NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

LIVESTOCK PIPELINE

(Ft.)

CODE 516

DEFINITION

A pipeline and appurtenances installed to convey water for livestock or wildlife.

PURPOSE

This practice may be applied as part of a resource management system to achieve one or more of the following purposes:

- Convey water to points of use for livestock or wildlife.
- Reduce energy use.
- Develop renewable energy systems.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to the conveyance of water through a closed conduit, from a source of supply to a watering facility, for use by livestock or wildlife.

This practice does not apply to the use of pipelines for irrigation, which are addressed by Natural Resources Conservation Service (NRCS) Conservation Practice Standard (CPS) Irrigation Pipeline (430).

CRITERIA

General Criteria Applicable to All Purposes

The volume, quality, and rate of delivery by the pipeline shall be sufficient to make use for livestock or wildlife practical and feasible.

Pipelines shall be placed only in or on soils with environmental conditions suitable for the type of material selected.

Laws and Regulations. This practice must conform to all federal, state, and local laws and regulations.

Livestock Water Distribution. Stock watering facilities should be located so the travel distance between forage and dependable water is no more than three quarters of a mile. Location of the facilities shall be planned in conjunction with the prescribed grazing plan.

Capacity. Capacity shall be sufficient to convey the design delivery flow rate for the planned conservation practices.

In computing the capacity requirements, allowance must be made for reasonable water losses during conveyance and use.

Capacity - Livestock Water. For livestock water, the installation shall provide the minimum capacity shown in Table 1. Higher flow rates may be needed to meet grazing plan goals.

On large extensive systems, peak use based on maximum flow from all outlets may not be needed. In these systems, capacity may be based on the maximum number of outlets used and livestock served at any one time.

Table 1. - Minimum Water Supply Per Animal	
Animal	Water, Gal./Day
Beef Cattle:	
Cows lactating with calves	18
Bred, Dry Cows and Heifers	15
400 lb. Growing Cattle	10
600 lb. Growing Cattle	13
800 lb. Growing Cattle	15
Bulls	19
600 lb. Finishing Cattle	15
800 lb. Finishing Cattle	18
1000 lb. Finishing Cattle	21
1200 lb. Finishing Cattle	23
Dairy Cattle:	
1400 lb. Dry Cow	16
1700 lb. Dry Cow	17
Lactating, 20 lb. Milk	18
Lactating, 60 lb. Milk	25
Lactating, 80 lb. Milk	28
Lactating, 100 lb. Milk	33
200 lb. Heifer	3
400 lb. Heifer	6
800 lb. Heifer	11
1200 lb. Heifer	15
Swine:	
Boars & Gestating Sows	3
Lactating Sows	5
15 – 50 lb. Feeder	0.75
50 – 120 lb. Feeder	1
120 lb. to Market	2
Horses:	
Mature	18
Weanling	8
Sheep & Goats:	
Rams & Dry Ewes	2
Ewes with lambs	3
Feeder Lambs	1.5
Suckling Lambs	0.3
Birds:	
100 Chickens	9
100 Turkeys	15

Capacity – Domestic Use. System capacity must be adequate for all planned uses. Normal minimum design capacity shall be 10 gallons per minute (gpm) and 360 gallons per day per headquarters or dwelling unit. For larger headquarters and/or multiple users, minimums are given in Tables 2 and 3.

Table 2. - Dwelling Minimum Water Supply	
Number of Dwellings	Minimum Gallons per Minute (gpm)
1	10
2	18
3	24
4	30
5	35
10	65
14	84

Table 3. - Farmstead Equipment Minimum Water Supply	
Equipment	Minimum Gallons per Minute (gpm)
Automatic waterers	
Cattle, hogs, sheep	
(20-40 head/bowl)	2
Poultry	
(100-150 layers)	1
Cleaning hose	10
Outdoor hydrant for uses other than firefighting	5
Fire fighting hydrant	20

(Suggested reference: Midwest Plan Service Structures, Environment Handbook (MWPS-1).

