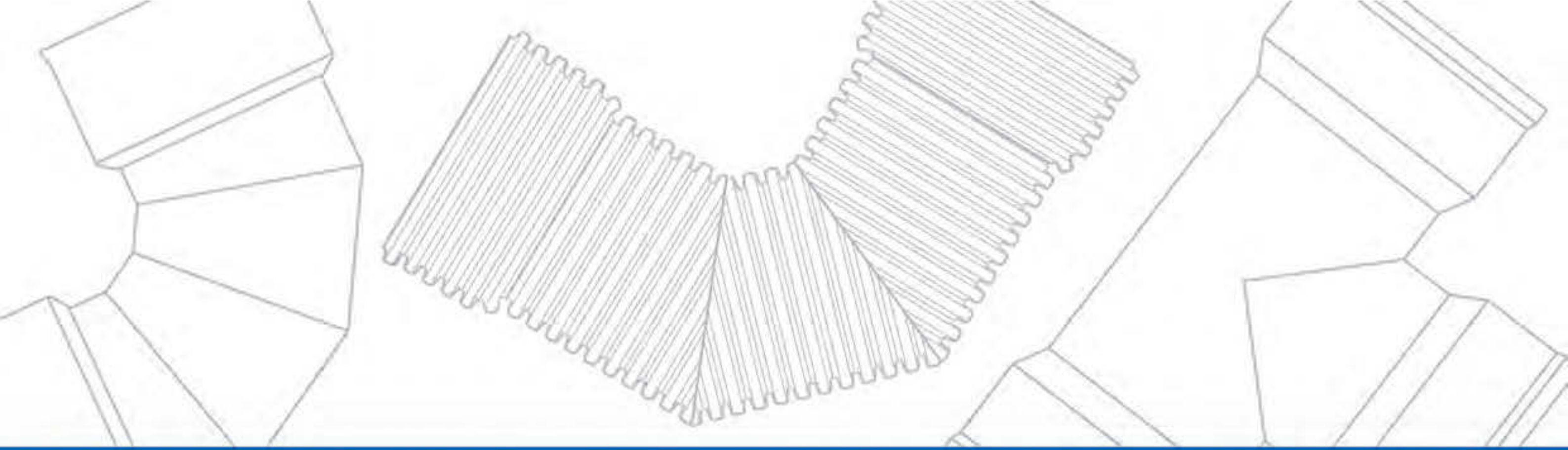
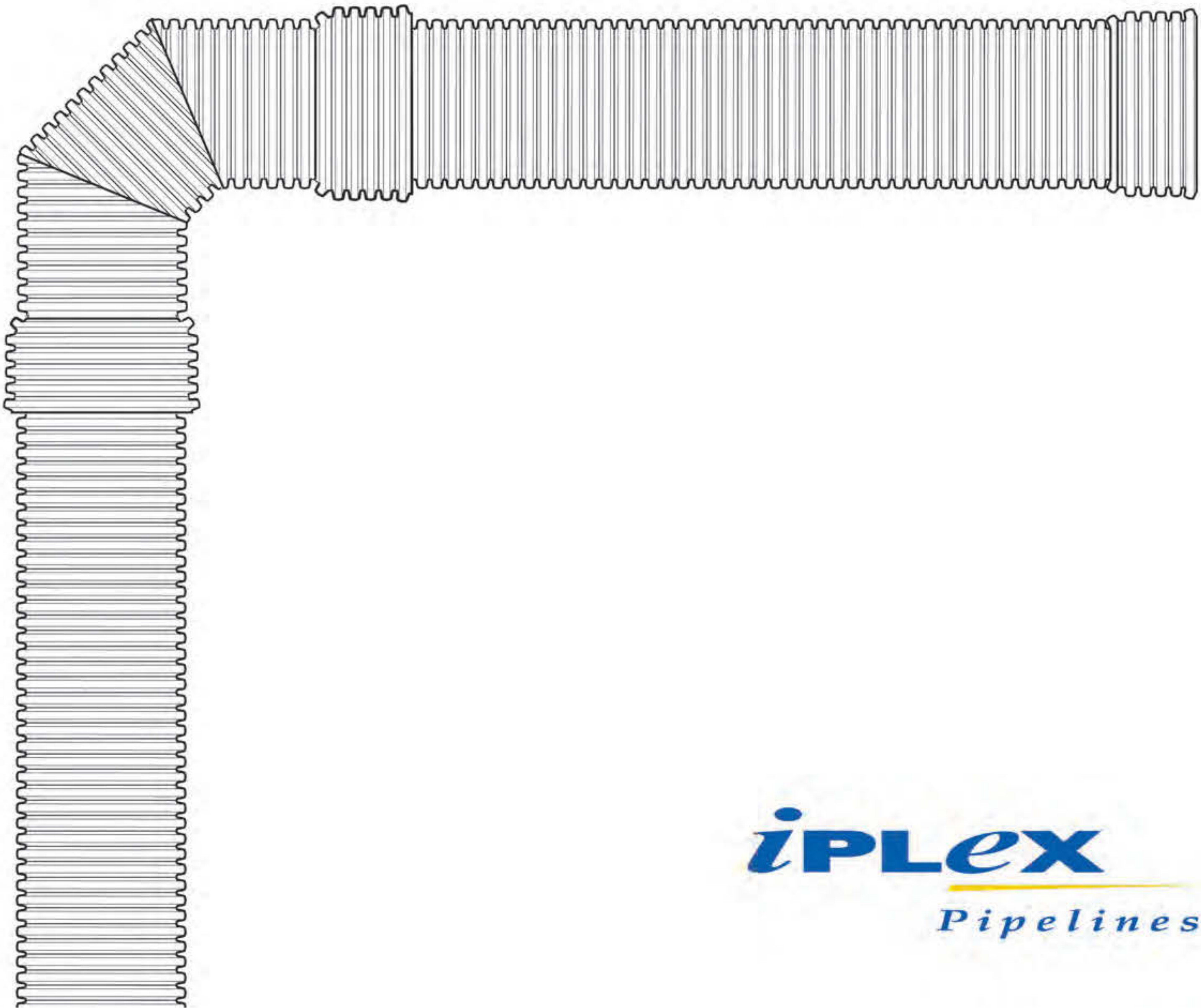


