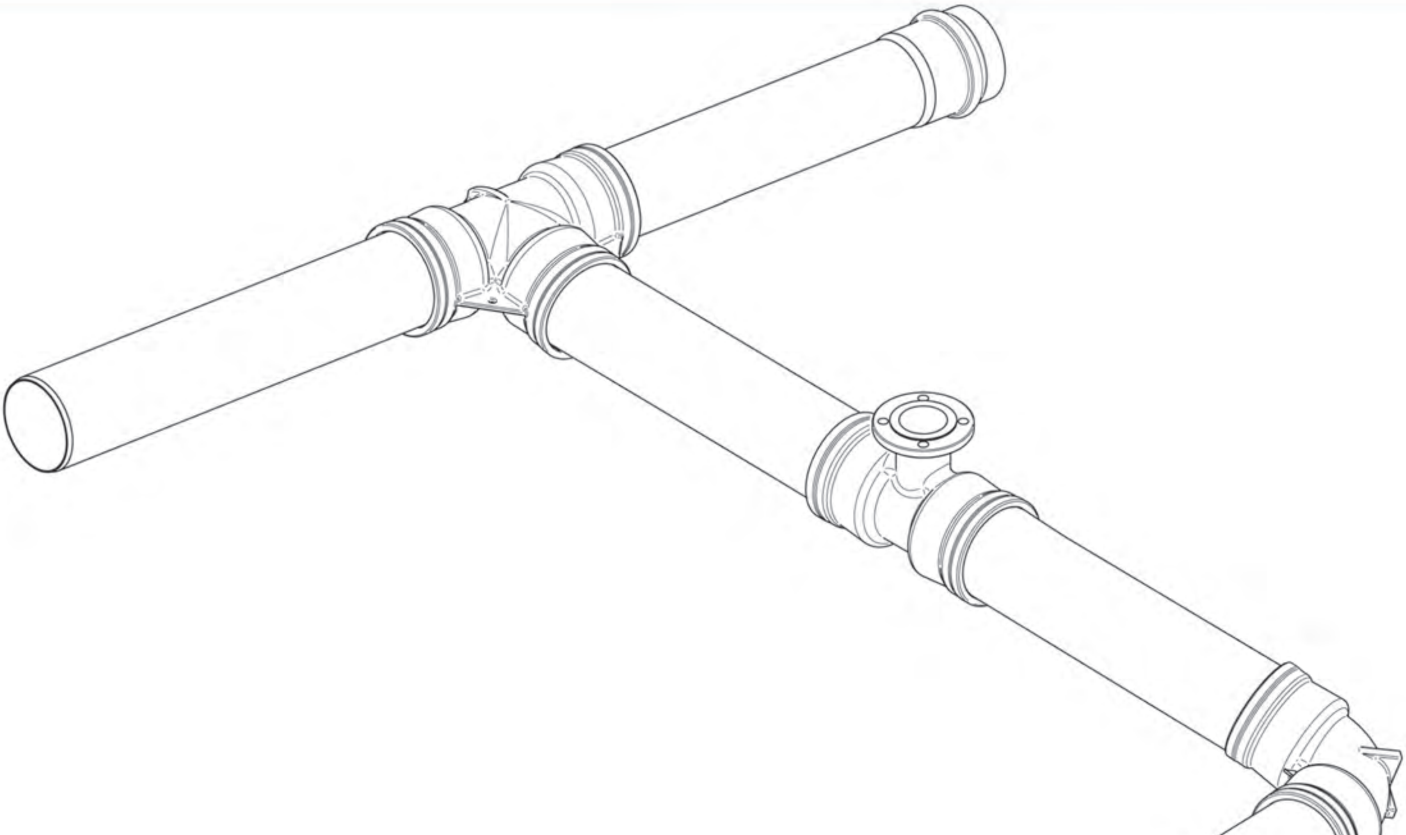
ENGINEERING DESIGN AND INSTALLATION GUIDE

BLUE Rhino™ & WHITE Rhino™
Modified PVC (PVC-M) Pressure Pipes



iPLEX Pipelines

Important Disclaimer

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1.1 What is modified PVC?

Modified PVC is similar in composition to the traditional PVC pressure pipe that has been used in Australia since the early 1970's. The difference is that an impact modifier has been added to alter the fracture mechanism, so the material behaves in a ductile manner.

This enhanced toughness enables PVC-M to be manufactured with a thinner wall with subsequent material savings and improved hydraulic properties. The important aspect of PVC-M is that the optimum combination of strength and ductility is produced by optimising the formulation and processing conditions so that the full benefit of the modifier is achieved.

PVC-M was introduced to the UK water industry approximately 15 years ago and to South Africa shortly after. PVC-M pipes were first produced in New Zealand in 1996 and have been used in Australia since 1997.

1.2 What do BLUE RHINO™ and WHITE RHINO™ PVC-M pressure pipe offer?

BLUE RHINO™ and WHITE RHINO™ pressure pipes are high performance thermoplastic pipes, incorporating the advancements of modified PVC pipe technology.

BLUE RHINO™ and WHITE RHINO™ provide superior characteristics over conventional un-plasticized PVC (PVC-U) pressure pipes, including higher impact resistance and ductility, reduced weight and greater hydraulic capacity.

Iplex modified PVC-M pipes do not contain any compounds based on lead, cadmium or mercury.

1.3 Applications

Iplex WHITE RHINO™ and BLUE RHINO™ PVC-M pipes are recognised for their advantages and have been used extensively in Australia since 1997 in the following applications,

- Potable water supply trunk and reticulation mains
- Industrial process pipelines
- Effluent pipelines for pumped sewage, industrial and rural wastes
- Slurry pipelines carrying abrasive and corrosive mine or quarry materials
- Irrigation and turf watering systems

Figure 1.1 - WHITE RHINO™ PVC-M Pipes being installed at the Wimmera Mallee Pipeline Project, Victoria.

1.4 Features and benefits

The tough, ductile nature of modified PVC (PVC-M), allows the use of a higher design stress, enabling pipes to be manufactured with reduced wall thicknesses and larger internal diameters. The benefits are greater flow capacity and lower pumping costs compared with PVC-U pipes with the same nominal diameters.

Other features are shown in Table 1.1.

Table 1.1: Features and benefits of PVC-M RHINO™

Features	Benefits
Toughness and ductility	Resistance to poor handling and installation damage.
Excellent corrosion resistance both internally and externally	Long service life, in excess of 100 years.
PVC-M pipe dimensions are compatible with existing AS/NZS 1477-Series 1 and Series 2 pipe systems	Interchangeable with PVC-U pipes and Series 2 pipes such as ductile iron, GRP and AC.
Flexibility	PVC-M RHINO™ pipes can be easily curved to a minimum radius on site.
High quality rubber ring joint with a factory fitted Rieber rubber ring.	Provides a secure joint, which is easy to assemble and join.
Light weight	Approximately 30% lighter than PVC-U improving on site handling and laying efficiencies

2.1 Material properties

The general physical properties of PVC-M are provided in Table 2.1.

Table 2.1 – Physical properties

Property	Value
Physical and mechanical	
Specific gravity	1.42
Vicat softening temperature - ISO 2507-2	>79°C
Effect on potable water - AS/NZS 4020	Complies
Hydrostatic design stress – AS/NZS 4765	17.5 MPa
Short term minimum hoop stress at 1 hour and 20°C	38.0 MPa
Minimum required strength (MRS) at 20°C extrapolated to 50 years	24.5 MPa
Minimum notched hoop strength at 20°C extrapolated to 50 years	24.5 MPa
Flexural modulus - ISO 9969	3000 MPa
Poisson's ratio	0.38 – 0.40
Thermal	
Coefficient of linear thermal expansion	70×10^{-6}/° C
Thermal conductivity	0.138 – 0.150 W/m.K
Specific heat	1045 J/kg.K
Maximum practicable working temperature	50°C
Fire resistance	
Flammability	Will not support combustion
Ignitability - AS 1530*	7
Smoke development - AS 1530*	9
Spread of flame - AS 1530*	0
Heat evolved - AS 1530*	2
* AWTA test report number 7-558803-CV	
Electrical	
Volume resistivity	10^{16} ohm.cm (60% RH)
Surface resistivity	10^{13} - 10^{14} ohm
Power factor	0.015 - 0.020 at 20°C
Dielectric constant	3.4 - 3.6 at 25°C (60 Hz)

2.2 Sustainability

Iplex RHINO™ pipe is a sustainable infrastructure pressure pipeline. It has low embodied energy, can utilise re-processible PVC from its manufacture and is fully recyclable at the end of its service life.

