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

II. 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.

III. 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 Conservation Practice Standard, Irrigation Pipeline (430).

IV. CRITERIA
A. 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.

1. 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.

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

For pipelines that deliver to watering facilities which provide livestock access to at least 10 square feet of open water, the minimum design flow capacity shall be based on meeting daily water requirements for the maximum planned herd size within 12 hours. Daily requirements are listed in the ND 614 Practice Standard.

For pipelines that deliver to watering facilities with less than 10 square feet of open water, such as prefabricated winter waterers designed for use in corrals and feedlots, it is recommended that the minimum design flow be based on 2 gpm per drinking space accessible to the herd at a single point in time. At a minimum, the design flow capacity shall be based on meeting daily water requirements within 12 hours.

For water sources that supply domestic use in addition to livestock, design the system to provide 10 gpm per household.

2. 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. 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. **Hydraulic design of PVC or HDPE pipelines shall be based on a Hazen-Williams roughness coefficient of no less than 150.** See NEH Part 650, Engineering Field Handbook, Chapter 3 Hydraulics for guidance on other materials.

3. 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.

**Minimum pipe size for stockwater pipelines shall be 1-1/4 inch nominal diameter. One inch diameter pipelines may be used for distances of less than half a mile, in situations where there is no potential for system expansion.**

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:

i. **Plastic Pipe.** 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 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.

Analysis of transient pressures has documented that design under below listed velocity criteria ensures the working pressure limitation is met in all cases:

<table>
<thead>
<tr>
<th>Design Velocity (ft/sec)</th>
<th>% Pressure Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 to 1.5</td>
<td>100%</td>
</tr>
<tr>
<td>1.6 to 3.0</td>
<td>90%</td>
</tr>
<tr>
<td>3.1 to 5.0</td>
<td>72%</td>
</tr>
</tbody>
</table>

Pressure ratings for pipes are normally based on a pipe temperature of 73.4°F. When operating temperatures are higher, the effective pressure rating of the pipe shall be reduced accordingly as described in this standard.

ii. **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, **Sec 636.5201.**

4. 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, **Sec 636.5206.**

5. 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 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, **Sec 636.5208.**

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.

6. Depth of Cover. Buried pipe shall be installed at sufficient depth below the ground surface to provide protection from hazards imposed by...
traffic loads, farming operations, livestock, wildlife, freezing temperatures, or soil cracking, as applicable.

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 or sufficient strength, a carrier (encasement) pipe or other mechanical measures shall be used.

If detailed structural design is not performed, the minimum depth of cover shall be as follows:

<table>
<thead>
<tr>
<th>Diameter (inches)</th>
<th>Depth of Cover (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>½ through 2-½</td>
<td>18</td>
</tr>
<tr>
<td>3 through 5</td>
<td>24</td>
</tr>
<tr>
<td>6 or more</td>
<td>30</td>
</tr>
</tbody>
</table>

In non-cultivated areas where the pipe is not susceptible to vehicle axle loads in excess of 2 tons, the minimum depth of cover may be reduced as follows:

<table>
<thead>
<tr>
<th>Diameter (inches)</th>
<th>Depth of Cover (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>½ through 1-½</td>
<td>6</td>
</tr>
<tr>
<td>2 through 3</td>
<td>12</td>
</tr>
<tr>
<td>4 through 5</td>
<td>18</td>
</tr>
</tbody>
</table>

If necessary, depth of cover may be met by placement of fill material over the pipe with a minimum 6 ft top width, and 4H:1V sideslopes.

Pipelines constructed out of PVC, PE (ASTM D2727), ABS, or steel that are buried at less than frost depth must have a means of fully evacuating water from them in the fall (drains at all low points, or appropriately designed blowouts).

Pipelines constructed out of fusion joined HDPE (ASTM PE3408,3608,4710) that are buried at less than frost depth must have a means of depressurizing and evacuating water from them in the fall at locations where mechanical joint adaptors are used to join HDPE pipe to plastic, brass, or steel appurtenances. Correctly sized gravel sumps may be utilized to provide drainage at curb stops or hydrants.

Pipelines installed below frost depth (6-8 feet of cover) do not require evacuation of water regardless of materials utilized.

For summer use only systems where it is not possible to bury pipe due to shallow bedrock, cultural resources, or easement limitations, steel or fusion joined HDPE (ASTM PE3408,3608,4710) may be installed above ground with the approval of the Area Engineer. Design of these pipelines must include consideration for anchoring and thermal effects. HDPE pipe installed above ground must have a minimum 160 psi pressure rating, and contain at least 2% carbon black. Permanent above ground pipelines must be buried, or otherwise protected, within 50 feet of watering facilities.

7. 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.

8. 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.

i. Check Valves and Backflow Prevention. A Check Valve shall be installed between the pump discharge and the pipeline if detrimental backflow may occur.

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

If the pipeline is connected to domestic or municipal water systems, the design must incorporate backflow prevention devices in accordance with National Engineering Manual Part 503- Safety. An air gap at the stock tank 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.
ii. **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 5 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.

iii. **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.

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 when the line is filled and operating under working pressure. 1-way valves are rarely used, but may be appropriate for minor summits on gravity pipelines, or on pipelines originating from wells with high volumes of entrained gas.

**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. Hydrants are considered a 2-way, manually operated, valve. 2-way valves are typically used at the ends of lines, on summits, and downstream of shutoffs to ensure proper drainage.

**Combination Air-Vacuum-Air Release Valve (3-Way Valve)**

Combines the functions of air-release and air-and-vacuum valves. 3-way valves are typically used on summits, particularly those nearest to pumps where air is continuously introduced into the pipeline during operation, and where vacuum pressures develop when pumps are pulled for maintenance work.