ENGINEERING DESIGN AND INSTALLATION GUIDE

BlackMAX™ AND SewerMAX™
Polypropylene Pipes and Fittings



iPLEX Pipelines

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page

1.0 INTRODUCTION

Iplex Pipelines Australia Pty Ltd is a major Australian manufacturer and supplier of plastic pipes and fittings suitable for civil, plumbing, irrigation, industrial and mining applications. As a leader in plastic pipe technology, Iplex Pipelines has continued to develop innovative products offering solutions for the demanding service and environmental needs of today. To meet these requirements, Iplex has introduced BlackMAX™ for stormwater drainage and low head irrigation and SewerMAX™ for gravity sewer pipelines.

BlackMAX™ and SewerMAX™ are cost-effective alternatives to rigid pipe materials, with improved performance and exceptional durability. They do not corrode and they resist abrasion in applications, which severely limit the life of more traditional materials.

The profile wall structure allows an efficient use of material and provides a pipe with high ring stiffness and low mass. As a result pipes are only a fraction of the weight of conventional materials and can readily withstand both installation and service loads. Figure 1.1 illustrates the wall cross-section.

Both BlackMAX™ and SewerMAX™ pipes are available in diameters DN225, DN300, DN375, DN450, DN525 and DN600 with a minimum pipe stiffness of not less than, 8000 N/m.m or SN8 for BlackMAX™ and 10000 N/m.m or SN10 for SewerMAX™.

Figure 1.1 Cross-section of the structured wall profile

BlackMAX™ pipes being cut to length during the manufacturing process.

WaterMark
AS/NZS 5065
Lic 20603
SAI Global

Certified Product
Australian Standard
AS/NZS 5065
Lic SMKP20603
SAI Global

1.1 MANUFACTURE

BlackMAX™ and SewerMAX™ pipes are manufactured using a combined continuous extrusion and vacuum moulding process. The polypropylene wall structure is comprised of a smooth inner and profiled outer wall. The inner and outer walls are extruded simultaneously one inside the other. As the profiled outer wall is being formed, the inner and outer walls are fused together ensuring they are fully moulded circumferentially at the trough of each corrugation. This innovative construction provides a smooth-bore pipe with a profiled external wall. The result is a high-stiffness pipe, which can be cut and rejoined anywhere along its length.

A range of fittings is available for use with BlackMAX™ and SewerMAX™ pipes providing a complete system. Fittings are moulded and/or fabricated and are suitable for gravity-flow municipal drainage, sewerage, mining, industrial and irrigation applications.

BlackMAX™ and SewerMAX™ pipes and fittings comply with Australian and New Zealand Standard, AS/NZS 5065 "*Polyethylene and polypropylene pipes and fittings for drainage and sewerage applications*" and carry StandardsMark and WaterMark third party product certifications under this standard.

1.2 PRODUCT FEATURES

Throughout Australia and New Zealand, BlackMAX™ and SewerMAX™ have been chosen for their unique characteristics and properties including;

Resistance to chemical attack

BlackMAX™ and SewerMAX™ pipes are manufactured from polypropylene, which provides excellent resistance in corrosive drainage, sewerage and industrial wastewater applications. The material is resistant to aggressive ground conditions, such as acid sulphate soils or saline ground waters.

