1.6 Pipes

Effluent can be conveyed by channels or pipes under gravity or in dedicated pipelines under pressure. If pipes are used, pressure rating, water-hammer and excessive friction losses must be considered during the design stage, and the deposition of entrained materials must be avoided. *Plumatella repens* (a bryozoan animal) and algae are biological agents that can build up on pipe walls and impede flow, and other organisms can attack pipe material, particularly concrete. Struvite (magnesium ammonium phosphate) is a crystalline chemical compound which can also constrict pipelines.

Gravity conveyance in pipes

The choice of pipes, often with grated entries, as opposed to surface channels or drains, to carry effluent needs to be considered in the light of each individual site and situation. The propensity for blockages in gravity pipes needs to be considered, along with the associated restricted access and OH&S issues. Reinforced concrete, PVC (polyvinylchloride) or HDPE (high-density polyethylene) pipes are commonly used for gravity conveyance, and a host of recycled plastic products are also used. PVC is more common, but HDPE pipes can be welded on site and are resilient and easily installed. Concrete and recycled plastic pipelines, though less common, depend on price and contractor preference.

The principal consideration for gravity conveyance is the presence of solids in the liquid. Tables 1 and 2 give recommended grade requirements of pipelines with and without solids in the effluent stream. Ideally, solids should be removed before pipeline conveyance. At least a threefold increase in velocity is required for satisfactory gravity discharge in a pipeline conveying solids relative to effluent without solids. The minimum pipe gradient for conveying effluent with solids therefore needs to be increased at least fifteen-fold relative to solids-free effluent. The minimum recommended pipe diameter for gravity conveyance of raw effluent on a farm is 100 mm based on operating experience. This is dictated not by hydraulics, but by the propensity for blockages. Sewer-class pipes should be used rather than stormwater-class pipes given the need for thicker walls and more resilience under impact.

Table 1. Minimum grades for gravity pipe drains conveying treated pond effluent.

Inside diameter (mm)	Minimum grade (%)	Velocity at full flow ($m{\cdot}s^{-1}$)
75	0.2	0.29
100	0.1	0.25
125	0.07	0.24
150	0.05	0.23

Table 2. Minimum grades for gravity pipe drains conveying raw effluent from yards or sumps.

Inside diameter (mm)	Minimum grade (%)	Velocity at full flow ($m{\cdot}s^{-1}$)
75	3.3	1.0
100	2.5	1.0
125	2.0	1.0
150	1.7	1.0

The data in Tables 1 and 2 are based on municipal effluent practice. Their successful application to dairy effluent has been demonstrated over many years. Wedel (2000) has, however, determined more appropriate critical velocities for control of scour and deposition of sand-laden manure, confirming the need for transmission velocities exceeding 1 m·s^{-1} to avoid deposition. Obviously, particle size is the major control, and the faster the passage of effluent, the larger the particle conveyed. To avoid the transport of sand, gravity removal is essential before diversion to a sump or storage.

Blockages are common in gravity drainage pipes, and the abovementioned gradients are minimum values only. The effectiveness of pipes for conveyance of effluent is dictated by the effectiveness of grates and mesh or sedimentation sumps for removing entrained solids.

Inspection pits should be installed at discrete intervals in any gravity drainage pipeline. Recommended spacings vary with diameter, but 20 m is common. These pits allow for venting and access for cleaning. Common practice is to use pits at any change of grade or direction, although T-junctions can be used to facilitate access as well.

Pressurised conveyance

Pipes are manufactured in a range of pressure classes, expressed in terms of a PN rating (nominal pressure rating at 20 °C). Table 3 details the common pipe classes for rural applications. The choice of design pressure needs to consider the impact of increased temperature, which will reduce the pressure rating for PVC and HDPE pipes. In addition, an allowance must be made for water-hammer. In the absence of a detailed investigation, it is prudent to opt for an increase in pressure class to allow for high-risk situations where high-pressure pumps stop and start without surge protection.

