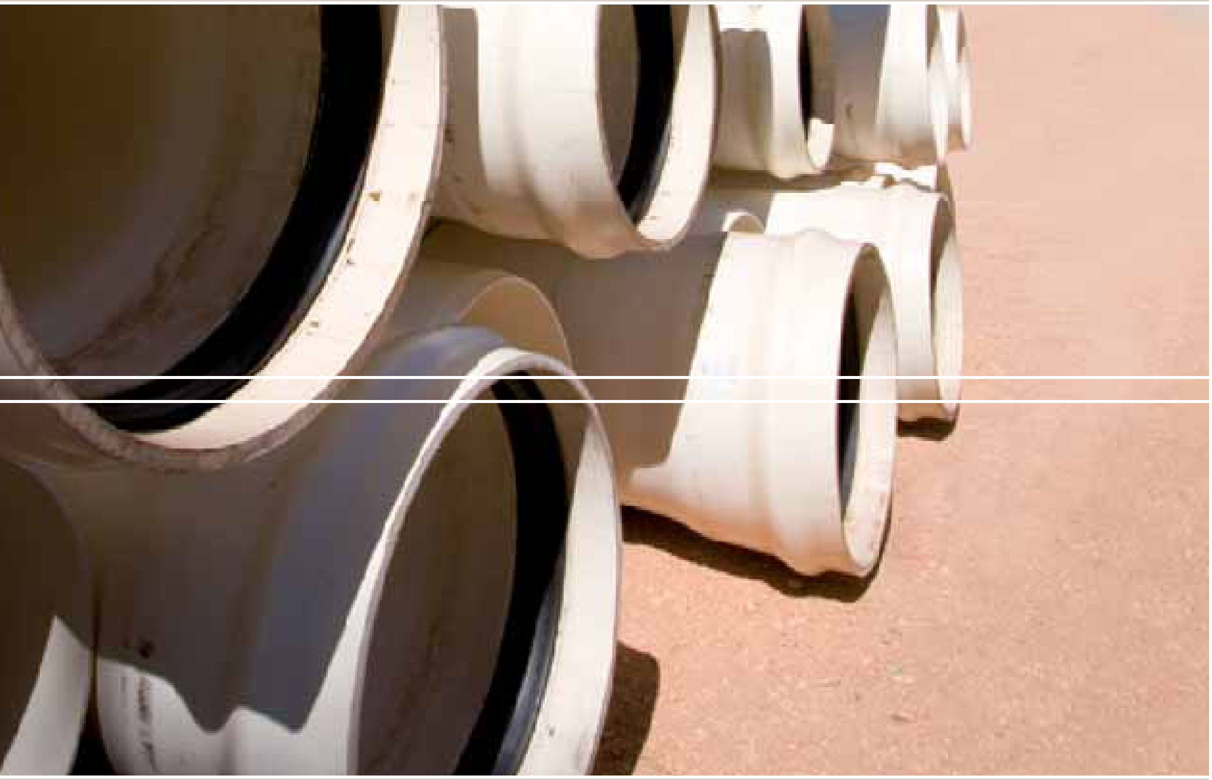
Systems & Solutions

Hydro™ PVC-M

Modified PVC for Potable Water & Irrigation Applications
Available in Pipe Sizes 100mm to 575mm Series 1 & 2



IMPROVED MATERIAL PERFORMANCE

HYDRAULIC EFFICIENCY

LIGHT WEIGHT

SYSTEM COMPATIBILITY

Quality System
Quality Endorsed Company
ISO 9001 Lic570
SAI Global

HYDRO™ PVC-M

Hydro™ PVC-M

INTRODUCTION

Unplasticised Poly Vinyl Chloride (PVC) has established an enviable reputation as the material of choice for infrastructure applications in both pressure and non-pressure pipelines.

With a service history dating back to the 1930's, industry has recognised the many benefits of PVC, material stability, corrosion resistance, high strength to weight ratio, ease of handling and installation and excellent flow characteristics.

Development in plastics over the last 50 years has been rapid with developments in pipeline systems being at the forefront. The result is an improved PVC material, Modified Poly Vinyl Chloride or PVC-M. PVC-M is manufactured by Vinidex under the trade name Vinidex Hydro™.

Vinidex Hydro™ PVC-M extends the proven benefits of PVC pipes with enhancements in fracture behaviour and hydraulic efficiency. A new standard has been developed for Hydro™ PVC-M, AS/NZS 4765:2007 "Modified PVC (PVC-M) pipes for pressure applications".