Capacity – Recreation. System capacity shall be adequate for all planned uses. Typical examples are drinking water, fire protection, showers, flush toilets, and irrigation of landscaped areas.

Capacity – Wildlife. Additional capacity will be provided for planned purposes. Daily water consumption may be calculated at one gallon per day per 100 pounds of body weight, or specific amounts based on species.

Sanitation Protection. If water from the pipeline is to be used for human consumption, applicable state and local regulations shall be met. Pipe conveying water for human consumption shall bear the National Sanitary Foundation Seal.

To prevent contamination or flow reversal on systems used for human consumption, double (or two single) spring-loaded check valves shall be used on all outlets or branch lines.

Pipe Size. Minimum nominal pipe diameter shall be three-quarter inch. Where deposits in pipelines occur, minimum pipe diameter shall be one and one-half inch (1½").

Friction and Other Losses. For design purposes, head loss for hydraulic grade line computations shall be based on using one of the following equations: Hazen-Williams, Darcy-Weisbach, or Manning's. Equation selection shall be based on the given flow conditions and the pipe materials used. Other head losses (also called minor losses) from change in velocity and direction of flow due to inlet type, valves, bends, enlargements or contractions can be significant and shall be included as appropriate. For closed, pressurized systems, the hydraulic grade line for all pipelines shall be maintained above the top of the pipeline at all locations for all flows, unless specifically designed for negative internal pressures.

Friction head losses shall be no less than those computed by using the roughness coefficients in Table 4:

Table 4. Pipe Roughness Coefficient

Pipe Type:	Steel/Iron	Thermoplastic
Manning's N	0.012	0.009
Hazen Williams C	110	150

Pipe Design. Pipelines shall be designed to meet all service requirements such that internal pressure, including hydraulic transients or static pressure at any point is less than the pressure rating of the pipe.

Flexible conduits such as plastic and metal pipe shall be designed using NRCS National Engineering Handbook (NEH), Part 636, Chapter 52, Structural Design of Flexible Conduits, and the following criteria:

Plastic Pipe. When operating at design capacity, the full-pipe flow velocity should not exceed five feet per second in pipelines with valves or some other flow control appurtenances placed within the pipeline or at the downstream end. As a safety factor against transient pressures (surge or water hammer), the working pressure at any point should not exceed 72 percent of the pressure rating of the pipe including any reductions for water temperature. Pipe pressure rating should be at least 100 pounds per square inch. If any of these limits are exceeded, an engineer must prepare a detailed hydraulic analysis to demonstrate adequate protection for the pipeline against transient pressures.

Pressure ratings for pipes are normally based on a pipe temperature of 73.4ºF. When operating temperatures are higher, the effective pressure rating of the pipe shall be reduced accordingly. Factors for adjusting allowable working pressure for higher water temperature are given in Table 5.

Note: To obtain reduced pipe pressure rating, multiply the normal pipe pressure rating by the appropriate factor from table.

Table 5. Pressure rating factors for PVC and PE pipe for water at elevated temperatures

Degrees F	PVC	PE
73.4	1.00	1.00
80	.88	.92
90	.75	.81
100	.62	.72
110	.50	.63
120	.40	.60
130	.30	.55
140	.22	.50

Plastic pipe shall meet ASTM D1785 or D2241 for polyvinyl chloride (PVC).

HDPE pipe material used shall be PE 3408 as per ASTM D3350 and pipe shall be manufactured in accordance with ASTM D2239 Polyethylene (PE) Plastic Pipe (SIDR-PR) based on Controlled Inside Diameter or, ASTM D3035 Polyethylene (PE) Plastic Pipe (SDR-DR) based on Controlled Outside Diameter. The pipe shall be Class C Polyethylene pipe compound as described in ASTM D2239 or D3035.

