AGRI-FACTS
Practical Information for Alberta's Agriculture Industry

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Pasture Pipeline Design

As pasture systems become more intensively managed, producers are considering piping water directly to paddocks. These pipelines are typically small diameter polyethylene (PE) pipes that are buried about 12 inches below the soil surface. They are only used in the summer and must be drained and blown out with an air compressor in the fall.

Pasture pipelines can be easily placed underground with a farm tractor and three-point hitch type of plough. The following section provides the information needed to design a basic system.

Designing a pipeline system

Note: Before designing the system or doing any type of excavation, telephone **Alberta 1st Call 1-800-242-3447** for buried line locations.

Consider the following factors before designing your pipeline system.

1. Number of livestock that will be using the water.
2. Expected peak water consumption per animal. See Table 1 – Peak water use.
3. Water pumping or drinking time required per day.
4. Pump and well capacity.
5. Distance to the farthest watering point.
6. Vertical lift from the pressure tank to the watering point.
7. Operating pressure at the pressure tank.
8. Friction loss in the pipeline. See Table 2.
9. Float valve pressure requirements. This value will vary with valve design and size.
10. Future expansion of the water system for more cattle or longer pipelines.

Table 1 - Peak water use

Cow/calf pair	15 gal./day
Yearlings	10 gal./day

Design steps

(unless otherwise specified, all gallons are in Imperial gallons)

Step 1. Calculate peak daily livestock water use

This number is determined by multiplying the number of livestock by the peak gallons per head per day. Here is an example using Table 1 as a guide:

80 cows (with calves) x 15 gal/cow/day=1,200 gal/day

Step 2. Calculate required flow rate

The required flow rate is determined by taking the daily water use and dividing it by the number of minutes of pumping time required per day.

1,200 gal per day ÷ 240 min = 5.0 gal/min

If the drinking trough will hold at least 50 per cent of the total daily requirement, the pumping time used in this calculation can be as much as 24 hours (1,440 min). If a small tank is used, plan for a minimum of 4 hours (240 min). If the paddocks are small and the cattle will wander back and forth to water a few at a time, you can probably design for up to 12 hours (720 min). If the fields are large and the cattle tend to water as a group, plan for as large a tank as practical and a 4 to 6 hour drinking time.

Step 3. Compare requirements with capacity

Compare the gallons per minute required with the capacities of your pump and/or well. If the flow is not adequate, you will have to consider a larger water trough, larger pump, additional well or fewer animals. Alternatively, there may be days when cattle will have to wait longer for water.

Table 2. Friction loss for PE pipe

Friction Loss - Polyethylene (PE)								
			Pressure loss from friction in PSI per 100 ft. of pipe Nominal size (inside diameter) in inches					
Flow US gal./min.	Flow Imperial gal./min.	Flow Metric Litres/min.	1/2 in.	3/4 in.	1 in.	1 1/4 in.	1 1/2 in.	2 in.
1	0.8	3.8	0.49	0.12	0.04	0.01		
2	1.7	7.6	1.76	0.45	0.14	0.02		
3	2.5	11.3	3.73	0.95	0.29	0.08	0.04	0.01
4	3.3	15.1	6.35	1.62	0.50	0.13	0.06	0.02
5	4.2	18.9		2.44	0.76	0.20	0.09	0.03
6	5.0	22.7		3.43	1.06	0.28	0.13	0.04
7	5.8	26.5		4.56	1.41	0.37	0.18	0.05
8	6.7	30.2		5.84	1.80	0.47	0.22	0.07
9	7.5	34.0			2.24	0.59	0.28	0.08
10	8.3	37.8			2.73	0.72	0.34	0.10
11	9.2	41.6			3.27	0.86	0.41	0.12
12	10.0	45.4			3.82	1.01	0.48	0.14
14	11.7	52.9				1.34	0.63	0.19
16	13.3	60.5				1.71	0.81	0.24
18	15.0	68.0				2.13	1.01	0.30
20	16.7	75.6				2.59	1.22	0.36
22	18.3	83.2				3.09	1.46	0.43
24	20.0	90.7					1.72	0.51
26	21.7	98.3					1.99	0.59
28	23.3	105.8					2.28	0.68
30	25.0	113.4					2.59	0.77
35	29.2	132.3						1.02
40	33.3	151.2						1.31
45	37.5	170.1						1.63
50	41.7	189.0						1.98