APPLICATIONS

Vinidex Hydro™ PVC-M is suitable for pressure applications for potable water, irrigation, fire fighting and general industrial applications in the temperature range 0 to 50° Celsius. Hydro™ is available in two diameter groups, Series 1 and Series 2, which denote the outside diameter of each group. In general the irrigation industry uses Series 1 and the potable water industry uses Series 2.

Hydro™ is available in sizes from DN 100 to 575 and pressure classes 6, 9, 12, 15, 16, 18 and 20 dependent on pipe series and diameter.

MATERIAL CHARACTERISTICS

PVC is formed by the combination of chlorine, carbon and hydrogen in the form of polymer chains. PVC-M is formed by the addition of compatible modifying agents to the PVC matrix, forming an alloy rather than a copolymer. The addition of modifying agents increases the ductility while virtually retaining the same material strength.

The modifying agents significantly improve toughness and impact properties with resistance to crack growth a key performance requirement. The change in material matrix gives greater ductile behaviour and thus enables the factor of safety to be lower than PVC. Short and long term tests on Vinidex Hydro™ pressure pipes have demonstrated consistently ductile behaviour, particularly in the presence of notches. The reduced factor of safety enables higher allowable stress levels, reduced wall thickness providing greater hydraulic efficiency.

Stabilisers are an integral component of PVC-M manufacture, maintaining thermal stability during the extrusion process. All Vinidex pressure pipes including Hydro™ PVC-M are manufactured using Calcium Zinc stabilisers.

AS/NZS 4765:2007 details a broad range of material acceptance tests which guarantee achievement of ductile material characteristics.

BENEFITS

Improved Material Performance

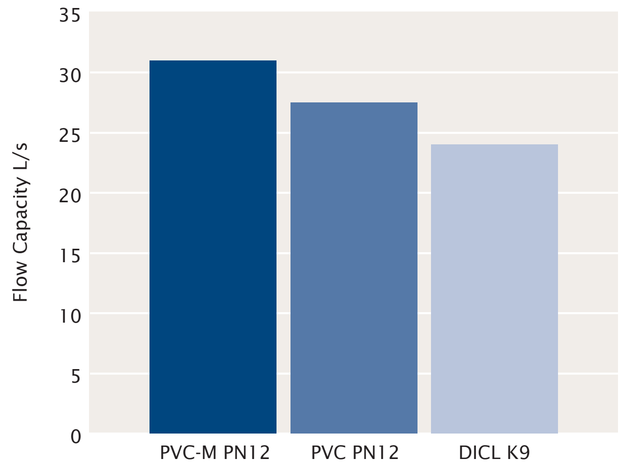
The alloying of PVC with modifying polymers achieves improvement in resistance to cracking. The result is the minimisation of the effect of stress concentrators such as scratches. With a consequent reduction in the factor of safety, higher wall stresses are allowable which lead to reduced wall thickness.

Hydraulic Efficiency

The increased internal diameter for a given external diameter makes Vinidex Hydro™ a more efficient conduit than PVC and ductile iron. The following graphs and tables illustrate that considerable savings in pumping costs or pipe sizing can be achieved with Vinidex Hydro™.

GRAPH 1 – DN 150 Gravity Flow Application

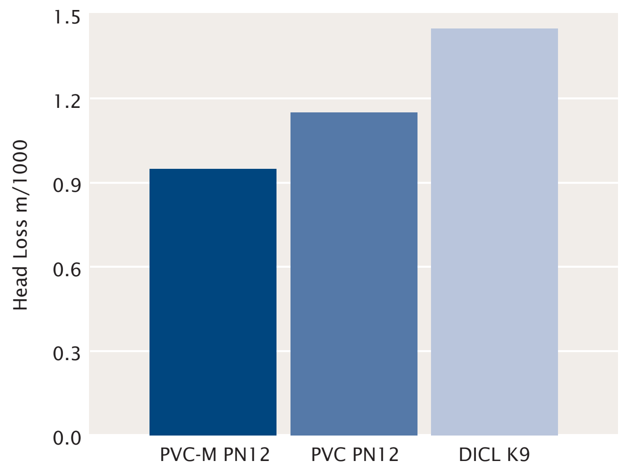
Pipe flow capacity for a constant hydraulic gradient of 1m/100m.



11% increase over PVC

GRAPH 2 – Pumped Application

Detailing head loss for a given discharge (Q=30L/s).