Iplex RHINO™ pipes are lightweight and as result require less non-renewable energy (e.g. diesel) during transportation. Lightweight RHINO™ pipe also allows the production of more lengths of pipe per tonne of raw material, compared with almost any other pressure pipe of similar diameter and pressure class.

Iplex RHINO™ pipes do not contain any compounds based on lead, cadmium or mercury. This actively prevents more of these compounds from entering the environment and positively reduces industry demand for these compounds upstream of the manufacturing process.

Iplex RHINO™ is chemically inert. There is no corrosion or chemical or gas emissions during its normal service life as a public water main or sewer.

Iplex RHINO™ pipe does not require any further application of protective coatings or sealing compounds, which are known to liberate volatile organic compounds to atmosphere.

Iplex RHINO™ is also very durable enabling a one off energy consumption in the manufacture of the pipe asset. This is only required once in its 100 year service life, if installed and operated to the relevant codes and standards.

For further information refer to the PIPA website, www.pipa.com.au/environment.

2.3 Temperature effect on pressure rating

Modified PVC pipes are suitable for service temperatures ranging from 0°C to 50°C. For temperatures above 20° C, provision must be made for pressure re-rating in accordance with Table 2.2.

*Table 2.2: Thermal re-rating factors**

Maximum service temperature (°C)	Multiplication factor for pressure re-rating
20	1.00
25	0.94
30	0.87
35	0.78
40	0.70
45	0.64
50	0.58

**Based on ISO 4422-2 Pipes and fittings made of un-plasticized polyvinyl chloride (PVC-U) for water supply Part 2: Pipes (with or without integral sockets)*

2.4 Chemical resistance

Resistance of PVC pipe and elastomeric seals to reaction with or attack by the chemical agents listed in the "Chemical Resistance Guide" has been determined by research, investigation and reference to data from international and local sources.

Information provided is intended as a guide only. Due to the complexity of some organochemical reactions, it is suggested that in critical applications, additional long-term testing be performed.

Data provided should not be necessarily regarded as applicable to all exposure durations, concentrations and working conditions likely to be encountered.

PVC has exceptional resistance to attack from high concentrations of alkalis and acids, except for strong oxidising agents at maximum or near maximum concentrations. The material is not recommended for use with aromatic and chlorinated hydrocarbons, ketones, esters and ethers.

For further information and chemical resistance charts refer to the Chemical Resistance Guide on the Iplex Website www.iplex.com.au in design tools.

3.1 Standards and testing

Iplex PVC-M pipes and associated materials are manufactured to relevant Australian Standards under third party accredited quality assurance programs complying with AS/NZS ISO 9001.

3.2 Pipes

BLUE RHINO™ and WHITE RHINO™ PVC-M pipes are manufactured in accordance with Australia/New Zealand Standard AS/NZS 4765 "Modified PVC (PVC-M) pipes for pressure applications.

The Water Services Association of Australia (WSAA), has appraised Iplex RHINO™ pipes, as fit for purpose and rated "A" with a life expectancy in excess of 100 years before major rehabilitation.

Refer to WSAA Product Appraisal No 04/02 for further information.

3.3 Certification

Iplex PVC-M pipes are StandardsMark licensed to AS/NZS 4765.

SAI Global licence numbers,

Certified Product™ Australian Standard

SMK02748
SMK02468
SMK02749
SMK02730

3.4 Colour and Markings

Iplex RHINO™ PVC-M pipes are colour coded as per AS/NZS 4765 and WSAA product specification WSA PS 209, to readily distinguish between the different types of pipe applications. The following is a summary of the colours used for common applications.

- WHITE RHINO™(Series 1) pipes for drinking water applications are white in colour
- BLUE RHINO™(Series 2) pipes for drinking water applications are light blue in colour.
- Series 1 and Series 2 pipes specified for recycled water applications are purple in colour
- Pipes intended for pressure sewerage applica tions are cream in colour

Figure 3.1 - Iplex DN450 PN12 Series 2 PVC-M purple pipes for recycled water at Willunga, South Australia.

3.5 Rubber ring seals

Iplex Rieber sealing rings comply with AS1646 'Elastomeric seals for waterworks purposes'. They are manufactured from SBR or EPDM polymer.

3.6 Product codes

The following computer identification codes used by Iplex Pipelines are shown in Table 3.1 and are in the form,

'**AAAA (A) BBCCC (D)**' – the brackets indicate the symbol is used only where required.

Examples

The product code for DN200 PN16 BLUE RHIN™ (Series 2) PVC-M Pipe in 6m length is:

"**PDHR16200**"

The product code for DN300 PN12 Cream RHINO (Series 1) PVC-M Pipe in 6m length is;

"**PPHRC12300**"

Table 3.1 Pipe product codes

Product description	Product code AAAA (A)	Pressure class		Nominal diameter		Pipe effective length	
		PN	Code BB	DN	Code CCC	(m)	Code (D)
WHITE RHINO™ Series 1	PPHR	6	06	100	100	1	A
Purple RHINO Series 1	PPHRL	9	09	150	150	2	B
Cream RHINO Series 1	PPHRC	12	12	200	200	3	C
BLUE RHINO™ Series 2	PDHR	15	15	225	225	4	D
Purple RHINO Series 2	PDHRL	16	16	300	300	5	E
Cream RHINO Series 2	PDHRC	18	18	375	375	6	-
		20	20	450	450		
				500	500		
				575	575		

Table 3.2 - Product codes for lubricants

Container size (grams)	Product code	
	Iplex standard lubricant	Iplex Plus* (Bactericidal)
500	JLO10500	JLB10500
1000	JLO11000	JLB11000
4000	JLO14000	JLB14000

** This product is accredited under the WaterMark Scheme to technical specification ATS 5200.014, licence No: WMKA00103.*

4.1 Pipe dimensions

Iplex manufacture WHITE RHINO™ as Series 1 pipe and BLUE RHINO™ as Series 2 pipe, however Purple RHINO and Cream RHINO can be supplied as Series 1 or Series 2 pipe as required. Tables 4.1 and 4.2 provide general details for Series 1 and Series 2 pipes respectively.

Table 4.1 – WHITE RHINO™ (Series 1) Pipe dimensions

Nominal diameter DN	Mean outside diameter	PN6		PN9		PN12		PN15		PN18	
		T	ID	T	ID	T	ID	T	ID	T	ID
100	114.3	3.2	108.7	3.2	108.0	4.1	106.1	5.1	104.2	6.0	102.3
150	160.3	3.7	152.9	4.3	151.7	5.7	148.9	7.1	146.2	8.3	143.7
200	225.3	5.2	215.0	6.1	213.1	8.0	209.3	9.9	205.5	11.7	202.0
225	250.4	5.8	238.8	6.7	237.0	8.8	232.8	10.9	228.6	13.1	224.3
250	280.4	6.4	267.6	7.5	265.5	9.9	260.6	12.4	255.6	14.5	251.4
300	315.5	7.2	301.1	8.4	298.7	11.2	293.2	13.8	288.0	16.3	282.9
375	400.5	9.2	382.1	10.6	379.3	14.1	372.3	17.5	365.6	20.7	359.1
450*	500.5	11.8	476.9	13.8	472.9	18.1	464.3	-	-	-	-
500*	560.5	13.2	534.1	15.5	529.6	20.3	520.0	-	-	-	-
575*	630.5	14.7	601.1	17.3	596.0	22.8	585.0	-	-	-	-

Table 4.2 – BLUE RHINO™ (Series 2) Pipe dimensions

Nominal diameter DN	Mean outside diameter	PN9		PN12		PN16		PN18		PN20	
		T	ID	T	ID	T	ID	T	ID	T	ID
100	121.9	-	-	4.4	113.1	5.7	110.3	6.4	109.1	7.1	107.8
150	177.4	-	-	6.3	164.8	8.3	160.8	9.2	159	10.2	157.0
200	232.3	-	-	8.2	215.9	10.8	210.7	12	208.3	13.3	205.8
225	259.3	7.0	245.4	9.2	241.0	12.0	235.1	13.4	232.5	14.8	229.7
250	286.2	7.7	270.9	10.1	266.0	13.3	259.7	14.8	256.6	16.4	253.4
300	345.4	9.3	326.9	12.2	321.0	16.0	313.5	17.8	309.8	19.7	306.1
375	426.2	11.4	403.5	14.9	396.4	19.7	386.9	22	382.2	24.3	377.7
450*	507.0	13.5	480.1	17.8	471.5	23.4	460.2	-	-	-	-
500*	560.3	18.4	523.6	20.3	519.8	-	-	-	-	-	-

** These sizes are made to order only. Contact Iplex Pipelines for further information.*

All dimensions are in millimetres.
T = average mean wall thickness
ID = average mean inside diameter
The standard effective length for all pipes is 6m+50/-0mm,

4.2 Ductile iron fittings

Conventional socketed fittings complying with AS/NZS 2280 – "Ductile Iron Pressure Pipes and Fittings" and WSAA TN2, are generally suitable for use with, BLUE RHINO™ Series 2 pressure pipes. A complete range of bends, tees reducers and flange-spigot pieces are available with rubber ring sockets in sizes DN100 to DN750.