Example

PN 4.5 (Class 4.5) pipe has a pressure rating of 450 kPa. Water-hammer (without surge protection) must be allowed for when you are selecting pipes which will be subject to rapid opening and closing of valves or starting and stopping of pumps. A hydraulic system requiring 400 kPa to be carried by the pipeline would require a PN 6 pipe—a pipe with a pressure rating of 600 kPa—to allow for water-hammer. This is based on experience and conservative practice.

Table 3. Pipe classes.

Imperial	Metric
Class A—150 ft head = 65 psi	PN 4.5 (Class 4.5) = 4.5 atmospheres = 450 kPa = 45 m head
Class B—200 ft head = 87 psi	PN 6 (Class 6) = 6 atmospheres = 600 kPa = 60 m head
Class C—300 ft head = 135 psi	PN 9 (Class 9) = 9 atmospheres = 900 kPa = 90 m head
Class D—400 ft head = 175 psi	PN 12 (Class 12) = 12 atmospheres = 1200 kPa = 120 m head

Table 3 is provided to assist in conversion of Imperial to metric units. It is still common to find pumps, pipes and pressure gauges marked in Imperial units, because the US irrigation market is dominant, and many contractors and farmers retain the old units. Some contractors have a personal preference for particular types of pipe, and as long as they have no pecuniary interest, their preferences should be catered for.

If small-diameter pipelines are to be used, it is wise to be able to flush the line with water. The life expectancy of PVC and HDPE pressure pipes is not really dictated by the corrosive nature of effluent, but reinforced concrete pipes react to sulphuric acid. Over time detritus builds up on pipe walls, causing friction losses, and sometimes poor bedding conditions contribute to abrasion of external walls. Poor bedding can also lead to pipe collapse and leaking at joints.

Types of pipe and fittings

Table 4 compares the properties of HDPE and PVC pipes. Although not commonly used for effluent conveyance, many other types of pressure pipe are available, including:

- galvanised iron
- cast iron
- ductile iron
- recycled plastic
- aluminium
- concrete.

Effluent can be corrosive when in contact with metallic or concrete pipes. If effluent contains sulphurous compounds from soil or cattle feed, corrosion of concrete can be accelerated. Concrete with a structural strength of 30 MPa should be used for pipes and hydraulic structures. The minimum reinforcement cover should not be less than 30 mm. Sulphate-resistant cement is recommended, and all exposed starter bars must be galvanised. Steel, cast iron and ductile iron pipes should be protected from corrosion.

Pipe fittings are commonly made in the same material as pipes. The mixing of different types of pipe and fittings is not recommended, owing to different rates of expansion and contraction and dimensional intolerances. Energy losses in fittings are due to frictional resistance, and these must be accounted for in any hydraulic analysis. The fittings not only dissipate energy, but also enable the build-up of debris, which will throttle flow. Ideally, any fitting or pipe join should avoid a sharp edge. The use of external fittings avoids internal obstructions.

Table 4. Comparison of the properties of pipes.

Property	Polyethylene (HDPE)	Polyvinylchloride (PVC)
Flow characteristics	Good	Good
Weight	Light	Light
Available lengths	Up to 300 m	6 m
Corrosion	No	No
Flexibility	Yes	Partially
Effect of temperature on strength	Sensitive	Sensitive
Installation	Simple	Simple
Impact resistance	Fair	Fair
Sunlight	Can withstand	Requires protection
Life expectancy	50 years	50 years
Cost equivalent	1 unit	1.5 to 2 units

Pipe cover, alignment and protection

Pipelines should not be located above ground where human, vehicle or animal traffic is encountered. Provide at least 300 mm cover for pipes in trenches. The larger the pipe and greater the traffic load, the greater the cover required.

The following are recommended minimum installation depths for Australian farming practice, but it is wise to ensure that Australian Standards are adhered to for specific types and pressure classes of pipe:

- open grazing country 300 mm
- garden 300 mm
- roads 400 mm
- cultivated ground 500 mm.