Resistance to abrasion

Polypropylene is notably resistant to abrasion and can be used in industrial and mining applications, handling slurries with high solids content.

Light-weight

BlackMAX™ & SewerMAX™ pipes are light-weight and can be easily manoeuvred in confined areas by hand or with light lifting equipment. Site handling and efficiency is therefore improved, which can result in significant savings on installation.

Long lengths

BlackMAX™ pipes are manufactured in 6 metre nominal effective lengths reducing the number of joints during installation and improving laying rates. SewerMAX™ pipes are produced in standard 3 metre nominal effective lengths for ease of handling in deep sewers with trench shields.

Flow characteristics

The smooth bore of BlackMAX™ and SewerMAX™ pipes, combined with their high resistance to scale and sediment build up provides excellent hydraulic performance. This can result in reduced grades to accomplish a given flow.

In-ground performance

BlackMAX™ and SewerMAX™ pipes have a high tolerance to deformation and can accommodate soil movement without structural damage.

Durability

The tough, ductile nature of polypropylene enables these pipes to resist impact sustained in the course of transportation and site handling, without damage.

Weathering resistance

Black BlackMAX™ pipes contain a minimum of 2% carbon black whereas grey pigmented SewerMAX™ pipes contain a minimum 0.2% HALS UV light stabilizer. In both cases these additives are used to allow storage of pipes in sunlight without undue degradation.

Rubber ring joint

The BlackMAX™ and SewerMAX™ rubber ring joint is designed for ease of assembly and jointing. Pipes can be cut to length on site and rejoined.

1.3 APPLICATIONS

BlackMAX™ and SewerMAX™ pipes and fittings are suitable for the following applications:

- Stormwater drainage pipelines
- Estuarine and Ocean outfalls
- Road culverts
- Gravity Sewer mains
- Low head Irrigation
- Rehabilitation (as liner pipe)
- Ventilation ducts
- Leachate collection
- Stormwater retention systems

DN600 BlackMAX™ Stormwater drainage pipes installed under roadway.

DN600 SewerMAX™ pipes in 3m lengths are easily lowered down the trench through the trench shield.

2.0 PRODUCT DATA

2.1 MATERIAL PROPERTIES

BlackMAX™ and SewerMAX™ pipes are manufactured from block (heterophasic) copolymer polypropylene, which is a thermoplastic of the polyolefin group. Polypropylene is noted for its excellent chemical resistance, high modulus and elevated temperature performance.

Table 2.1 Physical properties of BlackMAX™ & SewerMAX™ polypropylene pipes

Property	Description / Value	Relevant standard / Reference
Density of Pipe Compound	900 kg/m³	ISO 1183
Circumferential Flexural Modulus (2mm/min)	1300 MPa	ISO 178
Creep ratio (2 years)	3	ISO 9967
Circumferential Flexural Creep Modulus (50 years)	325 MPa	Derived from AS/NZS 2566.1
Pipe- Ring Bending Stiffness - **BlackMAX™**	≥ 8000 N/m.m	AS/NZS 1462.22
Pipe- Ring Bending Stiffness - **SewerMAX™**	≥10000 N/m.m	AS/NZS 1462.22
Flexural Yield Stress	24.5 MPa	ISO 178
Tensile Yield Stress (50mm/min)	28 MPa	ISO 527-2
Tensile Yield Strain (50mm/min)	6%	ISO 527-2
Poisson's Ratio	0.45	ISO 527-2
Thermal Co-efficient of Linear Expansion	150×10^{-6} / K	DIN 53752
Shore D Hardness	60	ISO 868
Pipe – Allowable Long Term Deflection	7.5%	AS/NZS2566.1 Table 2.1
Pipe – Allowable Long Term Ring Bending Strain	4.0%	AS/NZS2566.1 Table 2.1
De-rating Factor at 30°C (Pipe stiffness)	0.85	-
De-rating Factor at 40°C (Pipe stiffness)	0.70	-
De-rating Factor at 50°C (pipe stiffness)	0.55	-

***Note:** These are typical values which can be used for buried flexible pipe design purposes. Actual values may vary slightly for different sources of polymer.*

2.2 STANDARDS

The following standards relate to the manufacture, testing, design and installation of BlackMAX™ and SewerMAX™ pipes:

