**NATURAL RESOURCES CONSERVATION SERVICE**
**MONTANA CONSERVATION PRACTICE STANDARD**

# LIVESTOCK PIPELINE (FEET)

## 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 NRCS, **Field Office Technical Guide (FOTG), Section IV,** Conservation Practice Standard, 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.

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

For livestock or wildlife, provide the capacity necessary to meet the seasonal high daily water requirements for the number and species of animals to be supplied. **Minimum daily water requirements and recommended maximum travel distances are shown in the following two tables.**

**Minimum Daily Stockwater Requirement[1,2,3]**

| Animal | Conventional Grazing (gal/day) | Intensive Grazing (gal/day) |
|---|---|---|
| Range Cow | 15 | 20 |
| Cow and Small Calf | 20 | 25 |
| Dairy Cow | 25 | 30 |
| Horse | 15 | 20 |
| Buffalo | 20 | 25 |
| Sheep | 1.5 | 3 |
| Goat | 1.5 | 3 |
| Hog | 1.5 | 3 |
| Deer | 1.5 | -- |
| Antelope | 1.5 | -- |
| Elk | 6 | -- |

[1] **These are minimum volumes. If livestock are larger than average or there are other planning issues, the volume of storage should be increased accordingly.**

[2] **Daily water consumption for feeder cattle or winter use may be calculated at 1 gallon per day per 100 lbs.**

[3] **For summer conditions, a minimum of 2 gallons per day per 100 lbs. is recommended for cattle.**



**Conservation practice standards are reviewed periodically and updated if needed. To obtain the current version of this standard contact the Natural Resources Conservation Service.**

**NOTE:** This type of font **(AaBbCcDdEe 123..)** indicates NRCS National Standards.
**This type of font (AaBbCcDdEe 123..) indicates Montana Supplement.**

**Recommended Maximum Travel Distance to Watering Facilities**

| Type of Terrain | Conventional Grazing System Water Facility Maximum Travel Distance | Intensive Grazing System Water Facility Maximum Travel Distance [1] |
|---|---|---|
| Rough | 1/2 mile | 1/8 mile (660feet) |
| Rolling | 3/4 mile | 1/6 mile (880 feet) |
| Level | 1 mile | 1/4 mile [2] |
| NOTE: When two or more tanks are located in one pasture, tank spacing should be no farther than twice the travel distance. | | |
| [1] Livestock are checked daily. | | |
| [2] Assumes there are no visual obstructions in any direction between the livestock and the watering facility. If there are visual obstructions for an intensive water facility application, then use maximum travel distance for rolling terrain, 1/6 mile. | | |

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

**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, **FOTG, Section IV,** National Engineering Handbook (NEH), Part 636, Chapter 52, Structural Design of Flexible Conduits, and the following criteria:

**Minimum pipe size for stockwater pipelines shall be 1-1/4 inch nominal diameter. One inch diameter pipelines may be used for short distances with Area Engineer approval. These include ½-mile mainlines with no potential for expansion, or spurs to tanks up to 500' in length.**

Plastic Pipe. **The maximum system pressure for any condition shall not exceed the pressure rating of the pipe or appurtenances at any point in the pipeline. Pressure rating of plastic pipe and fittings shall be based on maximum water temperature.**

When operating at design capacity, the full-pipe flow velocity should not exceed 5 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, the working pressure **(pressure when the system is flowing at design capacity)** at any point should not exceed 72 percent of the pressure rating of the pipe. If either of these limits is exceeded, special design consideration must be given to the flow conditions, and measures must be taken to adequately protect the pipeline against transient pressures.

**Most livestock pipelines are designed with velocities less than 3 ft/sec. Transient analysis has shown that the maximum system pressure (working or static) shall not exceed:**

| Design Velocity (ft/sec) | % Pipe Pressure Rating |
|---|---|
| 0-1.5 | 100 |
| 1.5-3.0 | 90 |

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.

**Friction and Other Losses.** For design purposes, head loss for hydraulic grade line computations shall be based 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. **For plastic pipe design, the Hazen-Williams equation is most commonly used with C values of 150 for PVC and HDPE, and 145 for PE pipe with banded internal couplings. For steel pipe design, the Manning's Equation is most commonly used with a Manning's n value of 0.012 for un-lined and 0.010 for lined pipe.**

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.

**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.

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 **described in the Above Ground Pipe section of this Standard.**

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.

**HDPE shall be joined in accordance with the manufacturer's recommendations for the particular pipe to be installed. Fusion joining is the most common method of joining HDPE to HDPE pipe. Transition fittings are mechanical joint adapters used to join HDPE to metal pipe.**

**Protection for Buried Pipe.** Buried pipe shall be installed at sufficient depth below the ground surface to provide protection from hazards imposed by traffic loads, **livestock**, farming operations, freezing temperatures, or soil cracking as applicable.