A similar range of ductile iron fittings is also available with rubber ring sockets for Series 1 WHITE RHINO™ in sizes DN100 to DN375, (For larger sizes contact Iplex Pipelines). Reference should be made to the Water Services Association of Australia (WSAA) guidelines for the use of ductile iron elastomeric joint fittings with plastic pipes. If in doubt, contact Iplex Pipelines to confirm the suitability of any particular range of fittings.

Figure 4.1 - Example of a polymeric coated ductile iron socketed bend.

Ductile iron fittings can be protected from corrosion with the following:

- Polymeric coated (preferred)
- Cement lining and polyethylene wrap
- Epoxy coating

5.1 Flow capacity determination

The hydraulic 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 nutrient in the water.
- Roughening , due to wear by abrasive solids.
- Siltation or settlement of suspended particulate matter.
- Joint imperfections and fittings

To assist the designer in selecting the appropriate pipe diameter, 'flow calculation software' is available from Iplex Pipelines which allows variation in fluid temperature and pipe roughness to suit site conditions. The flow calculator is available at www.iplex.com.au in the Design Tools section.

Alternatively flow resistance charts for both WHITE RHINO™ Series 1 and BLUE RHINO™ Series 2 PVC-M pipes are shown in figures 5.2 and 5.3 respectively. The flow resistance charts relate friction loss to discharge and velocity for pipes running full and have been calculated using the Colebrook-White transition equation in the form;

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

where:

V = mean velocity (m/s)
g = acceleration due to gravity (m/s^2)
d = pipe internal diameter (m)
S = hydraulic gradient (m/m)
k = equivalent hydraulic roughness (m)
v = kinematic viscosity (m^2/s)

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

The flow resistance charts in Figures 5.2 and 5.3 have 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 PVC-M pipeline is straight, clean and concentrically jointed without fittings. Possible values ranging between 0.003 to 0.015 mm 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 3ºC below 20ºC and decreasing it by 1% for each 3ºC in excess of 20ºC.

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.

5.2 Pressure class selection

The *nominal* pressure rating in kilopascals (kPa) of a modified PVC pressure pipe (PVC-M) is equal to PN multiplied by 100. The pressure rating should not be exceeded at any location in the pipeline including water hammer pressure surcharges.

Where the pipeline will be operating at elevated temperatures, for example greater than 20° C, the nominal rating should be multiplied by the re-rating factor given in Table 2.2.

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.

Note: PN9 is the minimum class which should be used for full vacuum conditions in a buried pipeline, provided pipes have been embedded in a properly compacted non-cohesive material (such as sand or gravel). The compacted embedment must fully surround the pipe. Pipes installed above ground and subjected to vacuum should be specified as a minimum of PN12.

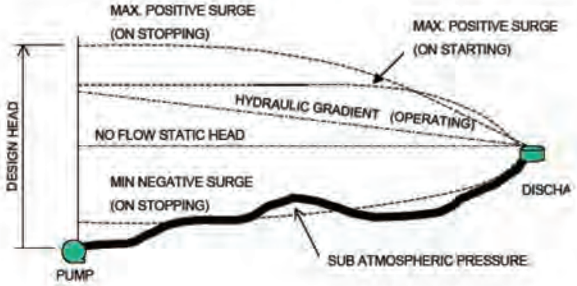
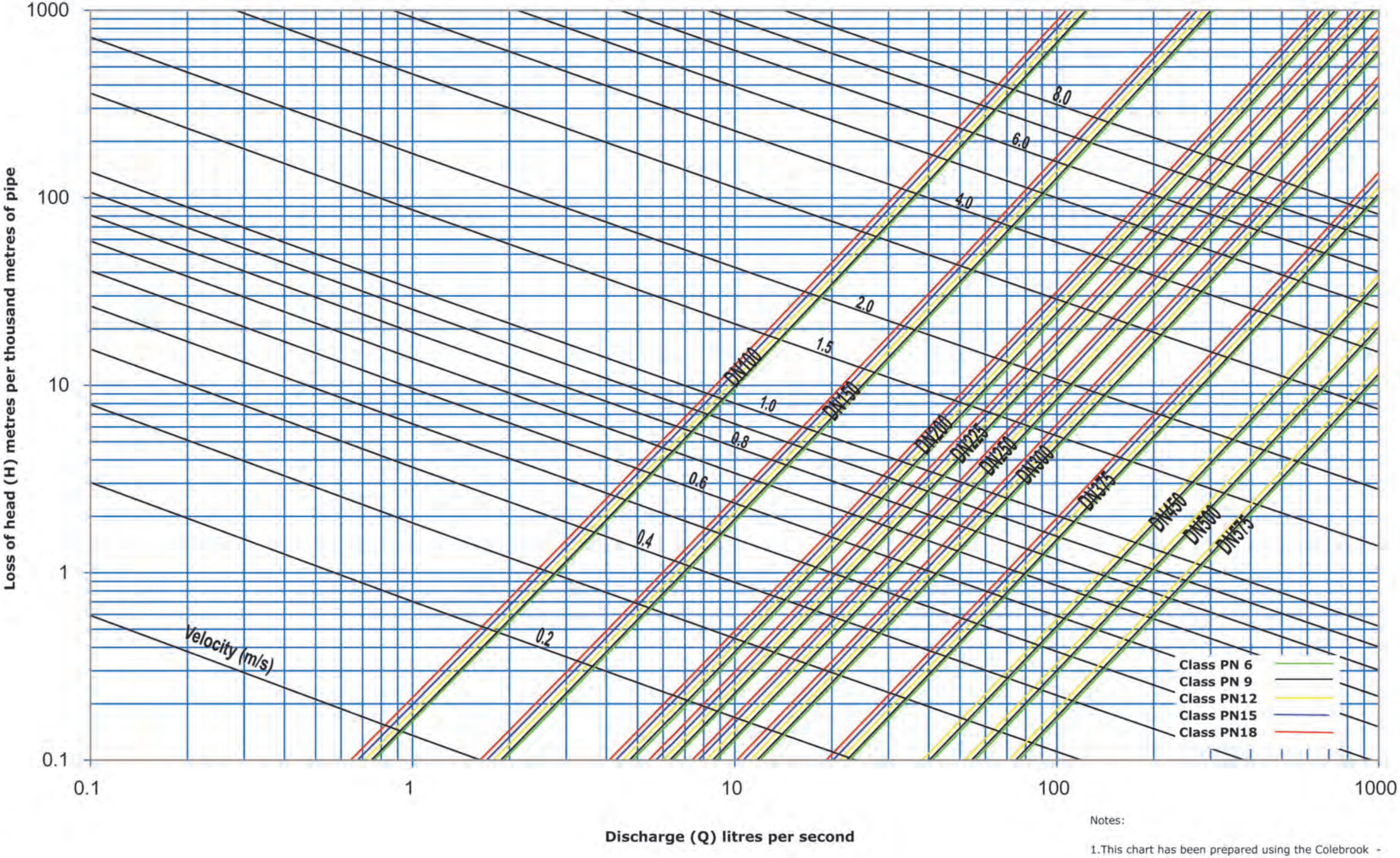