SewerMAX™ elastomeric seal joint test to AS/NZS 5065

- ***AS/NZS 1260*** "Section 3.4. Tests on Elastomeric Seal Joints"
- ***AS/NZS 1462.8 AS/NZS 1462.10 AS/NZS 1462.13 AS/NZS 1462.22*** "Methods of test of plastic pipes and fittings"
- ***AS 1646*** "Elastomeric seals for water works purposes"
- ***AS 2200*** "Design charts for water supply and sewerage"
- ***AS/NZS 2566.1*** "Buried flexible pipelines – Part 1, Structural design"
- ***AS/NZS 2566.2*** "Buried flexible pipelines – Part 2, Installation"
- ***Revision AS 3571*** "Glass reinforced thermosetting plastics (GRP) pipes – Polyester based – Water supply, sewerage and drainage applications"
- ***AS 4181*** "Stainless steel clamps for water-line and, works purposes".
- ***AS/NZS 5065*** "Polyethylene and polypropylene pipes & fittings for drainage and sewerage applications"
- ***ISO 9967*** "Thermoplastics pipes – Determination of creep ratio"
- ***AS/NZS ISO 9001*** "Quality management systems – requirements"

BlackMAX™ pipe stiffness test

WaterMark®
AS/NZS 5065
Lic 20603
SAI Global

Quality System™
Quality Endorsed Company
ISO 9001
Lic QEC037
SAI Global

Certified Product™
Australian Standard
AS/NZS 5065
Lic SMKP20603
SAI Global

2.3 LIFE EXPECTANCY

In determining the life expectancy of a buried pipe, it is necessary to consider all of the potential modes of failure and assess whether there is a real risk of the pipe failing by the particular mechanism under consideration. Polypropylene as a pipe material has been in existence for many years. As a profile wall pipe a service history of approximately 40 years is available. Polypropylene is an inert material, will not corrode or readily abrade in service and is not affected by high or low pH soils or saltwater environments. The polypropylene compound used for BlackMAX™ and SewerMAX™ will not breakdown in the presence of most strong acids. Therefore, their physical and chemical properties suggest BlackMAX™and SewerMAX™ will last for a period in excess of 100 years.

2.3.1 Independent product appraisal

The Water Services Association of Australia (WSAA) was formed in 1995 and is the peak body of the Australian urban water industry. WSAA provides a national focus for the provision of information on the urban water industry and represents the major water agencies and authorities throughout Australia.

It is the requirement of the major Australian water agencies that water, sewerage and drainage pipes have a realistic life expectancy of at least 100 years. BlackMAX™ and SewerMAX™ have been appraised by WSAA and the product appraisal 03/05 "BlackMAX and SewerMAX Pipe Systems" is now available on the WSAA website.

The executive summary concludes that BlackMAX™ and SewerMAX™ pipes and fittings are regarded as fit for purpose and have been rated ***A*** with a life expectancy in excess of 100 years.

2.3.2 Chemical resistance

BlackMAX™ and SewerMAX™ pipes are made from a copolymer of polypropylene (PP-B). The elastomeric seals used to join the pipes are made from styrene butadiene rubber (SBR).

Polypropylene is inherently resistant to a wide range of chemicals such as acids, alkalis, salts, wetting agents and alcohols. It is however attacked by oxidising acids such as fuming nitric acid or hot concentrated sulphuric acid, neither of which should be encountered in a drain. Polypropylene is swollen and softened by halogenated solvents (for example, trichlorethylene) and hydrocarbon solvents such as xylene and benzene. However, the effect is not immediate and the occasional contact with solvents such as petrol or diesel is acceptable for PP pipes used for drainage and sewerage applications.

SBR seals are also resistant to a wide range of chemicals such as salt solutions, alkalis, glycols and some alcohols. SBR is swollen by a number of organic solvents, however, the seals are encapsulated in the pipe profile and to a large extent, isolated from the contents of the pipe. As only a small part of the seal surface is in contact with liquid in the pipeline, any occasional spillages or illegal dumping of chemicals should have a minimal effect.

BlackMAX™ and SewerMAX™ pipelines are therefore suitable for drainage applications where they might occasionally be exposed to spillages or illegal dumping of chemicals and solvents.

2.3.3 Resistance to microbiological attack

There is no evidence that microbiological attack is a potential failure mechanism for polyethylene and polypropylene pipes. Polypropylene (PP) pipes are used widely for sewerage applications in most european countries.

2.3.4 Resistance to sunlight

BlackMAX™ pipes contain a minimum of 2% carbon black and SewerMAX™ pipes a minimum of 0.2% HALS light stabilizer for protection against UV radiation. This allows long-term storage of pipes in sunlight without degradation. Once buried, BlackMAX™ and SewerMAX™ pipes are not exposed to U.V radiation and therefore will not degrade by this mechanism.

2.3.5 Abrasion resistance

Polypropylene is highly resistant to abrasion and is therefore used for industrial and mining applications such as handling slurries with high solids content. It is also selected for a number of mechanical and automotive applications. Some examples are linings for truck trays, spoilers and bumpers for cars. In conjunction with Ipswich Water, Iplex examined a number of exhumed PVC sewer pipes that had been in service for up to 26 years. There was no discernable loss of wall thickness due to abrasion. As polypropylene is generally accepted as having a higher resistance to abrasion than PVC, abrasion loss is an unlikely failure mode for BlackMAX™ and SewerMAX™ pipes.