18% lower head loss compared with PVC

BENEFITS

TABLE 1 – Comparative Flow Rates (L/s)

Based on Velocity of 2m/s

Series 2	PVC	DICL K9	PVC-M	% increase	
				over PVC	over DICL
100/12	18.5	15.1	19.9	7.6	31.8
100/16	17.1	15.1	18.9	10.5	25.2
150/12	39.2	36.8	42.4	8.2	15.2
150/16	36.3	36.8	40.3	11	9.5
200/12	68.8	65.4	72.7	5.7	11.2
200/16	64.2	65.4	69.1	7.6	5.7
225/12	85.6	82.4	90.7	6	10.1
225/16	80.1	82.4	86.2	7.6	4.6
250/12	104	103	110	5.8	6.8
250/16	97.5	103	105	7.7	1.9
300/12	152	154	161	5.9	4.5
300/16	142	154	153	7.7	-0.6
375/6	257	240	259	0.8	7.9
375/9	244	240	255	4.5	6.3
375/12	232	240	245	5.6	2.1
375/16	216	240	235	8.8	-2.1
450/6	364	343	367	0.8	7
450/9	364	343	361	4.3	5.2
450/12	328	343	347	5.8	1.2

Light Weight

PVC is already recognised as the lightest and easiest of pipeline materials to handle. Vinidex Hydro™ further increases this advantage. Depending on size and class, weight savings in excess of 10% over PVC is available.

System Compatibility

Whether supplied in Series 1 for the irrigation industry or Series 2 for the water industry, Vinidex Hydro™ is fully compatible with existing pipeline systems with the full range of valves and fittings available.

PRODUCT LIST

Hydro™ PVC-M Series 1 – SCJ

VX Code	Description				Approx. Mass (kg/length)
17040	100	PN9	SCJ	6m	10
17050	100	PN12	SCJ	6m	13
17085	150	PN9	SCJ	6m	19
17095	150	PN12	SCJ	6m	24
17115	200	PN9	SCJ	6m	37
17125	200	PN12	SCJ	6m	48

Hydro™ PVC-M Series 1 – RRJ

VX Code	Description				Approx. Mass (kg/length)	
17035	100	PN9	RRJ	6m	10	
17045	100	PN12	RRJ	6m	13	
17080	150	PN9	RRJ	6m	19	
17090	150	PN12	RRJ	6m	24	
17100	200	PN6	RRJ	6m	31	
17110	200	PN9	RRJ	6m	37	
17120	200	PN12	RRJ	6m	48	
17135	225	PN9	RRJ	6m	45	
17140	225	PN12	RRJ	6m	59	
17145	250	PN6	RRJ	6m	50	
17150	250	PN9	RRJ	6m	57	
17155	250	PN12	RRJ	6m	74	
17160	300	PN6	RRJ	6m	62	
17165	300	PN9	RRJ	6m	71	
17170	300	PN12	RRJ	6m	93	
17175	375	PN6	RRJ	6m	101	
17180	375	PN9	RRJ	6m	115	
17174	375	PN12	RRJ	6m	150	
17171	450	PN6	RRJ	6m	153	
17172	450	PN9	RRJ	6m	179	
17173	450	PN12	RRJ	6m	234	
17415	500	PN6	RRJ	6m	201	NEW
17416	500	PN9	RRJ	6m	235	NEW
17417	500	PN12	RRJ	6m	308	NEW
17418	575	PN6	RRJ	6m	252	NEW
17419	575	PN9	RRJ	6m	295	NEW
17420	575	PN12	RRJ	6m	388	NEW

PRODUCT LIST

Hydro™ PVC-M Series 2 – RRJ

VX Code	Description				Approx. Mass (kg/length)	
17181	100	PN12	RRJ	6m	15	
17182	100	PN16	RRJ	6m	19	
17183	100	PN18	RRJ	6m	21	
17184	100	PN20	RRJ	6m	23	
17185	150	PN12	RRJ	6m	30	
17186	150	PN16	RRJ	6m	39	
17187	150	PN18	RRJ	6m	44	
17188	150	PN20	RRJ	6m	48	
17189	200	PN12	RRJ	6m	52	
17190	200	PN16	RRJ	6m	66	
17194	225	PN16	RRJ	6m	82	
17197	250	PN12	RRJ	6m	79	
17198	250	PN16	RRJ	6m	100	
17201	300	PN12	RRJ	6m	116	
17202	300	PN16	RRJ	6m	145	
17206	375	PN9	RRJ	6m	130	
17207	375	PN12	RRJ	6m	170	
17208	375	PN16	RRJ	6m	222	
17411	450	PN6	RRJ	6m	162	NEW
17412	450	PN9	RRJ	6m	190	NEW
17413	450	PN12	RRJ	6m	249	NEW
17414	450	PN16	RRJ	6m	325	NEW

PRODUCT DATA

Standards and Dimensions

Vinidex Hydro™ pipes are manufactured in accordance with AS/NZS 4765:2007 with Standards Mark numbers 2560, 2561, 2562 and 2563.