Equivalent plastic pipe, solvents, rubber gaskets, and fittings conforming to other ASTM or AWWA specifications may also be used as appropriate.

Material used in plastic pipe installed above ground (or otherwise exposed) must meet HDPE material requirements, contain a minimum of two percent carbon black and have a pressure rating of at least 160 pounds per square inch.

Metal Pipe. The specified maximum allowable pressure shall be determined using the hoop stress formula, limiting the allowable tensile stress to 50 percent of the yield-point stress for the material selected. Design stresses for commonly used metal pipes are shown in NEH, Part 636, Chapter 52.

Steel pipe shall meet the requirements of AWWA Specification C-200.

Support of Pipe. Pipelines installed above ground shall be supported, where needed, to provide stability against external and internal forces. Pipe support shall be designed using NEH, Part 636, Chapter 52.

Joints and Connections. All connections shall be designed and constructed to withstand the pipeline working pressure without leakage and leave the inside of the pipeline free of any obstruction that would reduce capacity.

Use of gasketed joints is preferred over solvent weld joints on thermoplastic pipelines one and one-half inch diameter and larger for increased thermal expansion capabilities.

Permissible joint deflection shall be obtained from the manufacturer for the type of joint and pipe material used.

For sloping metal pipe, expansion joints shall be placed adjacent to and downhill from anchors or thrust blocks.

For welded pipe joints, expansion joints shall be installed, as needed, to limit pipeline stresses to the allowable values.

The allowable longitudinal bending for the pipeline shall be based on type of material and the pressure rating, and shall be in accordance with industry standards, or as described in NEH, Part 636, Chapter 52.

For suspended pipelines, joints shall be designed for pipe loading, including the water in the pipe, wind, ice, and the effects of thermal expansion and contraction.

Joints and connections for metal pipes should be of similar materials whenever possible. If dissimilar materials are used, the joints or connections shall be protected against galvanic corrosion.

Depth of Cover. All pipe shall be buried to protect it from hazards such as traffic, farm operations, freezing temperatures, thermal expansion and contraction, ultra-violet degradation, and sharp rocks. Reasonable measures should be taken to protect the pipe from vandalism. Shallow burying or covering the pipe with six inches of soil may be used for seasonal use pipelines.

Depth of Cover Exception. Above ground pipe meeting HDPE material requirements may be used if one of the following conditions is met:

Pipeline is to be used in conjunction with the CPS Prescribed Grazing (528) where each pasture will be grazed two or more times per year with the livestock in each pasture no more than 2 consecutive weeks at a time. Pipe must be protected by placing under fence lines and shallow burying at gates, roads, or other crossings; or

Pipe length is less than 2,640 feet; or

Pipe length may be longer than 2,640 feet if shallow burial is required because of shallow soil, rock, cultural resource avoidance, slope stability, or other site-specific reasons throughout the majority of the length of the pipeline.

Pipelines used for water supply during freezing weather must be installed below average frost line or be otherwise protected from freezing.

Seasonal use pipelines that will be subject to freezing shall be drained prior to winter.

Normal frost free pipeline burial depth is shown in Figure 1.

For pipelines that will flow constantly (from springs, artesian wells, etc.,) minimum uninsulated burial depth for winter is one and one-half feet.

Plastic pipe may expand or contract 1.4 inches per 100 feet of pipe length for each 10°F change in temperature. Rigid pipes must include “slip” (rubber gaskets, etc.,) joints, and flexible pipes must be “snaked” to accommodate these length changes.