Figure 5.1 - Typical hydraulic grades and surge envelopes required for design

Figure 5.2 - Flow resistance chart – WHITE RHINO™ Pressure Pipe Series 1

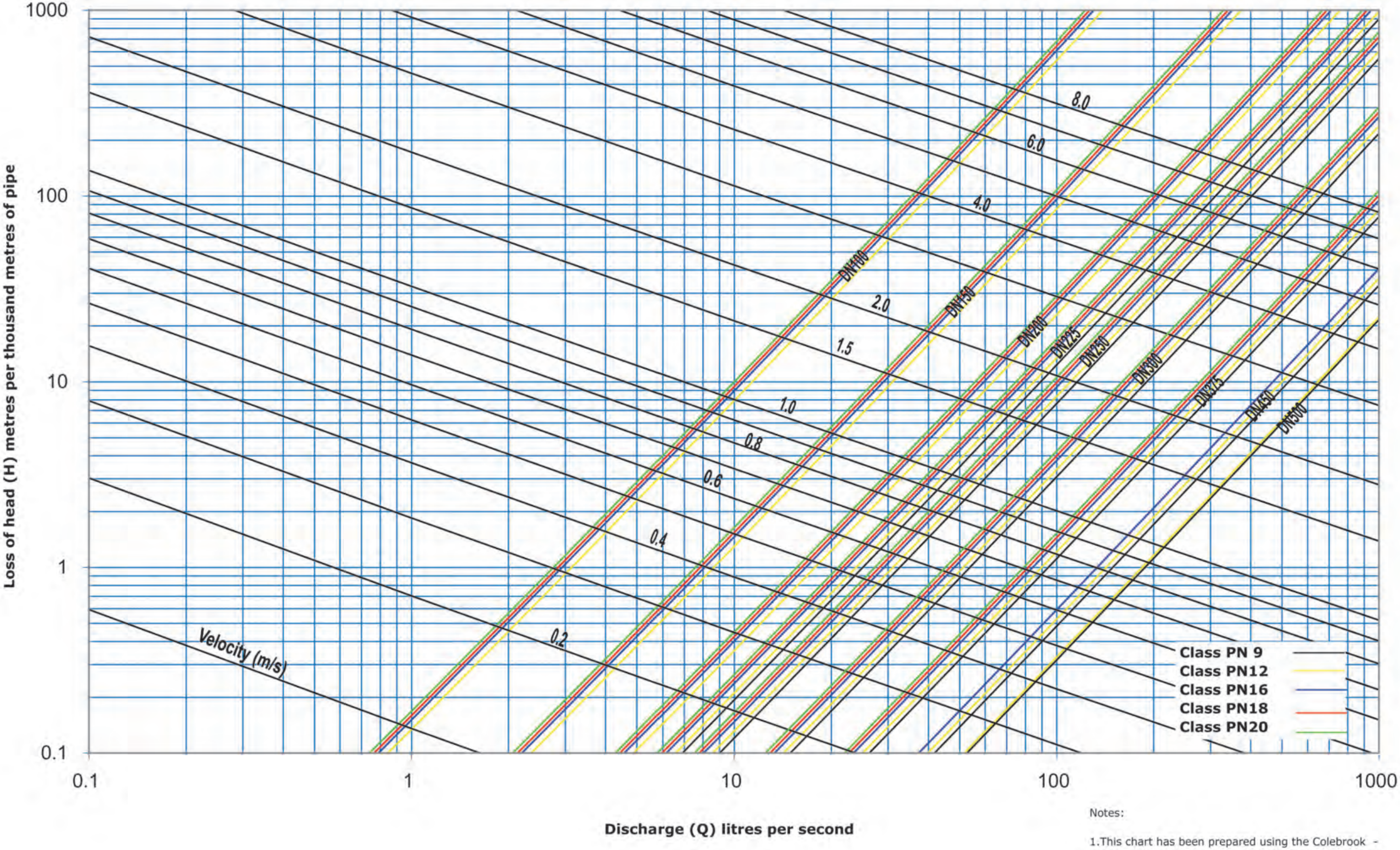


Notes:

1.This chart has been prepared using the Colebrook - White Formula with a roughness co-efficient k=0.003mm

2.This chart has been calculated for the viscosity of water at 20 C

Figure 5.3 - Flow resistance chart – BLUE RHINO™ Pressure Pipe Series 2



Notes:

1.This chart has been prepared using the Colebrook - White Formula with a roughness co-efficient k=0.003mm

2.This chart has been calculated for the viscosity of water at 20 C

5.3 Water hammer surges and cyclical effects

Water hammer affects in thermoplastic materials are considerably reduced compared with ductile iron, steel and concrete due to the much lower modulus of elasticity. Typical values for celerities for PVC-M pipes for various pressure classes are provided in table 5.1.

Table 5.1 - Water hammer celerity

Material	Approximate celerity (m/s)
6	254
9	276
12	319
15	357
16	365
18	392
20	409

PVC-M has characteristics similar to PVC-U, with respect to fatigue under cyclical pressures. The designer should take into account the frequency of the cyclic pressure fluctuations during the life of the pipeline. The amplitude of the pressure change between the maximum and minimum operating pressures, including all transients when divided by the load factor given in Table 5.2 should not exceed the nominal pressure class rating of the pipeline.

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.

Table 5.2 - PVC-M fatigue load factors reference - PIPA POP101

Total Cycles	Approximate number of cycles /day for 100 year life	Fatigue cycle factor f
26,400	1	1.00
100,000	3	0.67
200,000	5.5	0.54
500,000	14	0.41
1,000,000	27	0.33
2,500,000	82	0.25
5,000,000	137	0.25
10,000,000	274	0.25

Reference: PIPA Industry Guidelines "PVC Pressure Pipes, Design for Dynamic Stresses" Issue 1.2 POP101

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).

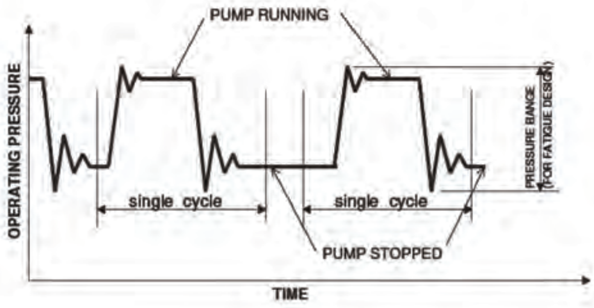


Figure 5.4- Inputs for fatigue design – pressure amplitude and frequency

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 (Maximum Cyclic Pressure Range) greater than the pressure range or amplitude.

Examples:

1) Question A water main will for most of its lifetime experience diurnal operating pressures of 55 metres and 85 metres, that is a pressure change amplitude of 30 metres with a total number of cycles over 50 years of 18250 fluctuations.

Solution: Since the maximum operating pressure is 85 metres and from Table 5.2, the fatigue load factor is 1, a PN 9 pipe would be suitable. No de-rating is needed for cycling.

