canal side slopes. Plain concrete linings are generally used in ditches and canals that have either a trapezoidal or parabolic cross section.

They may be used in rectangular sections if the sidewall height is not greater than 1½ ft. Side slopes for usual construction methods shall not be steeper than shown below:

Hand-placed, formed concrete:

Height of lining less than 1½ ftVertical

Hand-placed, screeded concrete:

Height of lining less than 2½ ft3/4H to 1V*

Height of lining more than 2½ ft1H to 1V

Slip form concrete:

Height of lining less than 3 ft1H to 1V

Height of lining more than 3 ft1¼H to 1V

*H – Horizontal, V – Vertical

Ditch or canal banks. Ditch and canal banks shall be constructed with earth to at least the top edge of the lining. In cut sections, other than in rock, a berm shall be constructed not less than two in. above the top of the lining.

Banks and berms shall be wide enough to ensure stability of fills and to prevent excessive deposition in cut sections.

When using siphon tubes, minimum berm or bank width of 12 in. 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 in. at 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 ft.

Outside bank slopes and slopes above the berm elevation in cut sections must be flat enough to insure stability and allow maintenance.

A minimum slope is 2H to 1V is recommended. Where vegetation will be maintained by mowing, the minimum slope shall be 3H to 1V.

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.

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

All structures shall meet applicable NRCS Conservation Practice Standard requirements for the type of structure used.

CONSIDERATIONS

Effects of downstream flows or aquifers that would affect other water usages 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.

Potential use for irrigation water management.

PLANS AND SPECIFICATIONS

Plans and specifications for installing plain concrete 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 plain concrete 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.

Minimum requirements to be addressed in the O&M Plan are: prompt repair or replacement of damaged components as necessary, removal of debris and foreign material, and maintenance of good vegetative cover on all slopes and watercourses.

This is in the existing state standard and is still required. The national standard listed typical O&M. SD wanted to be more specific as to what is required.

REFERENCES

USDA-NRCS, National Engineering Field Handbook for Conservation Practices, Chapters 3, 6, and 15.

ASAE Standard S289.1, Concrete Slip-form Canal Linings.