BLACKMAX® POLYPROPYLENE PIPES AND FITTINGS

HYDRAULIC DESIGN

HYDRAULIC PERFORMANCE

BlackMAX® pipelines fall into the smooth polymer pipe category of AS2200 "Design charts for water supply and sewerage" and provide exceptionally good hydraulic performance. However these may in some instances be affected by various adverse service factors including:

- Growth of slime (varies with the age of the pipeline and available nutrient in the water)
- Siltation or settlement of suspended particulate matter
- Fitting types and configurations

The notation used for equations in this section is as follows:

d = internal diameter (m)

f = Darcy friction co-efficient

g = acceleration due to gravity (m/sec2)

k = equivalent hydraulic roughness (m)

n = Manning n

Q = flow or discharge (L/s)

Q_p = most probable peak dry weather flow (L/s)

Q_f = flow or discharge - pipe flowing full (L/s)

R = hydraulic mean radius i.e. flow area/perimeter (m)

R_p = hydraulic mean radius for partly full pipe (m)

R_j = hydraulic mean radius for full pipe i.e. d/4 (m)

S = hydraulic gradient or slope of gravity flow sewer (m/m)

V = mean velocity (m/sec)

V_p = mean velocity in part full pipe (m/s)

V_f = mean velocity- pipe flowing full (m/s)

H_L = friction head loss (m)

y = depth of flow above pipe invert (m)

ρ = fluid density (kg/m^3)

ν = kinematic viscosity (m^2/sec)

2θ = angle (radians) subtended at pipe centre by water surface in invert - see Figure 4.0

τ = average boundary shear stress (Pa)

BLACKMAX® POLYPROPYLENE PIPES AND FITTINGS

HYDRAULIC DESIGN

These charts relate friction loss to discharge and velocity with pipes running full and have been calculated using the Colebrook-White transition equation (see equation 3.1). The two values of roughness are accepted practice for the given applications.

$$V = -2\sqrt{2gdS}\,\log\left(\frac{k}{3.7d} + \frac{2.51v}{d\sqrt{2gdS}}\right)$$

The Colebrook White equation takes into account the variation of viscosity with temperature and pipe roughness and is recognised as being one of the most accurate in general use, but requires iterative solutions.
The following flow resistance charts have been prepared based on the following assumptions:

- Temperature = 20°C
- Kinematic viscosity of water, V=1.01 x $10^{-6}m^2/s$
- Roughness, k = 0.006mm and 0.06 mm

The Iplex web site www.iplex.com.au also has a flow calculator, which provides a quick means of determining the flow for other conditions.

When comparing BlackMAX® with other pipe systems, designers should take into account both the smooth surface characteristics of polypropylene and the anticipated pipeline service. Different applications may require a variation of the values of roughness coefficients chosen to conform to accepted practice. For example, much higher values are commonly specified for stormwater systems to take into account of anticipated debris loading. In the case of sewers, it may be necessary to take into account possible slime development. Generally, smooth pipe materials have a Colebrook White k value equal to less than one fifth of the value used for rougher materials such as cement lined pipes, concrete and vitrified clay pipes used for the same purpose. Typical comparative values are given in the following table.

TABLE 1.0 TYPICAL COLEBROOK WHITE ROUGHNESS COEFFICIENTS k FOR DIFFERENT MATERIALS

APPLICATION	TYPICAL POLYMER PIPE ROUGHNESS k (mm)	TYPICAL NON-POLYMER PIPE ROUGHNESS k (mm)
Water Supply	0.006	0.03
Sewerage and drainage	0.06	0.6

Note that these values of roughness coefficient k are for clean water and assume the pipeline is straight, clean and concentrically jointed. Australian Standard AS 2200 "Design charls for water supply and sewerage", Table 1 gives a range of values for polymers of 0.003 mm to 0.015 mm under these conditions and 0.03 mm to 0.6 mm for non-polymer pipes.

BLACKMAX® POLYPROPYLENE PIPES AND FITTINGS

HYDRAULIC DESIGN

Alternative empirical formulae, exponential in form, have been used over many years for flow calculations. Being relatively easy to use, they are still favoured by hydraulic engineers. The Manning Equation is the most common for non-pressure gravity flow. It can be written as:

Equation 2.0

$$Q = \frac{4000}{n} \pi \left(\frac{d}{4}\right)^{8/3} S^{1/2}$$

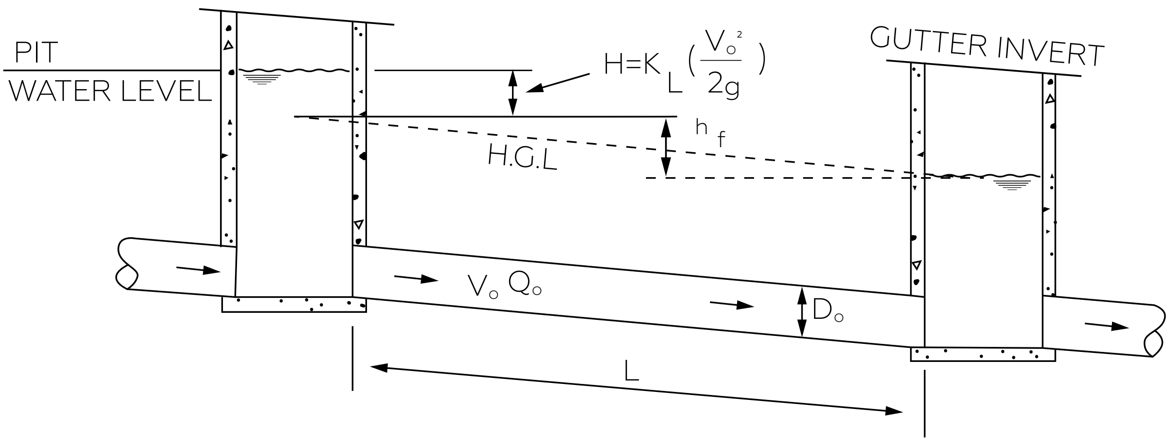
For clean polypropylene pipes such as BlackMAX® and, n is usually taken as being equal to 0.008. In the Australian Standard, AS 2200, n for polymeric materials is in the range of 0.008 to 0.009 whereas for vitrified clay n is in the range of 0.009 to 0.013. As a comparison, for the same internal diameter and gradient, this equates to a flow increase of between 12% to 44 % for BlackMAX® pipes.

STORMWATER DRAINAGE DESIGN

The design of drainage pipe networks is discussed in "Australian Rainfall and Runoff " published by the Institution of Engineers Australia. There are differences compared with other applications due to the frequency of inlets and junction pits, having a significant effect on the hydraulic capacity of the system and high head losses.

Pits may be rectangular, circular, benched or un-benched, with or without lateral pipe inlets, entries from gutters in roadways collecting surface storm-water and often involve changes in flow direction. The value for K_L in Figure 3.0 can range from 0.2 to 2.5 or greater depending on the pit configuration. Appropriate values can be obtained from ARRB Report No. 34 "Stormwater drainage design in small urban catchments" by John Argue. Another consideration affecting flow capacity is the debris and sediment load, which is often carried in stormwater flow.

FIGURE 3.0 HEAD LOSSES THROUGH STORMWATER PITS



The information contained in this document should serve as a guide only and is subject to change without notice. For more information please contact Iplex Pipelines Australia Pty Ltd.