APOLLO® PVC-O PIPELINE DESIGN

HYDRAULIC DESIGN

FLOW CAPACITY

The capacity of a pipeline can vary due to various factors, which include:

- Growth of slime, which will vary with the age of the pipeline and available nutrients in the water.
- Roughening, due to the wear by abrasive solids.
- Siltation or settlement of suspended particulate matter.
- Joint imperfections/fitting types and configurations.

To assist the designer in selecting the appropriate diameter, a flow resistance chart covering both PN12.5 and PN16 pressure classes can be downloaded from the Apollo® PVC-O Pipeline Design section of the Iplex website. The flow resistance chart relates friction loss to discharge and velocity for pipes running full and has been calculated using the Colebrook-White transition equation.

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

Where:

V = Mean velocity (m/s)

g = Acceleration due to gravity (m/s²)

d = Pipe internal diameter (m)

S = Hydraulic gradient (m/m)

k – Equivalent hydraulic roughness (m)

ν = Kinematic viscosity (m²/s)

The Colebrook-White transition equation takes into account the variation of viscosity with temperature and pipe roughness and is recognized as being the most accurate in general use, but requires iterative solutions.

The flow resistance chart in Figure 1.1 has been prepared based on a temperature of 20°C which corresponds to a kinematic viscosity for water v = 1.01 x 10-6 m2/s and equivalent pipe wall roughness co-efficient, k = 0.003 x 10-3 m.

This value of the equivalent roughness coefficient 'k' assumes the Apollo® pipeline is straight, clean and concentrically jointed without fittings. Possible values ranging between 0.003 to 0.015mm are given in AS 2200 'Design Charts for Water Supply and Sewerage' for PVC. An approximate allowance for the effect of variation in water temperature can be made by increasing the chart value of the head loss by 1% for each 3°C below 20°C and decreasing it by 1% for each 3°C in excess of 20°C.

The hydraulic performance of a pipeline may be adversely affected if combined air release and anti-vacuum valves are not installed at local high points in each section of a pipeline, with a maximum spacing not exceeding 500m. These are required to maintain full bore flow and limit the occurrence of sub atmospheric conditions.

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

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PRESSURE CLASS SELECTION

The nominal pressure rating of Apollo® pressure pipe is either 1250 kPa or 1600 kPa. The rated pressure should not be exceeded at any location in the pipeline by the maximum operating pressure including water hammer pressure surcharges. Where the pipeline will be operating at elevated temperatures that are higher than 20°C, the nominal rating should be multiplied by the re-rating factor for that temperature.

Fatigue and structural considerations should also be considered when selecting the pipe class. For example surge pressures commonly known as 'water hammer' must be considered when selecting the pipe class.

Apollo® pipes are manufactured with a minimum pipe stiffness of not less than 9000 N/m.m, which is greater than the recommended minimum for pipelines under full vacuum conditions without external soil support. The factor of safety for buried pipelines, fully embedded in a properly compacted non-cohesive material (such as sand or gravel) will therefore be even greater.

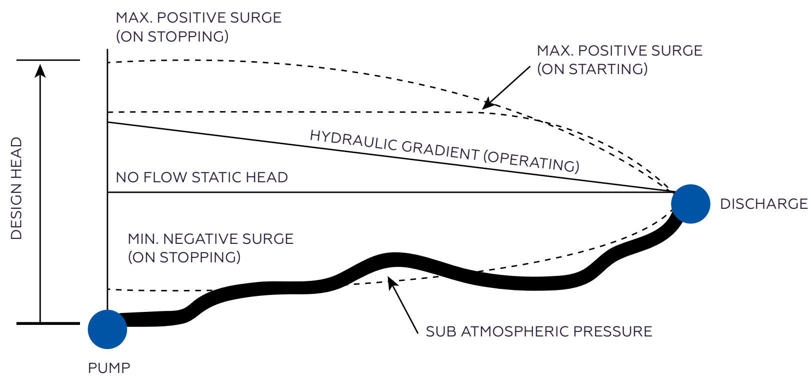

Figure 1.0 Typical hydraulic grades and surge envelopes required for design of PVC-O Pipe

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.