AS/NZS 4765:2007 provides two manufacturing series relating to the outside diameter of the pipe. Series 1 is ISO compatible outside diameters (mostly metric) and Series 2 is ductile iron compatible outside diameters.

Refer to **Table 2 and 3** for dimensional data. In general, the irrigation industry uses Series 1 and the potable water industry uses Series 2. Vinidex Hydro™ is available in both Series 1 and 2 to suit these industries.

TABLE 2 – Dimensions for Hydro™ PVC-M Pipes Series 1

Normal Size DN	Outside Diameter Mean OD		PN6		PN9		PN12	
	Dm min	Dn max	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax
100	114.1	114.5	–	–	2.9	3.9	3.8	4.9
125	140.0	140.4	–	–	3.6	4.7	4.7	6.0
150	160.0	160.5	–	–	4.1	5.3	5.3	6.6
200	225.0	225.6	4.8	6.1	5.7	7.1	7.5	9.2
225	250.0	250.7	–	–	6.3	7.8	8.3	10.1
250	280.0	280.8	6.0	7.4	7.1	8.7	9.3	11.2
300	315.0	315.9	6.7	8.3	7.9	9.6	10.5	12.6
375	400.0	401.0	8.6	10.4	10.1	12.2	13.3	15.8
450	500.0	501.0	10.7	12.9	12.6	15.0	16.6	19.6
500	560.0	561.0	12.0	14.3	14.1	16.8	18.6	21.9
575	630.0	631.0	13.4	16.0	15.8	18.7	20.9	24.6

TABLE 3 – Dimensions for Hydro™ PVC-M Pipes Series 2

Normal Size DN	Outside Diameter Mean OD		PN6		PN9		PN12		PN16	
	Dm min	Dn max	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax
100	121.7	122.1	–	–	–	–	4.1	5.3	5.4	6.8
150	177.1	177.6	–	–	–	–	5.9	7.3	7.8	9.5
200	231.9	232.6	–	–	–	–	7.7	9.4	10.2	12.3
225	258.9	259.6	–	–	–	–	8.6	10.4	11.4	13.7
250	285.8	286.6	–	–	–	–	9.5	11.5	12.5	14.9
300	344.9	345.8	–	–	–	–	11.5	13.8	15.1	17.9
375	425.7	426.7	9.1	11.0	10.7	12.9	14.2	16.9	18.7	21.1
450	506.5	507.5	10.8	13.0	12.7	15.2	16.8	19.9	22.2	26.1

DESIGN

System Life

It is a common misconception that plastics pipes have a design life of 50 years, arising from the use of regression curves and adoption of the 50 year point for classification purposes.

In relation to hydrostatic stress analysis and pipe life, AS/NZS 4765 states the following: "The analysis adopts the 50 years extrapolation point on the regression curve as the reference for design purposes. This is consistent with long standing international practice.

It should not be taken that either –

(a) the pipes weaken with time; or
(b) the predicted life is 50 years

Actual system life is dependent on manufacture, transport, handling, installation, operation, protection from third party damage and other external factors. For water supply applications, the actual life can logically be expected to be well in excess of 100 years before major rehabilitation is required."

Hydraulic

The principles of closed conduit flow and behaviour of fluids is well established. Vinidex recommend the use of the Colebrook-White formula for the analysis of flow parameters for Vinidex Hydro™ pipe.

A roughness coefficient k = 0.003mm is recommended and all computations are based on water at 20° C.

Additional background information on hydraulic design can be found in the Vinidex Water Supply Manual for PVC Pipe Systems. Computational assistance is available in the Vinidex program "Fluff", which can provide an analysis of a wide range of pipeline materials.

Flow Charts for Vinidex Hydro™ Series 1 and Series 2 are shown on pages 9 and 10.

Structural

Under general pressure pipe installation conditions, including under roads, detailed calculations predicting pipe performance are not necessary. Following an extensive study of installed pipe performance, a joint project conducted by the European Plastic Pipe and Fitting Association (TEPPFA) and independent experts concluded that final deflection of pipes was controlled by the settlement of the soil after installation.

Where installation was controlled, or self-compacting granular material was used, pipe deflections were consistently low regardless of installation depth and traffic or other loads.

For unusual conditions, or depths greater than 6 metres, design calculations may be performed in accordance with AS/NZS 2566.1. The structural design aspects of buried flexible pipes to be considered are vertical deflection, ring bending strain and buckling.

Differential pressure conditions between the inside and outside of a pipe can cause a pipe to buckle inwards leading to collapse. Such conditions can arise from high external loading or negative internal pressure transients as a consequence of pipeline operating conditions. A pipes resistance to buckling is directly proportional to ring bending stiffness.