**Air control where static or operating pressures exceed 10 psi:** Air and vacuum relief shall be installed on the first summit from the water source, if one exists, and on all other major summits. Major summits are defined as a high point in the line that is more than 50 ft above an adjacent low point.

It is recommended that additional air and vacuum relief be installed on minor summits (10-50 ft), on the basis of the volume of entrained gas that may be in the well water, length of mainline/spurs running upslope to that point, expected operating velocities, and need for vacuum relief. It is recommended that a 2-way valve be installed downstream of shutoffs if vacuum relief is needed to protect from pipe collapse or allow drainage.

**Air control requirements 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. Use of rigid pipe (PVC as opposed to HDPE or PE) is recommended for grades of less than 1% for distances over ¼ mile. Air release shall be provided at all summits (mechanical valves should not be utilized at working pressures less than 2 psi).

More frequent air vents should be considered on systems that originate from gas producing wells and on summits that collect air from multiple laterals or long reaches. In addition to local knowledge and physical indicators at the completed well, the potential for entrained...
gas can be evaluated using information from the ND Geologic Survey:

Flowing wells are particularly likely to have entrained gases.

iv. 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.

v. 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. Overflow outlets from stock tanks shall be protected from damage with rock, steel pipe, or concrete. It is recommended that the outlet daylight a minimum of 40 feet from the tank perimeter. Overflows on tanks supplied by spring developments, in particular, should be located in consideration of freezing (maximize sun exposure, ensure good slope away from the outlet).

9. Thrust Control. Abrupt changes in pipeline grade, horizontal alignment, or size reductions, may require an anchor or thrust blocks to absorb pipeline axial thrust particularly. 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. Typical small diameter (less than 3 inch) stockwater pipelines designed under the velocity limits of this standard do not require thrust control if buried.

10. 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 rating for pipe is normally based on a pipe temperature of 73.4°F. When operating temperatures are higher, the effective pressure rating of the pipe shall be reduced using the factors in Table 2, or other information provided by the manufacturer. Tests have shown that HDPE pipe exposed to the sun reached temperatures of 130°F when ambient air temperatures were 85°F.

**STRENGTH REDUCTION FACTORS FOR HIGH TEMPERATURES**

<table>
<thead>
<tr>
<th>Temperature, °F</th>
<th>PVC</th>
<th>HDPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;= 73.4</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>80</td>
<td>0.88</td>
<td>0.92</td>
</tr>
<tr>
<td>90</td>
<td>0.75</td>
<td>0.81</td>
</tr>
<tr>
<td>100</td>
<td>0.62</td>
<td>0.72</td>
</tr>
<tr>
<td>110</td>
<td>0.50</td>
<td>0.63</td>
</tr>
<tr>
<td>120</td>
<td>0.40</td>
<td>0.60</td>
</tr>
<tr>
<td>130</td>
<td>0.30</td>
<td>0.55</td>
</tr>
<tr>
<td>140</td>
<td>0.22</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Above ground HDPE pipelines in North Dakota shall be designed based on a 140 degree condition unless installed in a permanently shaded area. High temperature well water will be accounted for in pipeline designs based on direct field measurements.

11. 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.

Above ground HDPE pipelines may require bedding to protect against abrasion from sharp rocks, crevices, or other irregularities that could cause a point load. Avoid placement near cattle trails and in direct sunlight.

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. **Short sections of PVC pipe exposed in the vicinity of wells and tanks are not exempt from these requirements and should be painted or sleeved if exposed to sunlight.**

Above ground HDPE pipelines shall be designed to have adequate anchoring and slack for thermal movement to protect fittings and joints. See Idaho Technical Note #17 for design references. A minimum of 5% slack is required between anchors. On sloping ground HDPE pipe shall be adequately anchored to avoid pipe wall, joint, and connection stresses due to continuous downhill creep. Concrete or steel anchors are required at all points of abrupt change in grade, horizontal alignment, reduction in size, tees, wyes, and connections to tanks and pumps. The maximum distance between anchors shall be 400 feet. Anchors shall be of sufficient weight or embedment to withstand momentum, working pressure, and expansion and contraction forces that might cause pipe movement.

For above ground steel pipelines with welded joints, anchors and expansion joints shall be installed. The spacing shall limit pipe movement due to expansion or contraction to 40% of the sleeve length of the expansion coupling. The maximum pipe length between expansion joints shall be 500 feet. On slopes, ensure expansion joints are placed adjacent to and downhill from anchors.

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.

**12. 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.

**13. 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.

**14. 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.

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

If drainage is to be provided by compressed air, design blowout locations to ensure no more than two hours per discharge location is required. Based on the rated output of the compressor to be used on the system, the following table may be used:

<table>
<thead>
<tr>
<th>Pipe Size (in.)</th>
<th>Compressor Output (cubic feet per minute CFM @ 90 psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>1 1/4</td>
<td>28</td>
</tr>
<tr>
<td>1 1/2</td>
<td>36</td>
</tr>
<tr>
<td>2</td>
<td>57</td>
</tr>
</tbody>
</table>

Approximate Time (minutes) to Evacuate 1 mile of Pipeline with Compressed Air

**15. 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.

It is recommended that pressure relief valves be installed above the tank bottom elevation on hydrants (risers) of tanks, and not in below grade locations.

**16. 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 Conservation Practice Standard, Critical Area Planting (342).

**Consider the need to protect above ground HDPE pipelines from fire damage when planning revegetation.**

### B. 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.

### C. 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.

### V. 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.

**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.

### VI. 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, with stationing, tank locations, and all appurtenances labeled.
- Profile view of the pipeline.
- Locations and installation details for all required air/vacuum release valves, curb stops, pressure reducing valves, and any other required pipeline appurtenances.
- 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, including stabilization measures when trenching on steeper slopes.

### VII. 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, 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