**The minimum depth of cover for buried pipelines shall be 18 inches. If shallower depths are specified, provisions to protect the line shall be provided. Pipelines designed for winter use shall be designed with a minimum of 5 feet of cover, unless reliable weather data and an analysis indicate otherwise. In this case, Area Engineer approval is required.**

**Buried and above ground** pipelines shall have sufficient strength to withstand all external loads on the pipe for the given installation conditions. Appropriate live loads shall be used for the anticipated traffic conditions.

Where it is not possible to achieve sufficient cover **for road crossings**, or sufficient strength **for aerial spans**, a carrier (encasement) pipe or other mechanical measures shall be used.

Protection for Above Ground 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.

**In areas where it is not possible to bury the pipe due to shallow soils, rock, slopes, easement limitations for pipe burial, etc., the pipe shall be steel or High Density Polyethylene (HDPE).**

**The ground surface shall be as smooth as practical without projecting sharp rocks, crevices, or other irregularities that can create a point load or cause abrasion to the pipe. Avoid placement of above ground pipe on or near cattle trails, or in direct sunlight where water temperatures could deter livestock from drinking. Data indicates cattle prefer to drink water with moderate temperatures (63-82ºF).**

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.**

**For above ground steel pipelines with welded joints, anchor blocks and expansion joints shall be installed. The spacing shall limit pipe movement due to expansion or contraction to 40 percent of the sleeve length of the expansion coupling. The maximum pipe length between expansion joints shall be 500 feet.**

**For the design of above ground HDPE pipe (see Idaho Technical Note #17, Above-Ground Applications for Polyethylene Pipe).**

**Above ground HDPE pipe shall have adequate slack for thermal movement to protect fittings and joints. A minimum of 5 percent slack is required.**

**On sloping ground, HDPE pipe shall be adequately anchored to avoid pipe wall, joint, and connection stresses due to continuous downhill creep of the pipe. Anchors are required at all points of abrupt changes in grade, horizontal alignment, reduction in size, tees, wyes, and connections to livestock tanks, storage tanks, and pumps. The blocks shall be of sufficient size to withstand momentum, working pressure, and expansion and contraction forces that might cause pipe movement.**

Reasonable measures shall be taken to protect **above ground** pipe from potential vandalism.

**For above ground pipelines, all pipe shall be buried within 50 feet of a tank.**

**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.

**If water from the pipeline is to be connected to domestic or municipal water systems, include backflow prevention in accordance with National Engineering Manual (NEM), Part 503. An air gap is acceptable only when the watering facility is owned by the population at risk. If an air gap is used, the valve outlet shall be located above the rim of the tank a minimum of 2 inches.**

Pressure Reducing Valves. 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.

Pressure Relief Valves. A Pressure Relief Valve shall be installed between the pump discharge and the pipeline **in case the shutoff switch fails or** excessive pressure builds up when all valves are closed. **Pressure-relief valves shall also be installed downstream of pressure-reducing valves to prevent the pressure rating of the pipe from being exceeded should a** malfunction or failure of the Pressure Reducing Valve **occur**.

Pressure Relief Valves shall be set to open at a pressure as low as practical, **but no greater than 5 pounds per square inch above the pressure rating of the pipe.** The valves shall **be sized to release the entire flow rate before the pressure reaches 1.5 times the pressure rating of the pipe.** 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. 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.

**Air valve types are defined as follows:**

**Air-Release Valve (1-way valve)**

**A continuous acting valve that has a small venting orifice, generally ranging between 1/16 and 3/8 inch in size. This valve releases air from the pipeline once the line is filled and under working pressure.**

**Air-and-Vacuum Valve (2-way valve)**

**A large venting orifice which exhausts large quantities of air during filling operations and allows air to re-enter the line to prevent vacuum buildup during emptying. It is not continuous acting since air cannot escape once water enters the valve.**

**Combination Air-Vacuum-Air Release Valve (3 way valve)**

**Combines the functions of air-release and air-and-vacuum valves.**

**Pipelines at locations where static or operating pressures exceed 10 psi. An air-and-vacuum release and continuous acting air-release (3-way) valve shall be installed at the first summit from the water source and on all major summits. Major summits are defined as a high point in the line that is more than 50 feet above an adjacent low point.**

**An air-and-vacuum (2-way) valve shall be installed downstream of shutoffs if vacuum relief is needed to protect the pipeline from collapse, or allow pipe drainage. If needed, an air-and-vacuum valve shall be installed at the end of the pipeline to exhaust large volumes of air during filling. The need for valves at the end of pipelines shall be evaluated on a case-by-case basis. The need is based on an uphill grade at the end of the line and whether or not further escape of air is needed.**

**A continuous-acting air release (1-way) valve or manually-operated air vent shall be installed at all locations where the pipeline is more than 10 feet, but less than 50 feet above an adjacent low point. A frost-**