As PVC-M pipes have reduced wall thickness compared to PVC of the same PN rating, the ring bending stiffness is significantly reduced. Consequently the resistance to buckling of PVC-M is also significantly reduced. Designers should be aware of pipeline operating criteria and consult appropriate design material including AS/NZS 2566.1:1998 to ensure the suitability of PVC-M in such applications.

Table 4 and **Graph 3** of critical collapse pressures are based on short term loading of an unsupported circular pipe and does not include a factor of safety. The choice of factor of safety depends on the certainty of operation parameters and should be nominated by the designer.

For buried pipes the soil surround provides additional support against buckling providing the minimum cover height exceeds 500mm. Such support can only be realised where the embedment is properly placed and compacted with no voids around the pipe and the embedment cannot subsequently be removed or leached away.

In general where sustained negative pressures or full vacuum conditions are likely to occur, e.g. suction lines, Vinidex recommends that PN 12 pipe or higher be selected based on an appropriate factor of safety against buckling.

DESIGN

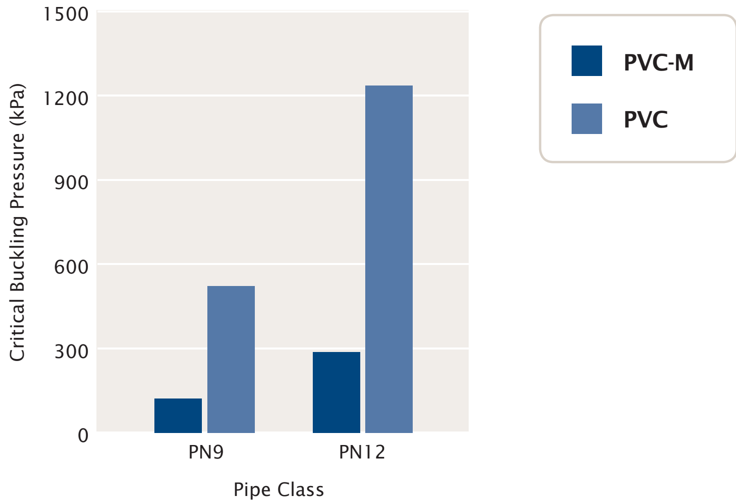
TABLE 4 – Unsupported Collapse Pressures (kPa)

Short term loading at 20°C.

	PN6	PN9	PN12
PVC-M all sizes	73	121	288
PVC ≤ DN150	155	522	1236
PVC < DN150	111	373	884

GRAPH 3 – Unsupported Collapse Pressures for DN150 Pipe

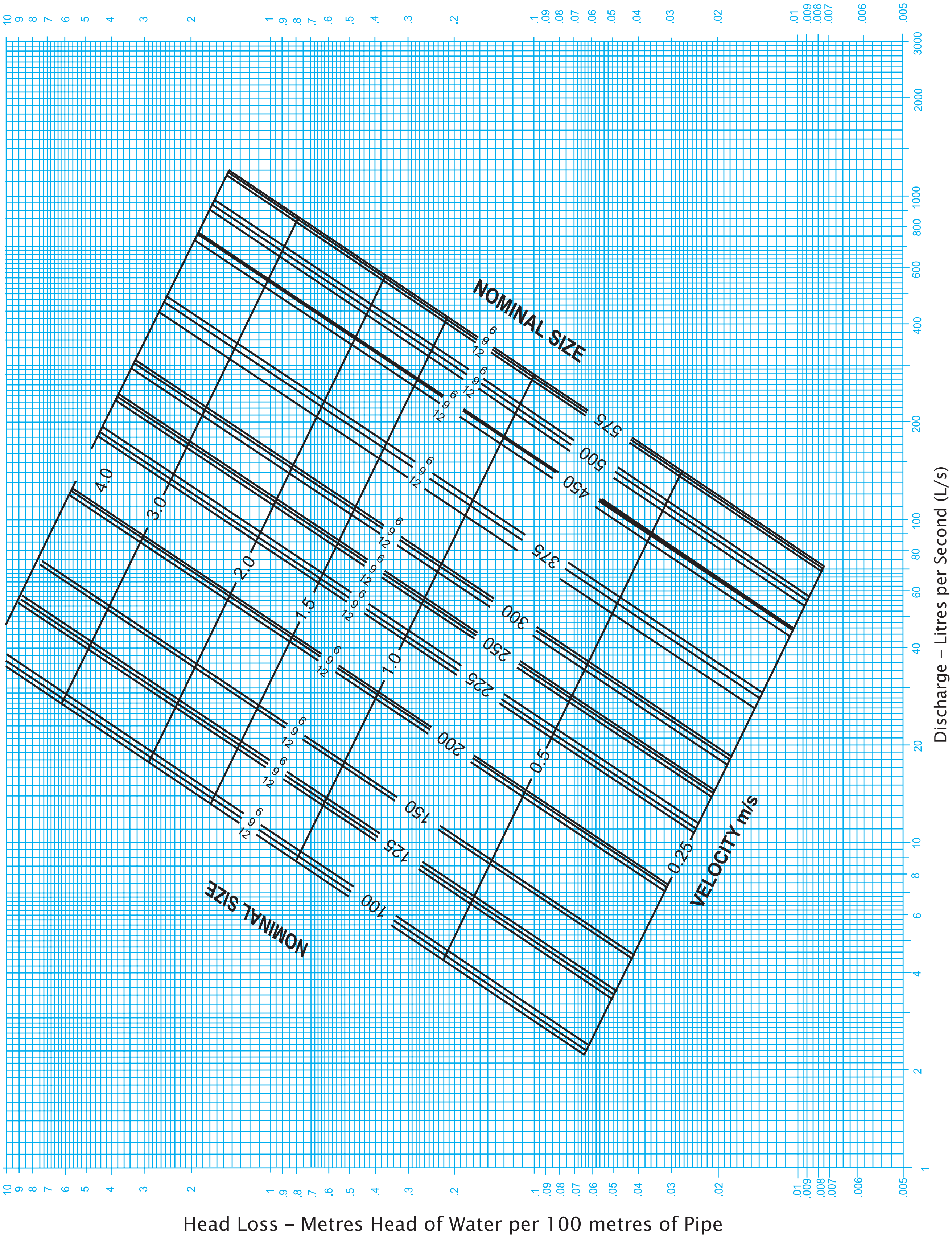
Short term loading at 20°C.