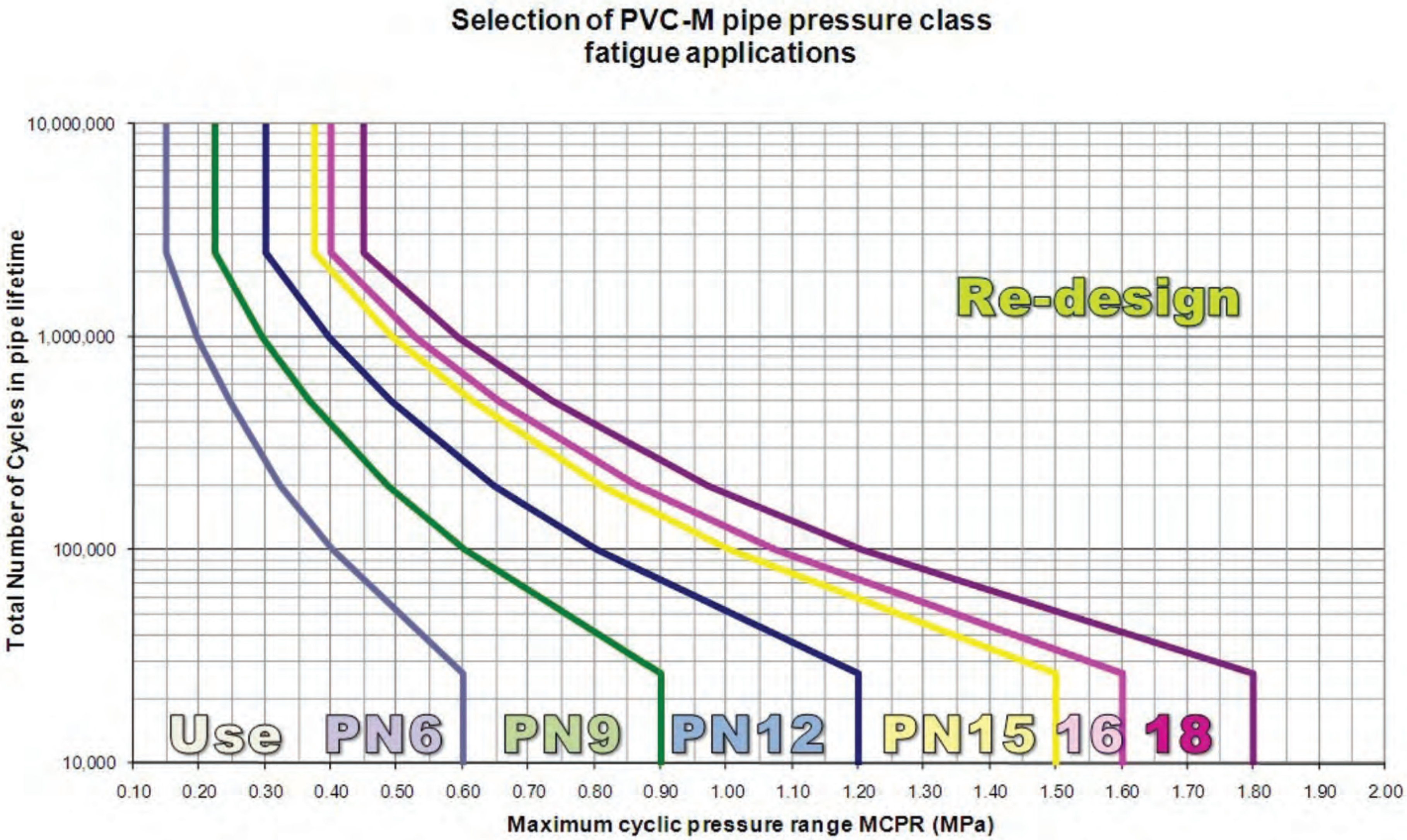
2) Question A sewer pump station has a wet well capacity which will require a pump start (and stop) 3 times per hour on average over a 40 year design life (for the rising main). The static head on the main without pump operation is 12 metres and with a maximum pump station operating of 29 metres. A surge analysis shows the normal shut down phase generates a (maximum) hammer effect of 32 metre maximum head and (minimum) minus 8 metre head at shut down.

Solution: Steady state operating conditions would suggest that a Class 6 pipe might be selected. However the amplitude of the maximum pressure transient during the pumping cycle is 32-(-8)= 40 metres and this must be checked for fatigue effect.

The number of cycles used for this check is usually the number of pump stop/start operations. But in this case the number of cycles is to be multiplied by 2, i.e.1,051,200 x 2 = 2,102,400 to allow for surge wave attenuation.

The dynamic fatigue consideration requires a pipe to be selected, which will give a maximum cyclic pressure range greater than the pressure fluctuation amplitude of 40 metres. Therefore the class rating can be obtained by dividing the pressure amplitude by the fatigue factor obtained from Table 5.2 for a frequency of 2.1 million pressure fluctuations. (It should be noted that pressure amplitude of 0.25 times the rated pressure is the threshold value below which fatigue will not occur irrespective of frequency.) Here 40 / 0.25 = 160 m. Therefore the appropriate pipe class selection would be PN16 rated to 160 metres. (Alternatively Figure 5.5 could be used to directly determine the appropriate class).

Figure 5.5 – Fatigue loading chart



6.1 Allowable cover heights

In engineering terminology the Iplex range of RHINO™ pipes are considered to be "flexible" pipes, which means they are designed to deform or deflect diametrically within specified limits without structural damage.

The external soil and live loadings above flexible pipes may cause a decrease in the vertical diameter and an increase in the horizontal diameter of the pipe. The horizontal movement of the pipe walls in the soil material at the sides develops a passive resistance within the soil to support the external load. That is, the pipeline performance is influenced by the soil type, density and height of water table. The higher the effective soil modulus at pipe depth, the less the pipe will deflect.

Initial deflections of up to 3% are permissible and will not affect the pressure rating of the pipe. A complete design procedure is available for Iplex PVC-M pipes. Consult Iplex for further details or refer to AS/NZS 2566.1 "Buried flexible pipelines" Part 1 Structural design". Iplex has developed computer software, which is available for download, free of charge. It is based on this standard and covers all its pipeline materials in addition to Series 1 & 2 PVC-M.

Table 6.1 – Estimated pipe stiffness (PVC-M pressure pipes)

Nominal pressure PN	Estimated stiffness (N/m.m)
6	2,500
9	4,200
12	10,200
15	20,500
16	23,400
18	36,400
20	46,600

6.2 Minimum cover heights – AS/NZS 2566

For areas with no traffic loading a minimum cover height of 450mm to the top of the pipe should be adopted. Under sealed roadways the minimum cover height is 600mm and in unsealed roadways, 750mm.

Pipe embedment material should have a minimum compaction Density Index of 65% or standard dry density compaction of 90%. After pipes are laid and centred in the trench, the embedment material should be compacted in 80-100mm layers to the specified density. The embedment should continue 80mm to 150mm above the pipe to provide protection from the backfill.

6.3 Thrust block design for fittings

For rubber ring jointed pipeline systems, provision must be made for potentially unrestrained forces at changes of size or direction. For e.g, bends, tees, reducers, valves and closed ends.

In buried installations, fittings are usually restrained by blocks of concrete cast in-situ. These thrust blocks are formed and sized to distribute the applied force from the fitting to a safe soil pressure / concrete interface. The resistance provided will depend on the soil type and depth.

Where bends are in the vertical plane, convex and close to the surface, the mass of a concrete anchor block alone may have to be the restraining force.

AS/NZS 2566.2 and AS2032 specify the use of thrust blocks for all in-line gate valves. Although no longer allowed, Water Agencies have in the past omitted valve restraints for small diameter (≤ DN 200) reticulation pipelines.

Where there is risk of axial thrust, it is strongly recommended that only those DI fittings with full circle bearing surfaces at the base of the socket should be used. It is also beneficial if the PVC-M spigots are trimmed back and the chamfer reduced to DI chamfer lengths. This serves to increase the effective end bearing area for the PVC spigot inside the DI socket.

Installers should be alerted to the potential for catastrophic failure where there is insufficient buried pipe downstream of an unanchored valve to provide enough soil friction to resist the hydrostatic thrust when the valve is closed.

Figure 6.1 - Typical thrust block arrangements (Reference: AS/NZS 2566)