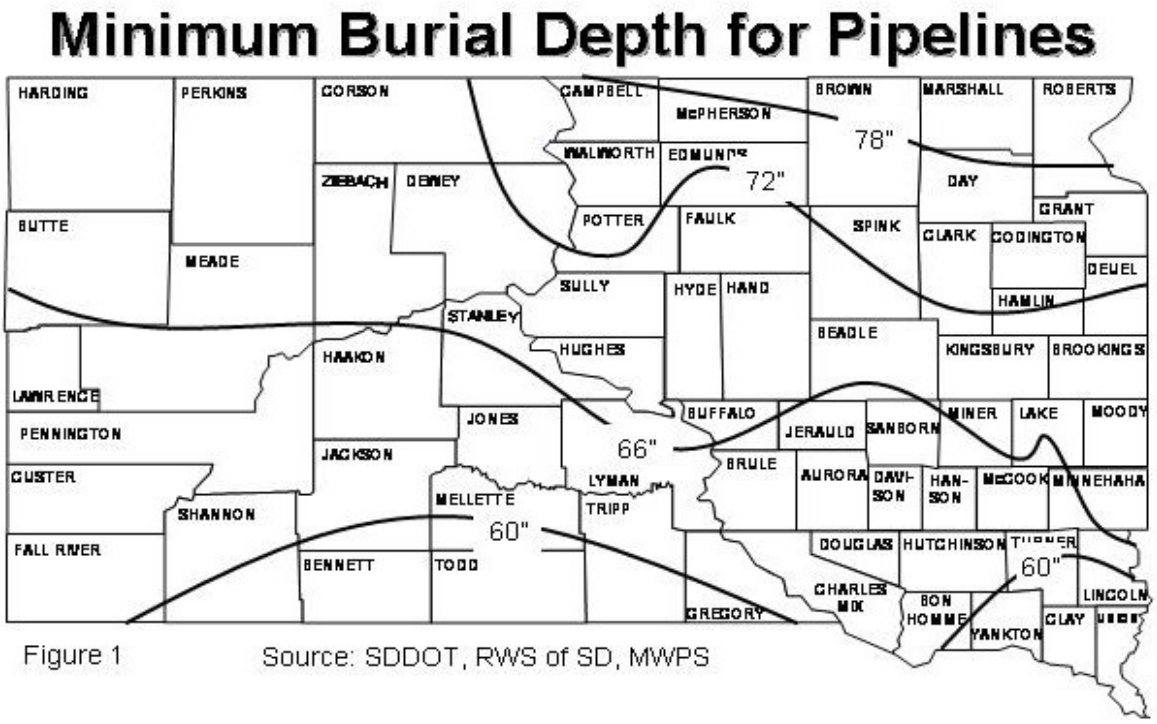

Figure 1 Source: SDDOT, RWS of SD, MWPS

Pressure Reduction. Pressure Reducing Valves or Breaker Tanks shall be incorporated in circumstances such as head gain exceeding pressure loss by a significant amount, excessive static pressures, or excessive flow rates.

Valves and Other Appurtenances. Pressure ratings of valves and other appurtenances shall equal or exceed the design working pressure. When lever operated valves are used, an analysis shall be performed to evaluate potential transient pressures, assuming rapid valve closure.

Check Valves and Backflow Prevention. A Check Valve shall be installed between the pump discharge and the pipeline if detrimental backflow may occur. Check valves may be required in pipelines delivering water to points at higher elevations to prevent flow reversal.

Approved backflow prevention devices shall be used on all pipelines where back flow may contaminate the source water supply or groundwater.

Pressure Relief Valves. A pressure relief valve shall be installed between the pump discharge and the pipeline if excessive pressure can build up when all valves are closed. If needed to protect the pipeline against malfunction or failure of pressure reducing valves, Pressure relief valves shall be installed downstream of pressure reducing valves.

Pressure relief valves shall be set to open at a pressure as low as practical, but no greater than

five pounds per square inch above the design working pressure rating or maximum allowable pressure of the pipe. The valves shall have sufficient flow capacity to reduce the excessive pressures in the pipeline. The pressure at which the valves start to open shall be marked on each pressure relief valve. Adjustable pressure relief valves shall be sealed or otherwise altered to prevent changing the adjustment from that marked on the valve.