DESIGN

FLOW CHART – Vinidex Hydro™ PVC-M Pressure Pipe Series 1

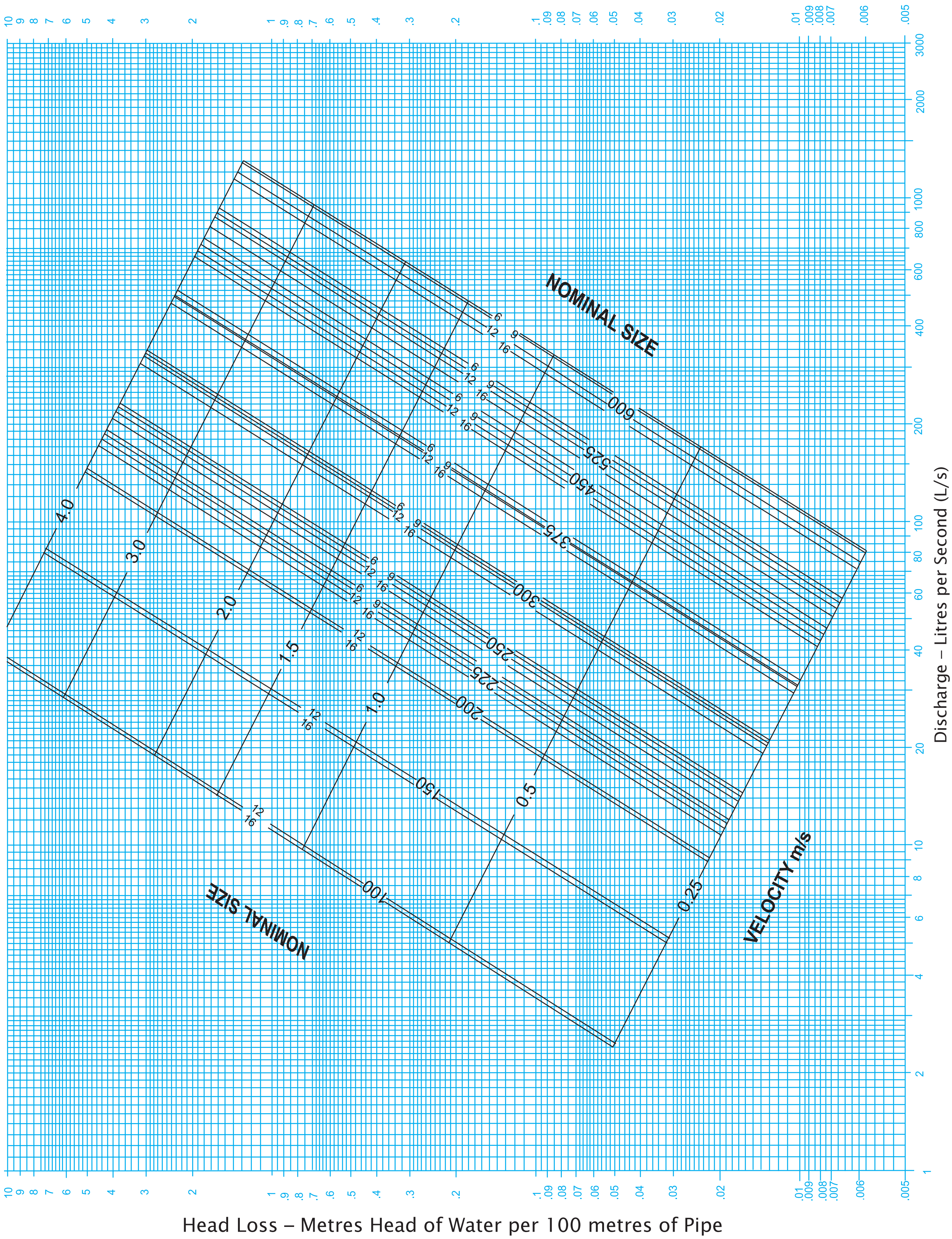
PN6, PN9 and PN12



DESIGN

FLOW CHART – Vinidex Hydro™ PVC-M Pressure Pipe Series 2

PN6, PN9, PN12 and PN16



DESIGN

Fatigue

Materials subject to repetitive or cyclic loads will fail at lower stress levels than materials subject to constant load. This is known as fatigue failure. For thermoplastics pipe materials, fatigue only becomes a design parameter when very high numbers of cycles are applied.

The behaviour of thermoplastic materials in cyclic operation conditions has been extensively studied. Vinidex has developed an appropriate design procedure for such applications.

The two design parameters are the magnitude of the stress range and the frequency of the application, leading to the calculation of the number of cycles applied over the design life of the pipeline. In cases where lifetime cycles exceed 26,000, a higher class of the pipe may be required than indicated by the static or maximum pressure.

Extensive studies into the fatigue behaviour of thermoplastics have been used to establish a relationship between stress range, defined as the difference between maximum and minimum stress (see **Figure 1**) and the number of cycles to failure. This relationship yields a load factor which is applied to the operating pressure to enable the selection of the appropriate class of pipe.