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WATER HAMMER SURGES AND CYCLICAL EFFECTS

Water hammer effects in thermoplastic materials are considerably reduced compared with iron, steel and concrete due to the much lower modulus of elasticity. Typical values for celerity for Apollo® and DI are shown in Table 1.0.

TABLE 1.0 WATER HAMMER CELERITY COMPARISON (AT 20 DEGREES C)

MATERIAL	APPROXIMATE CELERITY (M/S)
PVC-O	340
DI	1150

Apollo® has predictable characteristics with respect to fatigue under cyclical pressures. To eliminate risk of fatigue failure the designer should take into account the frequency of pressure fluctuations during the service life of the pipeline, which may be in excess of 100 years. This can be achieved by ensuring that the amplitude of the surge (i.e. the difference between the maximum and minimum steady state operating pressures including persistent water hammer effects, when divided by the load factor given in Table 1.1, does not exceed the nominal pressure rating of the pipe).

In practice the pressure changes in water reticulation systems are seldom of sufficient amplitude and frequency for fatigue to affect pipe class selection, but they can be an important consideration for sewer rising mains. The amplitude will be the difference in the hydraulic gradients, when the pump is running and when the pump is stopped.

TABLE 1.1 FATIGUE LOAD FACTORS FOR DIFFERENT PVC MATERIALS

TOTAL NUMBER OF CYCLES OVER 100 YEARS	APPROXIMATE NUMBER OF CYCLES/DAY FOR 100 YEAR LIFE	FATIGUE CYCLE LOAD FACTORS		
		PVC-U	PVC-M	APOLLO® PVC-O
26,400	1	1.00	1.00	1.00
100,000	3	1.00	0.67	0.75
200,000	5.5	0.81	0.54	0.66
500,000	14	0.62	0.41	0.56
1,000,000	27	0.50	0.33	0.49
2,500,000	68	0.38	0.25	0.41
5,000,000	137	0.38	0.25	0.41
10,000,000	274	0.38	0.25	0.41

Reference: PIPA Industry Guidelines 'PVC Pressure Pipes, Design for Dynamic Stresses' Issue 1.3 POP101

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The frequency is defined as the number of combined pump start and stop cycles. If an allowance is considered necessary to allow for attenuation of water hammer oscillations the frequency can then be taken as being twice the number of start/stop cycles. (It can be shown mathematically that this is appropriate for the exponential decay typical of pressure surge oscillations).

The dynamic fatigue consideration requires a pipe to be selected with a pressure rating which, when multiplied by the fatigue factor, will give a value greater than the pressure range.

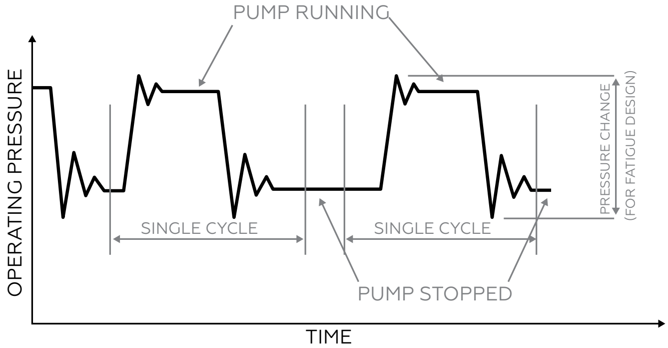

Figure 1.1 Inputs for fatigue design – pressure amplitude and frequency

Apollo® PN16 has a pressure rating of 160 metres. If a pipeline is proposed which is estimated to be subject to say 2.5 million cycles over its entire service life, Table 1.1 gives a fatigue load factor of 0.41. Therefore an Apollo® PN16 pipeline is suitable for a fluctuating pressure range of up to 160 x 0.41 = 65.6 metres.