**free hydrant may be considered a manually-operated air vent.**

**Air vent size shall be based on pipeline size, pipe slope towards drains, and filling requirements. For pipeline size up to 3-inch diameter, 1/2-inch, (2-way) valves are generally adequate for filling operations, or preventing a vacuum from forming during emptying. For larger pipeline sizes, refer to the "Pipe Collapse Pressure and Air Valve Sizing" spreadsheet found on the NRCS web site under Engineering Software, Montana Engineering Spreadsheet List.**

**Pipelines at locations where static or operating pressures are less than 10 psi. The pipe shall be laid to grade such that all summits are well defined and can be vented. An open vent or continuous-acting air release (1-way) valve shall be installed at all summits.**

**In order to seat properly, air valves shall meet the manufacturer's seating requirements. They shall only be used where working pressure is at least 2 psi.**

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.

Design **overflow** outlets and water level controls to withstand or be protected from damage by livestock, wildlife, freezing and ice damage. **Overflow** outlets shall be designed to minimize erosion, physical damage, or deterioration due to exposure. **For maximum protection, outlets should be located a minimum of 40 feet from the tank. Refer to Watering Facility (Code 614) for additional criteria.**

**Thrust Control.** Abrupt changes in pipeline grade, horizontal alignment, or size reductions, may require an anchor or thrust blocks to absorb pipeline axial thrust **if gasketed joints are used**. Thrust control is typically needed at the end of the pipeline, and at in-line control valves **if gasketed joints are used**. 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, **or as shown below.**

Pressure ratings for pipes are normally based on a pipe temperature of 73.4º F. When operating temperatures are higher, the effective pressure rating of the pipe shall be reduced **using the factors in Table 1, or factors obtained from the manufacturer. Tests have shown HDPE pipe exposed to the sun reached temperatures of 130º F. when ambient temperatures were 85º F.**

**TABLE 1**

| Strength Reduction Factors for High Temperatures | | |
|---|---|---|
| **Temperature, ºF** | **Buried PVC Pipe** | **PE Pipe** |
| **≤ 73.4** | **1.0** | **1.0** |
| **80** | **0.88** | **0.92** |
| **90** | **0.75** | **0.81** |
| **100** | **0.62** | **0.72** |
| **110** | **0.50** | **0.63** |
| **120** | **0.40** | **0.60** |
| **130** | **0.30** | **0.55** |
| **140** | **0.22** | **0.50** |

**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 1 foot per second in a closed to the atmosphere pipe system (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 for the complete removal of water from the pipeline by gravity or other means when:

- Freezing temperatures are a hazard.
- Draining is required by the pipe manufacturer.
- Draining of the pipeline is otherwise specified.

**Blowing water out of the pipeline with an air compressor is not allowed.**

The water drained from pipelines shall not cause water quality, soil erosion, or safety problems upon release. **Drain outlets shall be protected from damage with rock, steel pipe, or concrete, and shall be located a safe distance from the pipeline.**

**Where the pipeline is buried below probable frost (5 feet minimum unless an analysis indicate otherwise), drains may be omitted provided appurtenances are not affected.**

**Drains at low points shall be included on all pipelines with minimum 18" of cover. HDPE pipelines can be an exception provided the pipelines are depressurized and appurtenances are not affected.**

**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.

**Vegetation.** Reestablish vegetation or otherwise stabilize disturbed areas as soon as practical after construction. Seedbed preparation, seeding, fertilizing, and mulching shall meet applicable criteria in NRCS, **FOTG, Section IV,** Conservation Practice Standard, 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

**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.
- **For shallow bury HDPE pipelines where drains are not included, consider the need for operation during cold weather or before the line thaws in the spring. Drains will allow early operation and generally allow a more usable system.**
- **Select the pipeline route to eliminate or minimize undulating grade changes and/or impacts to cultural resources.**
- **Consider more frequent air venting for artesian systems than contain gas, summits with extremely low operating heads, (less than 20 psi), and summits collecting air from multiple laterals or long reaches.**
- **Consider the potential for future expansion of the pipeline.**
- **Consider the effects of erosion and sedimentation from disturbed areas during and following construction.**
- **On above ground pipelines consider route selection or shallow earth cover to minimize potential fire and livestock damage and reduce the effects of direct sunlight.**

**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. 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, **trench maintenance to fill in areas of settlement,** and recommended operating procedures, should be described as needed within the O&M Plan.

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. This information shall be provided to the operator, and shall be incorporated into the O&M Plan as appropriate.

## REFERENCES

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

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

Engineering Field Handbook (EFH)**, Part 650**

**Taylor, Ken, Design Technical Note SD2006-1 Watering Facility Design Criteria for Cattle.**

**Montana Stockwater Pipeline Manual (MSPM)**

**Plastic Pipe Institute, "Above Ground Applications for Polyethylene Pipe".**

**Unibell, Handbook of PVC Pipe.**

**USDA NRCS, Idaho, Technical Note #17, Above-Ground Applications for Polyethylene Pipe.**