In lieu of a detailed transient pressure analysis, the minimum size of pressure relief valve shall be ¼ inch nominal valve size per inch of the nominal pipeline diameter.

Air Vents. Provide for entry and removal of air along the pipeline, as needed to prevent air locking, hydraulic transients, or pipe collapse. Include provisions for air release and vacuum relief, as needed to protect the pipeline. Design the pipeline to remain below the hydraulic grade line during operation. If parts of the pipeline will be located above the hydraulic gradient, periodic use of an air pump may be required.

Surge Tanks and Air Chambers. Where surge tanks or air chambers are required for control of hydraulic transients or water column separation, they shall be of adequate size to ensure the water volume needs of the pipeline are met without the tank/chamber being emptied, and the required flow rate into the pipeline for the calculated pressure drop is met.

Outlets and Water Level Control.
Appurtenances to deliver water from the pipe to the watering facility shall have adequate capacity to deliver the required flow. Where water is supplied continuously to the watering facility, use automatic water level controls (such as float valves) to control the flow of water and to prevent unnecessary overflows.

Flow restrictor valves should be used on group pipelines to control flow to outlets and prevent periods of no flow on sections of the pipeline. They may also be used to maintain design flows.

Valves used to control flow may be smaller than the nominal size of the pipeline. Size shall be based on allowable velocity and headloss.

Suitable screens, strainers, or other protection should be considered to protect valves and other appurtenances that are prone to plugging.

Design outlets and water level controls to withstand or be protected from damage by livestock, wildlife, freezing and ice damage. Outlets shall be designed to minimize erosion, physical damage, or deterioration due to exposure.

Thrust Control. Abrupt changes in pipeline grade, horizontal alignment, or size reductions, may require an anchor or thrust blocks to absorb pipeline axial thrust. Thrust control is typically needed at the end of the pipeline, and at in-line control valves. The pipe manufacturer's recommendations for thrust control shall be followed. In absence of manufacturer's data, thrust blocks shall be designed using NEH, Part 636, Chapter 52.

Thermal Effects. For plastic pipe, thermal effects must be properly factored into system design. Values and procedures for pressure rating reduction shall follow information described in the NEH, Part 636, Chapter 52.

Physical Protection. Steel pipe installed above ground shall be galvanized or shall be protected with a suitable protective paint coating, including a primer coat and two or more final coats.

Plastic pipe installed above ground shall be resistant to ultraviolet light throughout the intended life of the pipe, or measures must be taken to protect the pipe from damage due to ultraviolet light.

All pipes shall be protected from hazards presented by traffic loads, farm operations, freezing temperatures, fire, thermal expansion and contraction. Reasonable measures shall be taken to protect the pipe from potential vandalism.

Filling. The pipeline system shall have a means of controlling the filling of the pipeline to prevent entrapment of air or excessive transient pressures.

Filling velocities greater than one foot per second in a pipe system that is closed to the atmosphere (i.e., all outlets closed), requires special evaluation and provisions to remove entrapped air and prevent excessive transient pressures.

If filling at a low flow rate is not possible, the system shall be open to the atmosphere (outlets

open) prior to pressurizing. The system shall be designed for air removal and excessive transient pressures that may develop at higher filling rates.

Flushing. If the sediment load in the water is significant, the pipeline shall have adequate velocity to ensure that sediment is moved through and flushed out of the pipeline.

If provisions are needed for flushing sediment or other foreign material, a suitable valve shall be installed at the distant end or low point of the pipeline.

Draining. Provisions shall be made to drain pipelines that are installed above the frost line. Check valves shall be installed as needed to protect water quality or maintain a full pipeline.

The water drained from pipelines shall not cause water quality, soil erosion, or safety problems upon release.

Safe Discharge of Water. Provisions shall be made for water being discharged from valves, especially air valves and pressure relief valves. These valves shall be located such that flows are directed away from system operators, livestock, electrical equipment, or other control valves.