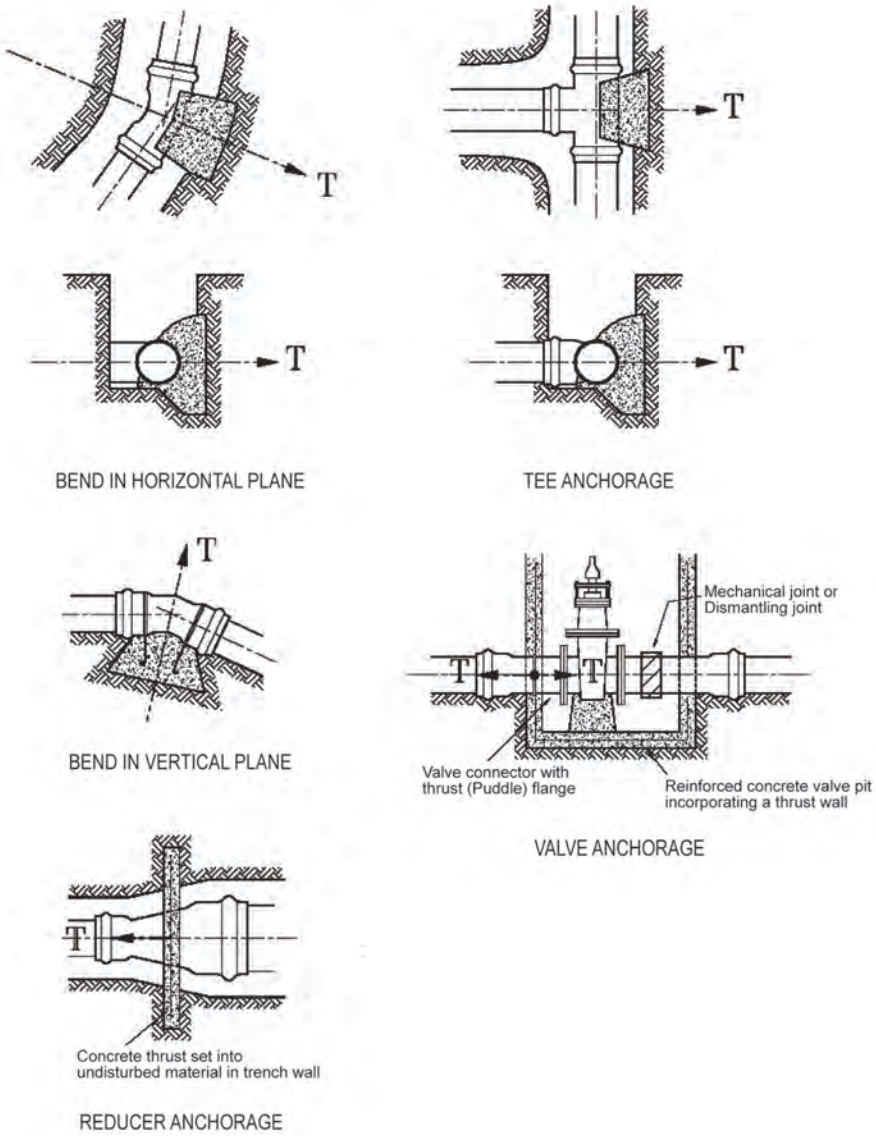


Table 6.2 - Hydrostatic forces (kN) on rubber ring jointed fittings per 10metres of hydrostatic head

Pipe DN	Pipe OD	Bend 90°	Bend 45°	Bend 22½°	Bend 11¼°	Tee/ Closed end/ valve
100	122	1.62	0.88	0.45	0.22	1.15
150	177	3.41	1.85	0.94	0.47	2.41
200	232	5.86	3.18	1.61	0.81	4.14
225	259	7.31	3.96	2.01	1.01	5.17
250	286	8.91	4.83	2.45	1.23	6.30
300	345	12.96	7.02	3.57	1.79	9.16
375	426	19.76	10.71	5.44	2.72	13.97
450	507	27.99	15.17	7.71	3.86	19.79
500	560	34.17	18.49	9.43	4.74	24.15
575	630	43.25	23.41	11.93	6.00	30.56

Note: For concentric reducers the resultant thrust will be the difference between the "closed end" forces for the two pipe sizes.

Table 6.3 – Typical soil bearing capacities (kPa)

Soil group description as per AS 1786	Minimum soil cover above centre line of thrust block in metres			
	0.75	1.0	1.25	1.5
GW,SW	57	76	95	114
GP,SP	48	64	80	97
GM,SM	48	64	80	96
GC,SC	79	92	105	119
CL	74	85	95	106
ML	69	81	93	106
OH	0	0	0	0

Thrust blocks must be configured to distribute the hydrostatic force to a 'wall' of undisturbed soil, which is approximately perpendicular to the imposed load.

The equation for this calculation is:

A = (T/ b) x f

Where,

A = area perpendicular to force (m^2)
T = hydrostatic thrust (kN)
b = soil bearing capacity (kPa)
f = factor of safety (in the order of 1.1 to 1.5)

Example:

Question A DN300 BLUE RHINO™ pipeline has a maximum operating head (include field test heads) of 150 metres. What is the minimum area for a thrust block for a 90° ductile iron bend buried with 1 metre cover to the centre-line in a type SC soil?

Solution: From Table 6.2, the hydrostatic thrust 'T' is 12.96kN x 15 = 194.4 kN.

From Table 6.3, 'b' = 92 kPa.

Therefore:

A = (194.4 / 92) x 1.1 = 2.32 m²

Figure 6.2 - Concrete thrust block, correctly oriented to transfer the hydraulic thrust to the specially trimmed undisturbed soil of the vertical

7.1 Handling and storage

While PVC-M pipes are light and easy to handle, careless handling can cause unnecessary damage. Pipes and fittings should not be dropped or thrown onto hard surfaces or allowed to come into contact with sharp objects or slide across sharp edges, which could inflict deep scratches. During construction, storage areas should be selected which are free from surface irregularities such as stones, branches or other sharp projections. Where gouging or heavy scratching to a depth of more than 10% of the pipe wall has occurred the pipes must be rejected for pressure applications.

PVC-M pipes are subject to distortion under high loads, particularly at elevated temperatures, and also to bowing due to uneven heating; Pipes should therefore be protected from direct sunlight, or other heat sources, if stored for extended periods.

If PVC-M pipes are stored for extended periods (greater than 12 months) they should be protected from direct sunlight by using hessian covers or similar which will allow adequate air circulation. Black plastic covers must not be used owing to the high temperatures developed when stored in the sun.

Socketed pipes should be stacked in layers with sockets placed at alternative ends of the rack and protruding to avoid uneven distortion. The sockets should not be allowed to carry loads.

If mechanical handling equipment such as forklifts or cranes is to be used on bundles, adequate spreader and lifting bars should be provided. Wire slings must be kept clear of the pipes. When unloading alongside excavated trenches, it is recommended that pipes should be placed on the opposite side of the trench from excavated material.

Jointing fluid, solvent cement and priming fluid should be stored under cover until pipe-laying commences.

Figure 7.1 - Standard crates for storing and transporting WHITE RHINO™ PVC Pipes

7.2 Trenching

Trenches should be excavated in accordance with the plans and specifications and should allow adequate space for compaction of the embedment material in the side support zone.

Trenches should be straight and as narrow as practicable at the top of the pipe. The minimum trench widths are specified in Table 7.1.

Table 7.1 - Minimum embedment zone dimensions – AS/NZS 2566

DN	h	B*	k
100	75	350	100
150	75	400	100
200	100	550	150
225	100	550	150
250	100	600	150
300	100	650	150
375	100	850	150
450	100	900	150
500	150	1150	150
575	150	1250	150

Note: The tabulated values may provide insufficient clearances for installation purposes in certain circumstances.

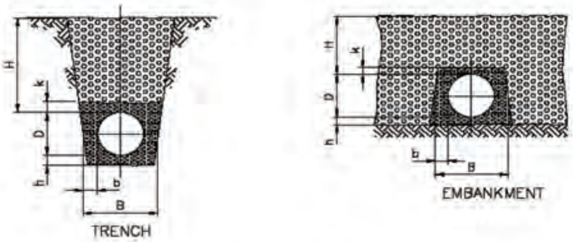


Figure 7.2 - Embedment, clearance and cover dimensions

7.3 Embedment & backfilling

The quality of the embedment material and its compaction, combined with the type and density of the native soil are all relevant to the ultimate performance of modified PVC pipes once installed.

The trench bottom should be as smooth as possible and to grade. Embedment material, used in the bedding, side support and overlay are generally non-cohesive granular materials. Pipes should not be buried in contact with soil particle sizes larger than 5% of pipe diameter, with 20 mm as maximum.

Soil clods must be excluded from the pipe embedment zone and under no circumstances should temporary supports such as bricks or timber be left under or in contact with pipes. If the excavated material is not granular or friable, or does not comply with the project specification, then suitable embedment must be imported.

Jointing or "clearance holes" should be excavated in the bedding for pipe sockets to ensure the pipes are evenly supported along their full length. In the absence of any specification and if the pipe classes are PN 6 or PN9, it is important that only non-cohesive or granular embedment be used. Careful attention to the placement of embedment material to the specified relative compaction with an absence of voids is important.