1.6 Pipes

Take care with the transportation, handling and installation of pipes, and follow manufacturers' laying procedures, particularly bedding specifications. Much greater care is required with the installation of gravity pipelines than with pressure lines, as these need to be installed at grade and cannot afford to settle. Manufacturers frequently recommend more conservative depths; commonly PVC is installed with 600 mm cover under sealed roads and 750 mm under unsealed roads. Under major roads carrying B-double vehicles and milk tankers, some councils require both PVC and HDPE pipes to be sleeved in steel or concrete.

The relevant Australian Standards are:

- AS/NZS 1254:2002 PVC pipes and fittings for storm and surface water applications (Standards Australia 2002b)
- AS/NZS 1260:2002 PVC-U pipes and fittings for drain, waste and vent application (Standards Australia 2002a)
- AS/NZS 1477:2006 PVC pipes and fittings for pressure applications (Standards Australia 2006b)
- AS/NZS 2032:2006 Installation of PVC pipe systems (Standards Australia 2006a)
- AS/NZS 2033:2008 Installation of polyethylene pipe systems (Standards Australia 2008)
- AS 2439.1–2007 Perforated plastics drainage and effluent pipe and fittings—Perforated drainage pipe and associated fittings (Standards Australia 2007a)
- AS 2439.2–2007 Perforated plastics drainage and effluent pipe and fittings—Perforated effluent pipe and associated fittings for sewerage applications (Standards Australia 2007b)
- AS 2698.2–2000 Plastics pipes and fittings for irrigation and rural applications—Polyethylene rural pipe (Standards Australia 2000)

Installers should seek guidance on pipe size, gradient and laying procedures from suppliers and contractors so that installation costs can be ascertained before the pipe and fittings are purchased. The cost of installation may well overshadow the cost of the pipe. If shallow rock, cracking clay or elevated water tables are present along a pipe route, very high installation costs are likely. Factors to consider with costing the installation of pipes include:

- constraints on availability owing to very high demand in district or region
- lack of competition in supply of pipes or between construction contractors
- quantity of pipes and reduced unit cost with increased scale
- weather during installation
- the deeper the pipe, the greater the excavation cost and the more limited the prospect for ploughing in
- the availability of bedding
- quality control for backfill
- water table height
- the amount of rock to be excavated.

Of paramount importance is the need to consider an appropriate alignment. Before excavating in unfamiliar ground, call the 'Dial Before You Dig' service to determine the type and proximity of services. In some jurisdictions a cultural heritage investigation will also be necessary.

References

Standards Australia 2000, *Perforated pipes and fittings for irrigation and rural applications—Polyethylene rural pipe*, Australian Standard AS 2698.2:2–2000, Standards Australia, Sydney.

Standards Australia 2002a, *PVC-U pipes and fittings for drain, waste and vent application*, Australian Standard AS/NZS 1260:2002, Standards Australia, Sydney.

Standards Australia 2002b, *PVC pipes and fittings for storm and surface water applications*, Australian Standard AS/NZS 1254:2002, Sydney, Standards Australia.

Standards Australia 2006a, *Installation of PVC pipe systems*, Australian Standard AS/NZS 2032:2006, Standards Australia, Sydney.

Standards Australia 2006b, *PVC pipes and fittings for pressure applications*, Australian Standard AS/NZS 1477:2006, Standards Australia, Sydney.

Standards Australia 2007a, *Perforated plastics drainage and effluent pipe and fittings—Perforated drainage pipe and associated fittings*, Australian Standard AS 2439:1–2007, Standards Australia, Sydney.

Standards Australia 2007b, *Perforated plastics drainage and effluent pipe and fittings—Perforated effluent pipe and associated fittings for sewerage applications*, Australian Standard AS 2439.2:2–2007, Standards Australia, Sydney.

Standards Australia 2008, *Installation of polyethylene pipe systems*, Australian Standard AS/NZS 2033:2008, Standards Australia, Sydney.

Wedel, A.W. 2000, 'Hydraulic conveyance of sand-laden dairy manure in collection channels', Paper No. 004106, *ASAE Annual International Meeting*, Milwaukee, Wisconsin, USA, 9–12 July 2000, ASAE.