Design Considerations for Small Pipelines for Distribution of Livestock Water on Rangelands

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Highlight

Rapid development of the plastic pipe industry has brought about a revolution in distribution of water on Southwestern rangelands during the past several years. This article discusses and illustrates several considerations important in the planning, designing, and installation of range pipeline systems for distribution of stored water.

Improper distribution of livestock and grazing on semi-arid Southwestern rangeland results from the poor distribution of watering places. For years, Southwestern ranchers have constructed ponds and dugouts to collect surface runoff and store it at strategic points over the range—but as years progressed, it was learned that at best this water was temporary or seasonal. In fact, in dry years when proper grazing distribution became even more important to the rancher, the water supply from natural runoff was usually depleted. In many areas of the Southwest wells are few and far between. Depth to water and drilling costs make exploration drilling unfeasible from an economic standpoint.

During the past several years a revolution has taken place on Southwestern rangelands as ranchers have begun to pipe water from central water sources to stock water tanks, called "tubs," located in areas where no permanent natural supplies of water occur. In many cases it has become necessary to pump the water considerable distance to reach a site suitable for a permanent storage tank which in turn supplies water which is carried by gravity through pipelines to drinking tubs at various locations on the ranch.

The development and popularity of this relatively new method of water distribution on rangeland was brought about by the rapid development of the plastic pipe industry. Flexible plastic pipe is particularly well suited to laying pipelines over rough terrain. There are several considerations that are important in proper planning, designing, and installation of range pipeline systems for the distribution of stored water.

Considerations

I. Water Quality.—Before water from any one source is piped over a considerable portion of a ranch, there should be an analysis of the water to determine suitability for livestock use. This is especially true if the source is relatively new and unproven. Some ground water in the West contains high concentrations of mineral salts. Reduced gains and in extreme cases even death loss may result from range stock drinking water containing high concentrations of sodium sulphate (NaSO₄), sodium chloride (NaCl) and magnesium sulphate (MgSO₄).

Studies in South Dakota indicate that 7,000 ppm of soluble salts cause no apparent harm to livestock, although they may drink less of the salty water. However, toxic effects can be expected from concentrations of 10,000 p.p.m. regardless of the type of salts.¹

II. Quantity of Water.—Range pipeline systems usually have a large storage tank located at the source of supply (pump, windmill, or spring) or on a high point as near as possible to the water source from which the pipeline or pipelines serve adjacent sections of the ranch. The Soil Conservation Service recommends that this storage be large enough to hold at least a 7-day supply for the area to be served when a motor or engine driven pump is to be used, or a 14-day supply when a windmill is to be used. As an example: Assume that the maximum number of cattle and sheep in the area to be served by the storage is 100 and 500 respectively. Using 12 gal/day/cow and 1.5 gal/day/sheep as requirements, the storage would be (12 X 100 head) + (1.5 X 500 head) 7 days or 13,650 gal, assuming the use of an engine or motor driven pump. Flow quantities within the system depend upon the size of each drinking tub along the line. Recharge to each tub should be sufficient to prevent depletion when an entire herd waters at any given tub.

III. Line Routing and Placement of Drinking Facilities.—The pipeline system usually will include a storage tank, so initial routing will in most cases be from the well to this advantageous storage site. The site for the storage facility is at such an elevation that all points needing water can be watered by gravity flow through the pipelines with an absolute minimum number of booster pumps. From the central storage, pipeline routing depends on two fundamentals:

1. The location of points where water is needed, and
2. Topography of the land.

The location of drinking facilities along any given line depends on two factors:

1. Where tubs are needed, and
2. Where it is necessary to break the pressure in the pipeline.

Normally these two factors can be satisfied with one facility, saving considerable expense. See details under "V. Gravity Flow Determinations".

IV. Materials.—Usually a range pipeline is installed with one of four kinds of pipe:

1. ABS (Acrylonitrile-Butadiene-Styrene) plastic
2. PVC (Polyvinal Chloride) plastic

3. PE (Polyethylene) plastic
4. Steel

The polyethylene is most commonly used for range pipelines. It is flexible and may be purchased in lengths to 400 ft, thus making it practical to place by mechanical methods. Polyethylene pipe is manufactured with three pressure ratings: 80, 100, and 125 psi. These are normally sufficient for range pipelines. When greater pressures are experienced either PVC or ABS plastic or steel pipe is used. Steel pipe if used should be zinc coated.

V. Gravity Line Determinations.—From the storage along a given line decreasing in elevation, the flow in the line is dependent on the elevation difference in the water surface at the source and the water surface at the delivery point. The elevation differential is known as the

Fig. 1. Example of gravity system of water flow in small diameter plastic pipe.

Fig. 2. Chart for estimating friction losses in small plastic pipe.
available head. It is equal to the head required to produce a given flow through a certain length of conduit. It is normal procedure in the design of range pipelines to neglect minor losses and consider only loss due to friction.

A Mannings "n" value for plastic pipe of .009 and for galvanized pipe of .012 is generally used in computing friction loss and determining pipeline capacity. An example of determining flow in small diameter plastic pipe using a nomograph prepared by the SCS is shown below.