Mechanical joints, especially flanged joints, should be left exposed if possible until the line is tested. Pipes should not be left uncovered. The possibility of pipe flotation in the event of rain and water in trench, will occur unless it is backfilled to a height of at least one and a half diameters above the pipe. The method of placing the remainder of the trench backfill will depend on whether the pipeline is located in an area with no traffic loading or under a roadway. In a roadway it is normal practice to continue backfilling and compacting with good quality embedment material up to pavement level. Heavy compaction of backfill should not commence without at least 300mm of material covering the pipeline.

Figure 7.3 - DN450 PN 9 WHITE RHINO™ pressure pipe for irrigation supply in Hunter Valley, NSW

7.4 Joining instructions – Rubber ring joint pipe

Modified PVC WHITE RHINO™ and BLUE RHINO™ pipes are supplied with the Rieber jointing system. The Rieber seal is fitted at the time of manufacture and subsequently MUST NOT BE REMOVED.

If the ring is tampered with or damaged in any way after leaving the factory then the socket and affected ring must be cut off and scrapped. It is essential to use Iplex Standard or Iplex Plus bactericidal jointing fluid with the Rieber joint.

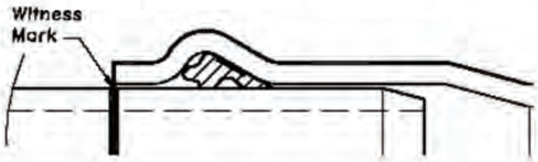


Figure 7.4 - Rieber rubber ring joint (Series 1 and 2 pipe – ring supplied pre installed in pipe socket and cannot be removed)

7.4.1 Cutting pipes

PVC-M pipes can be cut to length on site using either a hand saw or powered cutting disc. Ensure that the cut end is then chamfered with an appropriate field-lathing tool to the correct length. The chamfer and new witness mark should replicate the manufactured dimensions.

7.4.2 Cleaning

Remove all dust and dirt from the pipe spigot and socket paying particular attention to the cleanliness of the fixed ring.

7.4.3 Lubricate

Apply lubricant to the spigot, fully covering the circumference up to the witness mark. Ensure the lubricant is also applied to the pipe chamfer.

7.4.4 Assembly

Insert the leading edge of the spigot into the socket mouth. It is essential that the pipes be aligned in a straight line before attempting to make the joint. A small, longitudinal force applied to the socket end of the pipe is sufficient to insert the spigot into the adjacent pipe socket. For larger diameter pipes requiring a crowbar for jointing, protect the pipe socket with a wooden block.

Care must be taken to ensure that the pipe is not under-inserted as this may result in a leaking joint as the pipe contracts as a result of Poisson's and/or thermal effects. Under-insertion is signified by the witness mark not being pushed up to the end of the socket. *Note: When pressurised, Poisson contraction will cause a shortening of the pipes and this might re-expose the witness mark. This is acceptable.*

If simple insertion past the witness mark has occurred there is no significant risk to the performance of the joint. Only if the spigot has been forced so hard that it has stressed the transition region at the back of the socket to the barrel of the pipe is there a cause for concern. This is generally only a risk with uncontrolled insertion using mechanical equipment like the bucket of a back hoe.

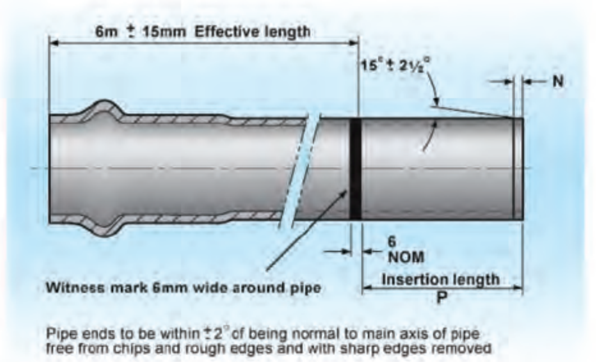


Figure 7.5 – Typical pipe spigot details for rubber ring joint pipes.

Table 7.2 – Typical pipe spigot details

DN	Series 1		Series 2	
	Mean "P"	Mean "N"	Mean "P"	Mean "N"
100	155	19	152	15
150	166	17	174	18
200	199	21	201	21
225	203	23	209	22
250	220	25	218	23
300	227	27	234	26
375	262	32	280	30
450	309	38	307	32
500	327	42	320	42
575	351	45	-	-

7.5 Ductile iron socket joints

Modified PVC pipes can be used with ductile iron socketed fittings complying with AS/NZS 2280.

Note: The witness marks and chamfers to suit these particular sockets should be used.

Figure 7.6 – New witness mark is being stencilled to cater for the ductile iron socket being used.

7.6 Mechanical jointing systems

Where cut-ins or repairs are needed in an existing PVC-M pressure main, Iplex recommends fittings complying with WSA 105 and AS/NZS 4998 'Unrestrained mechanical couplings', should be used. E.g. the AVK coupling

Figure 7.7 –AVK mechanical coupling for field repairs.

7.7 Jointing fluids (lubricants)

Note: It is essential to use Iplex Standard or Iplex Plus bactericidal jointing fluid with all Iplex PVC-M elastomeric jointed systems. Other lubricants especially MINERAL BASED GREASES, MUST NOT BE USED.

Iplex Plus bactericidal jointing fluid is recommended for potable water supplies as it contains a bactericide designed to limit the growth of bacteria by disinfection at its source. During installation bacteria can enter the system and form a colony in the joint area, which is highly resistant, (even to high levels of chlorine) and can cause continuing infection of the line. Being water-soluble, the fluid is quickly removed from potable water systems when flushing commences.

Iplex Plus is safe and has no detrimental effect on the rubbers used in gasket materials and because of its properties, can also lower jointing forces.

Keep the container closed when not in use to avoid spillage or contamination by dust or dirt.

As a safety precaution avoid contact with eyes. If contact does occur, flush with copious amounts of water. If ingested drink copious amounts of water.

7.8 Expansion and contraction

Distortion can occur when laying pipes in direct sunlight. When one side of the pipe is hotter than the other it may develop a slightly bent shape, which may make jointing difficult. Common practice is to rotate pipes or place pipes in the shade to offset any uneven temperatures within the pipe.

Plastic pipe will contract as it cools, after laying in hot weather. A 6-metre length of PVC-M will expand or contract approximately 5mm for each 10ºC rise or fall in temperature.

The following precautions should be taken to ensure that the joints do not pull apart:

Laying is best done in the cooler parts of the day.

Rubber ring systems will allow for thermal movement of the pipeline after having been laid. In both cases, backfill each length, at least partially, as laying proceeds.

7.9 Installing on a curved alignment

PVC-M pipes are flexible enough to be easily curved evenly along their length. Pipes should always be joined directly in line before the alignment of the pipes is altered.

Table 7.3 - Minimum pipeline radii

Pipe Class	Radius of curved pipe*
All	300 x Nominal pipe diameter

**Note: Some authorities may not allow PVC-M pipes to be curved or may not allow curved PVC-M pipes to be drilled or tapped. As an alternative, tapped DI connectors can be used.*

Figure 7.8 - DN 150 PN 6 S1 RHINO™ pipeline laid on a curved alignment near Broke, NSW

7.10 Concrete encasement

Where concrete encasement is required, PVC-M pipes shall be set to line and level on either bags of natural fibre filled with sand and cement mix or on concrete blocks or saddles cast to the outside diameter of the barrel and located near the socket. Precautions shall be taken to prevent movement, flotation or deformation of the pipe while pouring concrete.

Where damage to pressure pipe surfaces could occur as a result of differential movement of the encased pipe, the pipe and fittings shall be protected by wrapping the pipe in a compressible membrane made of polyethylene, PVC, Petrolatum tape or felt.

For further information refer to AS/NZS 2032 'Installation of PVC pipe systems'.

7.11 Tapped service connections

Modified PVC pipes can be tapped using approved tapping bands and hole cutters. Fine toothed 'shell cutters' or hole saws are recommended.

Several proprietary bands including Crevet Taptite DI and Milnes Gunmetal bands are recommended for use with modified PVC pipe. Tapping saddles must comply with AS/NZS 4793 "Mechanical Tapping Bands for Waterworks Purposes".

7.12 Above ground suspended pipelines

Modified PVC pressure pipes can be used above ground provided they are protected from long-term exposure to ultra violet radiation. In direct sunlight acrylic paint may be a suitable barrier. As a general rule pipes should be rubber ring jointed and a minimum class PN 12 should be specified.