2.3.6 Oxidation

The polypropylene compound used for BlackMAX™ and SewerMAX™ contains an antioxidant to protect against oxidation. Under normal ambient temperatures the level of protection is sufficient to provide in excess of one hundred years service life.

2.3.7 Corrosion

Polypropylene, as with other plastics does not corrode.

2.4 PIPE RANGE, DIMENSIONS & PRODUCT CODES

Figure 2.1 BlackMAX™ & SewerMAX™ pipe – Longitudinal cross-section

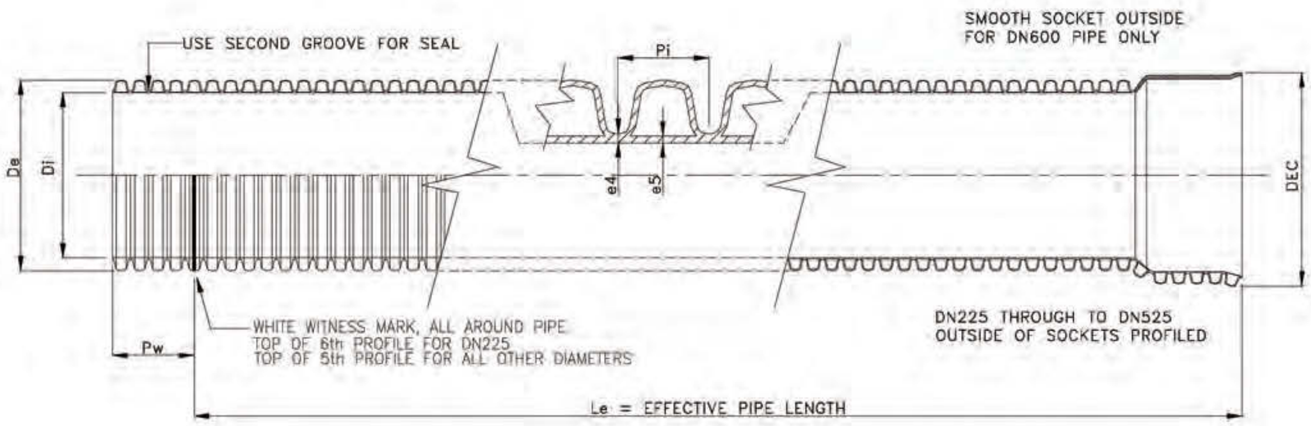


Table 2.2 BlackMAX™ & SewerMAX™ pipe dimensions

Nominal diameter DN (mm)	Mean pipe outside diameter De (mm)	Mean pipe internal diameter Di (mm)	Maximum overall socket diameter DEC (mm)	Witness mark length, socket insert length Pw (mm)	Profile pitch Pi (mm)	Minimum waterway thickness e4 (mm)	Minimum waterway thickness e5 (mm)	Approx. pipe mass (kg/m)
225	259	225	300	135	24.9	1.7	1.4	4
300	344	300	400	147	33.2	2.0	1.7	7
375	428	373	500	176	39.8	2.4	2.1	11
450	514	447	595	222	49.8	2.8	2.8	14
525	600	522	705	254	56.9	3.2	3.2	19
600	682	596	725	296	66.4	3.5	3.5	25

NOTES:

1. *Standard nominal effective lengths in all diameters are L = 6 metres or in the case of SewerMAX™ L=3m. Refer to Table 2.3 for actual effective lengths and tolerances.*
2. *All diameters except for DN 600 are supplied with ribbed sockets.*
3. *Waterway thicknesses are as per AS/NZS 5065 for BlackMAX™ and are increased for SewerMAX™*