The approach adopted by Vinidex is conservative recognising that the experimental data demonstrates a degree of scatter. This ensures an appropriate factor of safety given potential changes in the pipeline operating conditions over the life of the pipe and other operational conditions such as installation and maintenance standards.

For simplicity, the pressure range is defined as the maximum pressure minus the minimum pressure including all transients experienced by the system during normal operations as per Figure 1. The effect of accidental conditions such as power failure may be excluded. Figure 1 illustrates the definition of a cycle as a repetitive event. In some cases the cycle pattern may be complex and it may be necessary to consider the contribution of secondary cycles.

For more detailed background information on the fatigue design of thermoplastic pipe including examples and a full list of references, consult Vinidex technical notes VX-TN-4J and VX-TN-4H.

Note that in fatigue loading applications, the maximum pressure in a cycle should not exceed the static pressure rating of the pipe. **Figure 2** and **Table 5** provide graphical and numerical values of the recommended fatigue load factors.

FIGURE 1 – Pressure Cycle

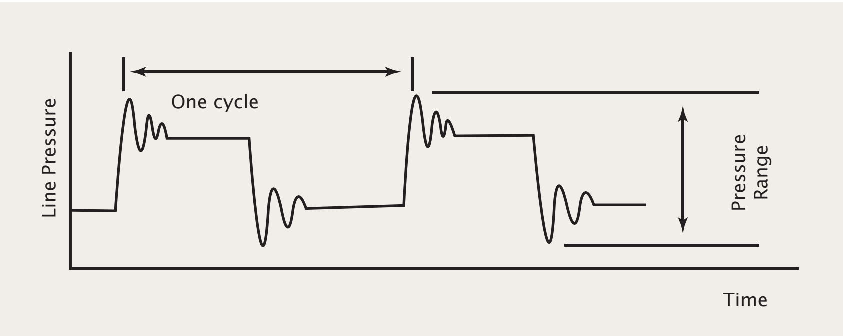
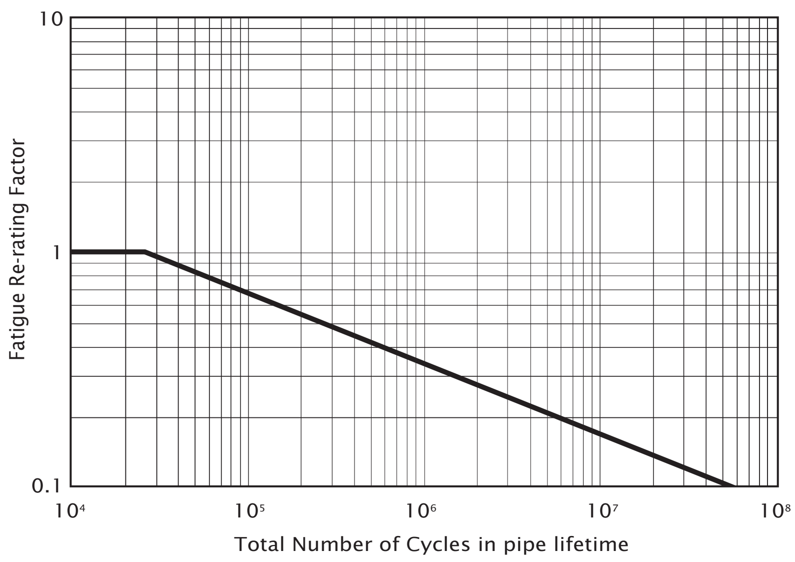