Step 4. Determine pressure required by float valve

A float valve designed for large flow rates can require as little as 5 psi to operate. However, in the same situation, a float valve with a small opening or orifice designed for low flow rates can require over 20 psi. Choose a float valve and establish the pressure to get the expected flow through the float valve.

For this example, assume 20 psi

Step 5. Calculate friction losses in the pipeline

Friction loss is determined by taking the furthest pipeline distance to the watering point, dividing it by 100, then multiplying it by the friction loss value in **Table 2 – Friction loss for PE pipe.** The PE pipe size indicates inside diameter. For this example, assume 1 in. pipe, which has a friction loss of 1.06 psi per 100 feet of pipe at a flow of 5.0 gal/min.

(2600 ft ÷ 100) x 1.06 psi = 27.6 psi

Step 6. Pressure required for lift

Calculate the pressure required to lift the water from the pressure tank to the trough. To lift water 1 ft. takes 0.433 psi.

25 ft. of lift x 0.433 psi per ft. of lift = 10.8 psi.

Step 7. Total pressure required

The total pressure required is determined by taking the pressure required at the float valve and adding it to the pressure lost to friction loss and the pressure required to overcome the vertical lift.

20 psi + 27.6 psi + 10.8 psi = 58.4 psi.

If the total pressure (58.4 psi) required is too great, increase the pipe size and recalculate from Step 5. Typical plastic pipe has a maximum pressure rating of 75 psi, and many pressure systems are only set to deliver up to 60 psi. Information on pipe specifications is given in *Agrifacts 716 (C43) Plastic Pipe for Farm Water Distribution.*

To aid you in selecting appropriate pipe sizes for your system, you will find the approximate delivery for PE pipe at varying distance and pressure provided in Table 3 - Approximate water delivery through polyethylene (PE) pipe.

Step 8. Make design changes

Assess the potential **pitfalls** and make appropriate design changes.

- Always consider the potential for **expanding the capacity** of the system.
- Surface laid pipes can be heated up significantly if unshaded by grass or fenceline. This situation can significantly weaken the pipe, so higher pressure rated pipe is often used, if affordable.
- Pipe **friction loss** charts assume new pipe with smooth, shiny inside walls. Minerals in the water will often create a film on this inside surface. This rough film will tend to increase the friction loss over time. For this reason, it does no harm to increase the calculated friction loss by 50 per cent.
- Extra fittings in the pipeline will increase the friction loss.

Table 3. Approximate water delivery through polyethylene (PE) pipe

Approximate delivery from 1.0" PE pipe in Imperial Gallons per minute (g.p.m.)

Length	**Pipe Pressure in lb. Per sq.in. (p.s.i.)**						
	10	**20**	**30**	**40**	**50**	**60**	**70**
100 feet	16.3	23.9	29.8	34.9	39.4	43.6	47.4
500 feet	6.5	9.6	12.2	14.3	16.3	18.0	19.6
1000 feet	4.4	6.5	8.2	9.6	10.9	12.2	13.3
3000 feet	2.4	3.5	4.4	5.2	5.8	6.5	7.1
1 miles	1.7	2.5	3.2	3.7	4.2	4.7	5.1
2 miles	1.1	1.7	2.1	2.5	2.9	3.2	3.5

* Flow rates below 10 g.p.m. are recommended for most applications

Approximate delivery from 1.25" PE pipe in Imperial Gallons per minute (g.p.m.)