2.4 PIPE RANGE, DIMENSIONS & PRODUCT CODES (continued)

Cross-section of the BlackMAX™ *structured wall pipe*

Table 2.3 Effective pipe lengths

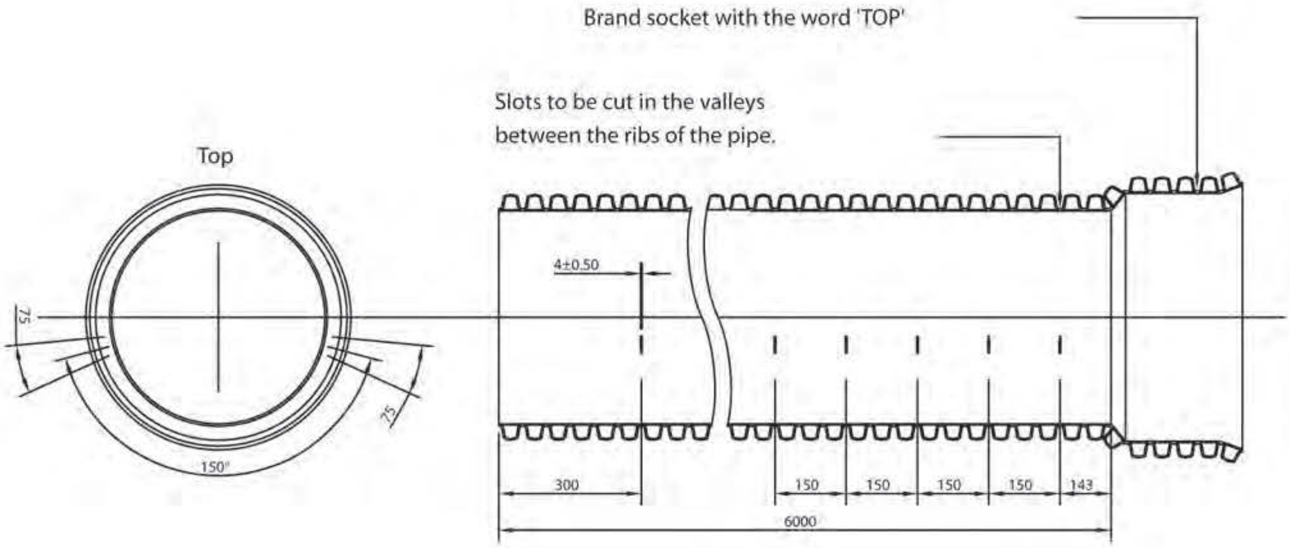
Nominal diameter DN (mm)	Actual effective lengths 'L' (mm) Tolerances on effective lengths for BlackMAX™ are +30/-0 mm and for SewerMAX™ are +15/-0 mm	
	BlackMAX™ drainage pipes (6 metre nominal lengths)	SewerMAX™ dewerage pipes (3 metre nominal lengths)
225	6010	3005
300	6020	3005
375	6025	3030
450	6030	3015
525	6015	3005
600	5910	2765

Table 2.4 Product codes - BlackMAX™ and SewerMAX™ pipes

Nominal diameter DN (mm)	BlackMAX™ drainage pipes (6 metre nominal lengths)	BlackMAX™ sub soil drainage pipes (6 metre nominal lengths)	SewerMAX™ sewerage pipes (3 metre nominal lengths)
225	GR8225	GR8225SL	GR10225C
300	GR8300	-	GR10300C
375	GR8375	-	GR10375C
450	GR8450	-	GR10450C
525	GR8525	-	GR10525C
600	GR8600	-	GR10600C

2.4.1 DN225 BlackMAX™ slotted subsoil drainage pipe

Figure 2.2 DN225 BlackMAX™ slotted subsoil drainage pipe - Cross-section



DN225 BlackMAX™ pipes are available for use as a subsoil drainage pipe with circumferential slots distributed along the barrel as shown in Figure 2.2. The usual configuration is to have two rows of fifteen slots, each displaced alternately around the circumference by 150 degrees. Each slot measures approximately 100mm x 6mm yielding approximately 18,000 mm^2 per 6 m pipe length.

The slots are oriented downwards when laid as shown in Figure 2.2.This provides a draw down level below the spring line. Pipes are branded with the word *TOP* for correct orientation when buried in the trench. All other pipe dimensions are as shown in Table 2.2.

The structured wall profile combined with the small perforations prevents large particles from entering the pipeline. In sandy or fine soil conditions, geo-textile may be required to fully encapsulate the embedment material to prevent fine soil particles migrating into the coarse embedment material. Refer to AS/NZS 2566.2 for further information.

2.5 FITTINGS RANGE & DIMENSIONS

A range of standard fittings, including bends, tees, junctions, closed ends, couplings, plugs, reducers, saddles and adaptors are manufactured for use with BlackMAX™ and SewerMAX™ pipes. Fittings can be fabricated from BlackMAX™ or SewerMAX™ pipe sections, PVC pipe sections, GRP / PVC and GRP / VC composite materials.

BlackMAX™ stormwater drainage fittings in sizes DN225, DN300 and DN375 are generally fabricated from PVC pipe sections with moulded socketed ends for connection to BlackMAX™ pipe spigots. The use of PVC in these sizes provides improved manufacturing efficiencies and reduced costs compared with the PP fabrication process. The PVC BlackMAX™ range of fittings (Section 2.5.2) complies with Australian Standard AS/NZS 1260: *"PVC-U pipes and fittings for drain waste and vent applications"*.

BlackMAX™ stormwater drainage fittings in sizes DN450, DN525 and DN600 are fabricated from BlackMAX™ (PP) pipe sections (Section 2.5.1) and are generally supplied with socketed ends suitable for rubber ring jointing. Other configurations, such as all spigoted ends, are also available on request with separate pipe couplings for jointing. DN100 and DN150 components are supplied with either PVC (RRJ or SWJ sockets) or standard solid wall polypropylene plain-ended spigots (110mm OD) and (160mm OD), allowing lateral side connections such as property branch connections. BlackMAX™ (PP) fittings comply with Australian Standard AS/NZS5065 *"Polyethylene and polypropylene pipes & fittings for drainage and sewerage applications"*.