Assume that there is 50 ft of available head between the water surface in storage A and tub B shown in Fig. 1, and the distance AB is 3,000 ft. This means that there is 16.7 ft/1,000 ft of head available to overcome friction. The plan is to use plastic pipe and require a minimum of 5 gpm delivery. Flow in the line should be determined with the water surface at the bottom of the higher storage tank and static pressure determined with the tank filled.

Enter the chart in Fig. 2 at 16.7 ft/1,000 ft on the bottom scale and read vertically to the line representing a 1-inch pipe and the line representing 1.25-inch pipe.

From these two points reading horizontally, find that the 1-inch pipe will deliver 4.45 gpm and the 1.25-inch 9.2 gpm. Since 5 gpm was a minimum requirement, use the 1.25-inch pipe.

Referring back to Fig. 1, notice the static heads developed on the line as the floats at tubs B and C close. It can be determined that maximum pressure on gravity lines normally occurs not during flow, but when the system is static.

There are two methods of tub installation. Fig. 3 shows the connection when it is not desirable to break line pressure and Fig. 4 shows installation method to be used when it is desirable to break the pressure in the line. It is readily apparent that the tubs in Fig. 1 were tied into the line by the method shown in Fig. 4.

VI. Pump Line Determinations.

—In gravity lines, pipe size and amount of fall determine the actual flow that will occur. In the
design of pump lines for any given pipe size (providing the pipe would withstand pressure created) any given quantity of water may be pumped through the line by increasing or decreasing the power applied to the pump. Therefore, it may be readily seen (Fig. 5) that the maximum pressure on a pump line normally occurs at the pump or at a lower point in elevation along the pipe relatively near the pump.

For an example, using Fig. 5, assume the need to deliver 10 gpm to 50 ft through a 1.5-inch line. The elevation difference between 0 and the water surface in the tank at 50 ft is 175.0 ft. The friction loss in the 1.5-inch pipe flowing 10 gpm would be 8.6 ft/1,000 or 43.0 ft total for the 5,000 ft of pipe. Neglecting minor losses, the total head would equal the elevation difference plus friction loss, or 218.0 ft at 0 ft.

On gravity and pump lines, the maximum pressure on any segment of the line should be checked. The maximum pressure occurs where the hydraulic gradient or the static head is a maximum distance above the center line of the pipe. This head in feet is easily converted to pressure in lb/in² (P).

\[ P = 62.4 \times \text{Head in ft} / 144 \]

VII. Pumping Plant. — Pumping water for livestock considerable distance against a high head normally requires only small pumping plants. Horsepower is an expression of the time rate of doing work. Work is defined as a force (lb) moving through a distance (ft). One horsepower is defined as 550 ft-lb/second or 33,000 ft-lb/minute. The first step in determining power requirements is to determine the waterhorsepower required.

When \( Q = \) Quantity of flow in gpm.

\[ \text{Water HP} = \frac{8.33Qh}{33,000} = \frac{Qh}{3960} \]

Referring back to the line in Fig. 5, it was determined the total pumping head was 218 ft. In this case Water Horsepower would be:

\[ \text{HP}_w = (10)(218) = .55 \text{HP} \]

With a gasoline engine it may be safely assumed that an overall pumping plant efficiency of 50% could be obtained. This includes pump efficiency, transmission efficiency, and efficiency of the engine itself. In the sample problem an engine of 1.1 rated horsepower should be sufficient. Selection of a power unit for this system would probably be a 1.5 horsepower engine. Care must be taken in selecting pump and engine and matching them in respect to performance data. Performance data is available from the manufacturers.

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**TECHNICAL NOTES**

**Mortality of Rock Goldenrod in Sagebrush Stands Sprayed With 2,4-D**

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**Highlight**

Rock goldenrod, an undesirable range plant, was sprayed with 2,4-D incidental to a sagebrush-control project on the Ashley National Forest north of Vernal, Utah, provided an opportunity to determine if 2,4-D will kill rock goldenrod (*Petradoria pumila* (Nutt.) Green). Rock goldenrod is an undersirable range plant that grows in a wide altitudinal range (3,500-11,000 ft) extending from Wyoming and southeast Idaho, south into northern Arizona and New Mexico, and west to the mountains of California's Mohave Desert (Anderson, 1963). It grows with other forbs and with grasses in the understory of big sagebrush (*Artemisia tridentata* Nutt.) communities, and is most abundant on rocky ridges and other areas with shallow soils. It is also abundant in some areas on deep soils that have been cultivated and seeded to introduced grasses.

Sagebrush-control projects on the Ashley National Forest north of Vernal, Utah, provided an opportunity to determine if 2,4-D will kill rock goldenrod (*P. pumila* ssp. *pumila* (Anderson, 1963). It grows with other forbs and with grasses in the understory of big sagebrush (*A. tridentata* Nutt.) communities, and is most abundant on rocky ridges and other areas with shallow soils. It is also abundant in some areas on deep soils that have been cultivated and seeded to introduced grasses.

This paper does not report a "study" of the usual sort — merely some observations incidental to the sagebrush control projects mentioned above. Since rock goldenrod