Length	**Pipe Pressure in lb. Per sq.in. (p.s.i.)**						
	10	**20**	**30**	**40**	**50**	**60**	**70**
100 feet	29.0	42.6	53.3	62.5	70.6	78.0	84.9
500 feet	11.8	17.4	21.8	25.6	29.0	32.1	34.9
1000 feet	8.0	11.8	14.9	17.4	19.7	21.8	23.8
3000 feet	4.3	6.4	8.0	9.5	10.7	11.8	12.9
1 miles	3.1	4.7	5.9	6.9	7.8	8.6	9.4
2 miles	2.1	3.1	3.9	4.7	5.3	5.9	6.4

* Flow rates below 18.3 g.p.m. are recommended for most applications

Table 3. Approximate water delivery through polyethylene (PE) pipe (cont'd)

Approximate delivery from 1.5" PE pipe in Imperial Gallons per minute (g.p.m.)

Length	Pipe Pressure in lb. Per sq.in. (p.s.i.)						
	10	20	30	40	50	60	70
100 feet	46.6	68.7	86.1	100.9	114.2	126.3	137.3
500 feet	19.1	28.0	35.0	41.1	46.6	51.7	56.4
1000 feet	13.1	19.1	23.8	28.0	31.7	35.0	38.2
3000 feet	7.1	10.5	13.1	15.3	17.3	19.1	20.8
1 miles	5.2	7.7	9.6	11.2	12.7	14.0	15.3
2 miles	3.5	5.2	6.5	7.7	8.7	9.6	10.5

* Flow rates below 25 g.p.m. are recommended for most applications

Approximate delivery from 2.0" PE pipe in Imperial Gallons per minute (g.p.m.)

Length	Pipe Pressure in lb. Per sq.in. (p.s.i.)						
	10	20	30	40	50	60	70
100 feet	99.9	147.6	184.7	216.2	244.2	269.7	293.3
500 feet	40.1	59.3	74.9	88.1	99.9	110.7	120.7
1000 feet	27.5	40.1	50.3	59.3	67.5	74.9	81.7
3000 feet	15.4	22.2	27.5	32.0	36.2	40.1	43.7
1 miles	11.3	16.5	20.4	23.8	26.7	29.4	31.9
2 miles	7.7	11.3	14.1	16.5	18.5	20.4	22.1

* Flow rates below 41.7 g.p.m. are recommended for most applications

Assumptions:

1. The PE pipe indicates the **minimum inside diameter** in inches to achieve these flow rates. Actual, as manufactured, inside diameter will be slightly larger however solids buildup on the inside surface can reduce the diameter and flow rates over time.
2. Darcy-Weisbeck formula used to estimate flow rates using inside diameter indicated.
3. Changes in flow rate due to elevation difference between water source and outlet are not included in these tables
4. In gravity installations with significant elevation differences, other factors such as water hammer, maximum water velocities, flow restrictors, clearing of air gaps may need to be considered.
5. Pressure in pipe should not exceed recommended maximum pressure for pipe used (i.e Series 75 pipe max. = 75 psi) Reduced pipe strength due to increased surface temperature of surface laid pipes should be accounted for.
6. Pressure requirements in the design must account for float valve requirements. A float valve designed for large flow rates can require as little as 5 psi however a float valve with a small orifice designed for low flow rates can require over 20 psi of operating pressure.

- **Air bubbles** can collect in high spots in the line. These can restrict water flow unless flushed out or released at the high spots using a valve.
- Many **float valves** are very restrictive to water flow. Use a valve that produces minimum back pressure.
- Watch out for **competing water** uses on the same water supply. Another stock waterer or the farm house will usually provide an easier place for the water to go if it is given a choice.
- **Do not pump your well at a higher rate than it can handle**.
- Ensure the pipe supplier provides pipe with the **appropriate inside diameter.**

For more information on pasture pipeline design, contact the Agricultural Water Specialists with Alberta Agriculture and Food at the following locations:

Lethbridge	(403) 381-5846
Red Deer	(403) 340-5324
Edmonton	(780) 427-2963

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