GRP, GRP/PVC and GRP/VC composite fittings (Section 2.5.3) are manufactured specifically for use with SewerMAX™ pipes with socketed ends for connection to SewerMAX™ pipe spigots. GRP fittings are also available with PVC or VC socket or spigot ends for lateral connections to incoming PVC or VC sewer pipes. GRP SewerMAX™ fittings comply with Australian Standard Revision AS3571 *"Glass reinforced thermosetting plastics (GRP) pipes – Polyester based – Water supply, sewerage and drainage applications"*.

A range of stainless steel, jointing and repair clamps (Section 2.5.4) are available in sizes DN225, DN300, DN375, DN450, DN525 & DN600 for repairs and maintenance of SewerMAX™ pipes. SewerMAX™ SS Junctions with reducing DN100 and DN150 DWV branch off-takes at 45° are also available, simplifying lateral side connections to property branch sewer lines without the need of cutting-in a new junction. The stainless junctions and clamps have been designed specifically for SewerMAX™ pipes and comply with the requirements of Australian Standard *"AS4181 Stainless steel clamps for water works purposes"*.

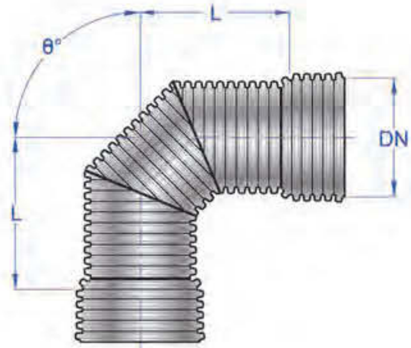
2.5.1 BlackMAX™(PP) fittings range

BENDS (PP) Socket x Socket: one cut / two segment

Product code			Dimensions	
Θ = 15°	Θ = 30°	Θ = 45°	DN (mm)	L (mm)
GR0222515*	GR0222530*	GR0222545*	225	160
GR0230015*	GR0230030*	GR0230045*	300	246
GR0237515*	GR0237530*	GR0237545*	375	284
GR0245015	GR0245030	GR0245045	450	360
GR0252515	GR0252530	GR0252545	525	428
GR0260015	GR0260030	GR0260045	600	473

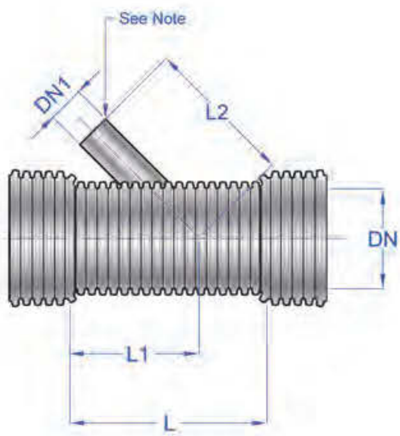
BENDS (PP) Socket x Socket: two cut / three segment

Product code	Dimensions	
Θ = 90°	DN (mm)	L (mm)
GR0222590*	225	456
GR0230090*	300	493
GR0237590*	375	530
GR0245090	450	568
GR0252590	525	607
GR0260090	600	644



REDUCING JUNCTIONS (PP) x 45°: Socket x Socket x Spigot[1]

Product code	Dimensions				
	DN (mm)	DN1[1] (mm)	L (mm)	L1 (mm)	L2 (mm)
GR25221045*	225	100	555	392	426
GR25221545*	225	150	626	428	450
GR25301045*	300	100	555	430	475
GR25301545*	300	150	626	465	500
GR25371045*	375	100	555	466	525
GR25371545*	375	150	626	502	550
GR25451045	450	100	555	505	575
GR25451545	450	150	626	540	600
GR25521045	525	100	555	543	630
GR25521545	525	150	626	580	655
GR25601045	600	100	615	600	700
GR25601545	600	150	686	636	725



[1] *DN100 & DN150 branches are PP pipe spigots suitable for connection to PVC (DWV) RRJ sockets or couplings. DN100 = 110mm OD & DN150 = 160mm OD.*

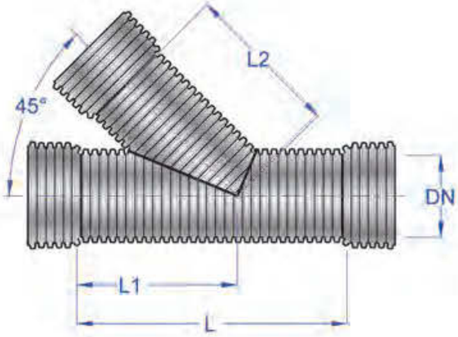
** These sizes are POA only and subject to availability at time of ordering.*