Water Bars. Water bars (flow barriers) should be installed across the pipe trench on long slopes or other locations where runoff water may cause erosion.

Vegetation. Disturbed areas not expected to naturally revegetate shall be vegetated or otherwise stabilized as soon as practical after construction. Vegetation establishment shall conform to NRCS CPS Critical Area Planting (342).

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.

Additional Criteria Applicable to Develop Renewable Energy Systems

Renewable energy systems shall meet applicable design criteria in NRCS and/or industry standards, and shall be in accordance with manufacturer's recommendations. Hydropower systems shall be designed, operated, and maintained in accordance with the Microhydropower Handbook, Sections 4 and 5, as appropriate.

CONSIDERATIONS

Consider location of water supply outlets to avoid concentration of livestock near homes, recreation areas, streams, lakes, and other areas needing protection.

Above ground pipelines may be moved to a point where the original design may not be valid. The pipeline/owner operator shall be instructed that moving the pipe may change the performance of the pipeline and lead to the failure of the pipe.

Safety. Pipeline systems may present a hazard to the safety of people, during installation and operation. Consider safety as follows:

- Address trench safety in design and during construction.
- Provide protection for people from high pressure water blowing from pressure relief, air release, and other valves.
- Determine the existence or non-existence of underground utilities prior to construction.

Economics. Consider economics in pipeline design, as follows:

- Select pipe sizes based on lifetime energy requirements, versus initial costs of materials.
- Select pipe material based upon the expected service life of practice.
- Consider hydropower applications as alternatives to the use of pressure reducing valves or reduced pipe diameters to induce friction loss.

Other Resources. Consider potential impacts to other resources as follows:

- Address rare plant species and cultural resources during the installation of buried pipelines. When possible, avoid these resources, as well as wetlands and other habitats that are highly sensitive to disturbance, or include measures to minimize impacts.
- Consider the visual design of pipelines and appurtenances, especially in areas of high public visibility.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for Livestock Pipelines that describe the requirements for applying the practice according to this standard. As a minimum, the plans and specifications shall include:

- A plan view of the layout of the pipeline.
- Profile view of the pipeline.
- Pipe sizes and materials.
- Pipe joint requirements.
- Site specific construction specifications that describe in writing the installation of the pipeline. Include requirements for pressure testing of the pipeline.
- Depth of cover and backfill requirements.
- Vegetative establishment requirements.

OPERATION AND MAINTENANCE

An Operation and Maintenance (O&M) Plan shall be developed for each Livestock Pipeline system installed and shall be provided to the owner/operator. The plan should document needed actions to ensure that practices perform adequately throughout their expected life.

O&M requirements shall be included as an identifiable part of the design. Depending on the scope of the project, this may be accomplished by written statements in the plans and specifications, the conservation plan narrative, or as a separate O&M Plan.

Other aspects of O&M, such as draining procedures, marking crossing locations, valve operation to prevent pipe or appurtenant damage, appurtenance or pipe maintenance, and recommended operating procedures, should be described as needed within the O&M Plan.

Changing the location of above ground pipe will change the performance of the pipe. A redesign of the pipeline at the new proposed location may be required.

Monitoring of any cathodic protection systems shall be performed as specified in the O&M Plan.

A filling procedure shall be developed, which details allowable flow rates and appurtenance operation at the various phases of the filling process, required to assure safe filling of the pipeline. Flow measuring devices, such as flow meters or other means (e.g., number of turns of a gate valve), should be used to determine the rate of flow into the pipeline system.

REFERENCES

Engineering Field Handbook

Unibell “Handbook of PVC Pipe”

McKinney, J.D., et al. Microhydropower Handbook, IDO-10107, Volumes 1 & 2. U.S. Department of Energy, Idaho Operations Office.

USDA-NRCS, National Engineering Handbook, Part 636, Chapter 52, Structural Design of Flexible Conduits.