Full circle supports should surround the pipes and "padded" with compressible material such as 3mm thick insertion rubber, protecting the exterior surface of the pipe from abrasion. Special provision for thrust support of fittings is also required.

Table 7.4 indicates the maximum support spacing for pipes filled with water where aesthetic considerations require long-term deflections to be limited by the span distance divided by 500.

Table 7.4 - Span between supports (for deflections less than L/500)

Pipe designation	Span (metre)
DN100 PN12 or higher	2
DN150 PN12 or higher	2
DN200 to DN 450 PN12 or higher	3

8.1 Field testing

The test procedures of clause 6.3.3 of AS/NZS 2566.2 "Buried flexible pipelines, Part 2: Installation" are recommended for PVC-M. The recommended test pressure should not be less than the maximum design pressure and at the same time not exceed 1.25 times the pressure rating at any point along the pipeline.

Before carrying out the test, ensure the pipe installation, including, backfilling and curing of concrete thrust and anchor blocks is completed. Pipes should also be substantially backfilled to ensure they cannot move. Where joints are exposed some movement of the witness mark away from the socket will be apparent due to "Poissons effect" that is the shortening of the pipes under circumferential working stress.

It is recommended that mechanical joints and flanged connections remain exposed so that they can be visually checked for leaks. When testing against closed valves, arrangements should also be made for checking these for leaks. Appendix M4 of AS/NZS 2566.2 describes the test procedure and Figure 8.2 illustrates the usual test equipment arrangement.

Figure 8.1 gives an example of how variations in the elevation of the pipeline and the maximum design pressure envelope, can be accommodated when setting the location of the test section and magnitude of the hydrostatic test pressure. If thrust restraints are part of the installation they should be designed for the full test pressure to be applied.

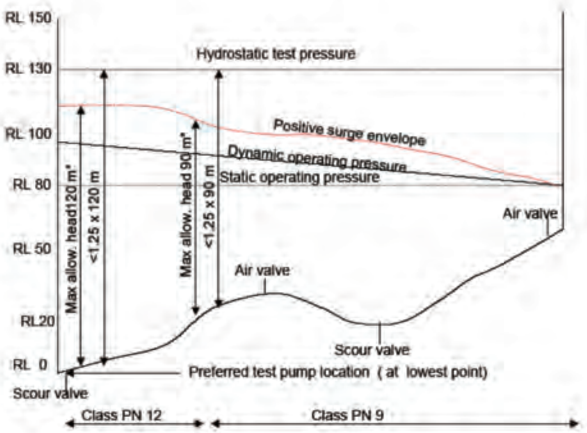


Figure 8.1 - Using longitudinal section of pipeline for determining appropriate hydrostatic test pressures

If no make-up water is required to maintain pressure after one hour at test pressure, or after the time needed to inspect the whole pipeline, it can be considered that the test has passed. The need for make up water may not indicate a leak if it is within certain limits. Clause 6.3.4.1 of AS/NZS 2566.2 gives the following equation for calculating the allowable make – up necessary to maintain the test pressure.

Q < 0.14.L.D.H

Where,

Q = allowable make-up water, (litres per hour)
D = nominal diameter, in (metres)
L = test length, in (kilometers)
H = average test head over length of pipeline under test, in (metres)

This allowance is intended to compensate in particular for the apparent loss due to entrapped air being forced into solution.

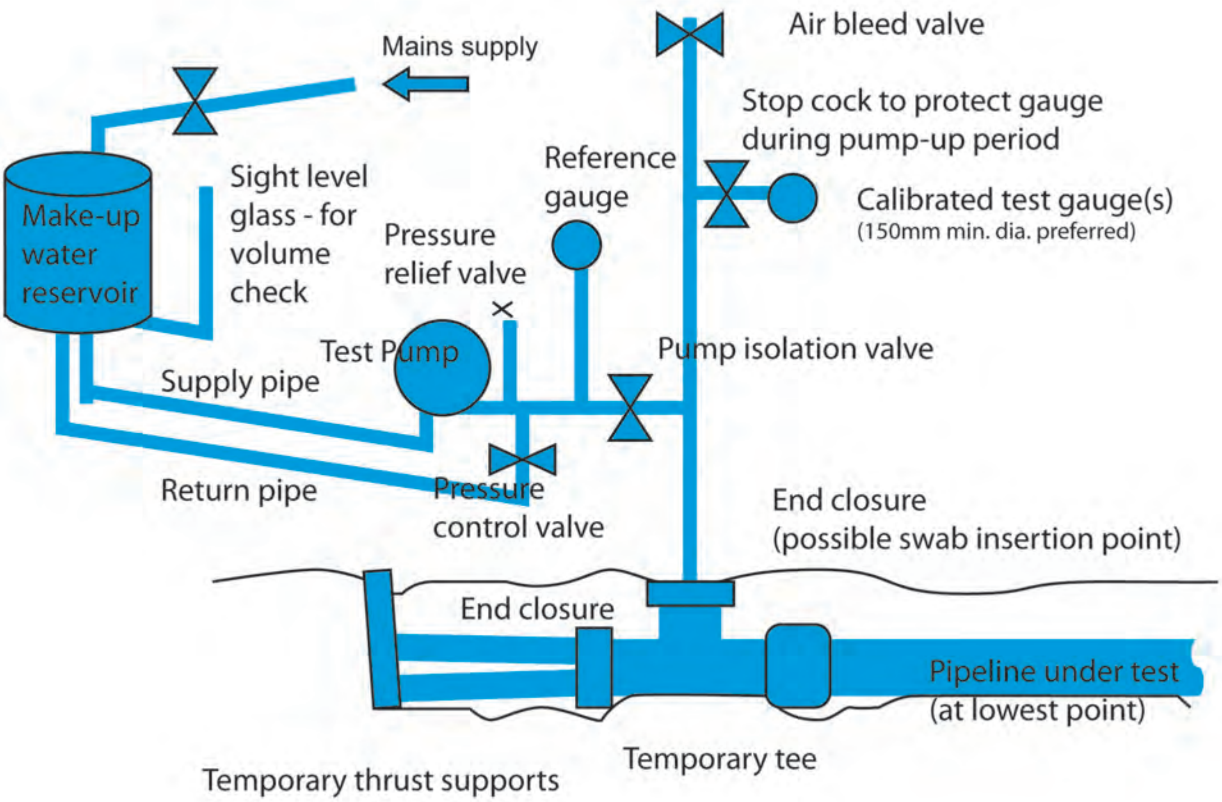


Figure 8.2 - Typical arrangement of testing equipment

WARNING:
High pressure (i.e. >30kPa) air testing is not recommended for safety reasons as the energy stored by compressed air or other gas in a pipeline can be extremely destructive and life threatening if released accidentally.

Q1) Is Iplex PVC-M interchangeable with PVC-U pressure pipes?

A) Yes it is interchangeable, however the effects of cyclic loading (high amplitudes and frequency pressure operations) should be checked. Also PVC-M is not as stiff as the equivalent PVC-U pressure pipe and this may be significant where negative pressure or high soil loadings occur.

Q2) Can a mixture of solvent weld joint fittings and ductile iron fittings be used in the same pipeline / system?

A) Yes, both types of fittings can be used, however thrust blocks must be used when using ductile iron fittings.

Q3) Can PVC-M pipes be used above ground?

A) Yes, these pipes must be supported at regular intervals and can be painted with acrylic based paint to reduce the effects of UV radiation.

Q4) Is PVC-M suitable for use in compressed air lines?

A) No, PVC pipes are not suitable for use as compressed air lines. Polyethylene pipes can be used for these applications.

Q5) Can tapping saddles be used on PVC-M pipes?

A) Yes, tapping saddles can be used on PVC-M pipes. Note: it is important not to use a tapping saddle within 600mm of the pipe joint and if using multiple saddles, there must be a distance of at least 600mm between saddles.

Q6) Can PVC-M pipe be used as bore casing?

A) Yes, however as PVC-M pipes have thinner walls than PVC-U pipes of the same PN rating, a higher pressure rated pipe must be used. For more information, refer to the technical guidelines published by PIPA or contact Iplex Technical Service.

Pipelines

ABN 56 079 613 308

FOR ALL ENQUIRIES AND ORDERS CONTACT IPLEX ONLINE:

Phone: 13 18 40

Fax: 13 18 60

www.iplex.com.au