TABLE 5 – Fatigue Load Factors by number of Cycles

Total cycles	Approx No. cycles/ day for 100 year life	PVC-M Fatigue Load Factors
26,400	1	1.00
100,000	3	0.67
500,000	14	0.41
1,000,000	27	0.33
5,000,000	137	0.21
10,000,000	274	0.17
50,000,000	1370	0.10

FIGURE 2 – Fatigue Load Factors for PVC-M Pipes



DESIGN

Fatigue Design Procedure

To select the appropriate pipe class for fatigue loading, the following procedure should be adopted:

1. Estimate the likely pressure range, ΔP i.e. the maximum pressure minus the minimum pressure.
2. Estimate the frequency or the number of cycles per day, which are expected to occur.
3. Determine the required service life and calculate the total number of cycles which will occur in the pipe lifetime.
4. Using **Table 5** or **Figure 2**, look up the fatigue load factor for the appropriate number of cycles.
5. Divide the pressure range by the fatigue load factor to obtain an equivalent operating pressure.
6. Use the equivalent operating pressure to determine the class of pipe required.

Temperature

The nominal working pressure rating of Vinidex Hydro™ pipes is determined at 20˚C. However, Hydro™ pipes are suitable for use at temperatures up to 50˚C. Where the service temperature exceeds 20˚C, use **Table 6** to determine appropriate pipe class.

TABLE 6 – Temperature Rating of Hydro™ PVC-M Pipes

Maximum Allowable Pressure (MPa).

	Temperature ˚C					
	≤ 25	30	35	40	45	50
PN6	0.60	0.54	0.48	0.42	0.36	0.30
PN9	0.90	0.81	0.71	0.63	0.54	0.45
PN12	1.20	1.08	0.96	0.84	0.71	0.60
PN16	1.60	1.44	1.28	1.12	0.96	0.80
PN18	1.80	1.62	1.44	1.26	1.08	0.90
PN20	2.00	1.80	1.60	1.40	1.20	1.00

INSTALLATION

Vinidex recommend that Hydro™ PVC-M pipes are constructed in accordance with AS 2032 – Installation of PVC pipe systems and the Vinidex Water Supply Manual.

Installation techniques for Hydro™ pipes are similar to those used for standard PVC pipes and the same degree of care and caution must be exercised. Note that the thinner wall of Hydro™ pipes means that they will experience higher lateral loads and care should be taken to ensure that the pipe is fully supported.

Quality non-cohesive material should be used for pipe bedding, side support and overlay. In general 1˚ deflection for rubber ring joints, is available at each socket-spigot joint. The pipe side support material should be placed evenly on both sides of the pipeline to two thirds the height of the pipe diameter and compacted by hand tamping.

Side fill material should be worked under the sides of the pipe to eliminate all voids and provide maximum pipe haunching. The pipe overlay material should be levelled and compacted in layers to a minimum height of 150mm above the crown of the pipe or as specified.

For above ground installations the support spacings recommended in AS 2032 can also be used for Hydro™ pipes. These support spacing result in negligible deflection in PVC pipes full of water. For PVC-M pipes supported at these intervals, the stress levels in the pipe wall are still within acceptable limits.

However, for the same class of pipe, deflection between the supports will be increased by around 50%. Since deflections are very small, this will not usually be of functional significance. The field testing procedures specified in AS2032 and the Vinidex Water Supply Manual should also be followed for Hydro™ pipes.

Systems & Solutions

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