Note: *All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.1 BlackMAX™ (PP) fittings range (continued)

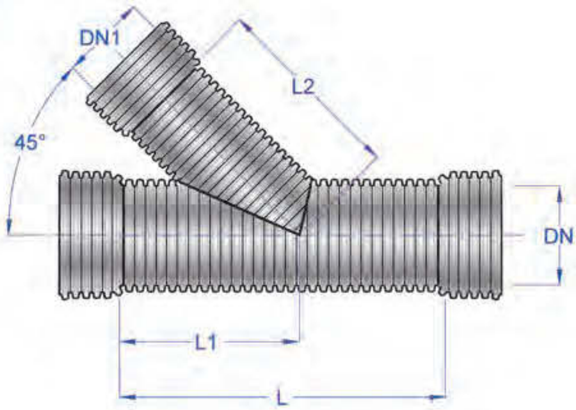
EQUAL JUNCTIONS (PP) x 45°: Socket x Socket x Socket

Product code	Dimensions			
	DN (mm)	L (mm)	L1 (mm)	L2 (mm)
GR2422545*	225	778	477	477
GR2430045*	300	902	568	568
GR2437545*	375	1013	656	656
GR2445045	450	1042	748	748
GR2452545	525	1158	838	838
GR2460045	600	1356	956	956



REDUCING JUNCTIONS (PP) x 45°: Socket x Socket x Socket

Product code	Dimensions				
	DN (mm)	DN1 (mm)	L (mm)	L1 (mm)	L2 (mm)
GR25302245*	300	225	725	515	500
GR25372245*	375	225	725	551	549
GR25373045*	375	300	831	604	624
GR25452245	450	225	725	590	604
GR25453045	450	300	831	643	678
GR25453745	450	375	925	684	700
GR25522245	525	225	732	635	658
GR25523045	525	300	838	688	732
GR25523745	525	375	941	741	753
GR25524545	525	450	1048	793	820
GR25602245	600	225	735	686	725
GR25603045	600	300	841	739	800
GR25603745	600	375	953	791	820
GR25604545	600	450	1048	834	887
GR25605245	600	525	1422	1090	906



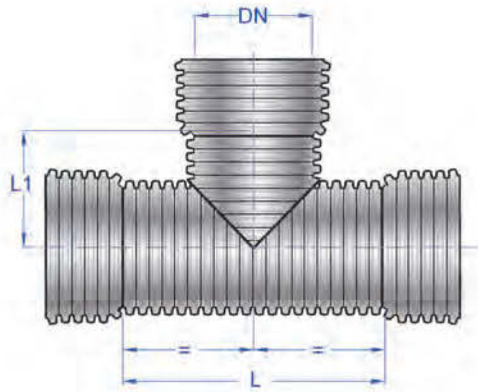
** These sizes are POA only and subject to availability at time of ordering.*

Note: *All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.1 BlackMAX™(PP) fittings range (continued)

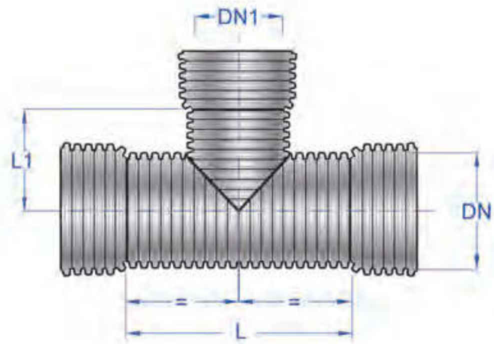
EQUAL TEES (PP) x 90º: Socket x Socket x Socket

Product code	Dimensions		
	DN (mm)	L (mm)	L1 (mm)
GR2422590*	225	630	315
GR2430090*	300	704	352
GR2437590*	375	780	390
GR2445090	450	810	405
GR2452590	525	930	465
GR2460090	600	1008	504



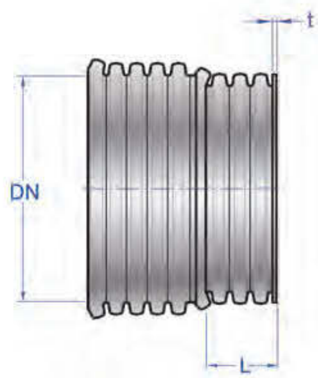
REDUCING TEES (PP) x 90º: Socket x Socket x Socket

Product code	Dimensions			
	DN (mm)	DN1 (mm)	L (mm)	L1 (mm)
GR25302290*	300	225	630	352
GR25372290*	375	225	630	389
GR25373090*	375	300	706	389
GR25452290	450	225	630	427
GR25453090	450	300	704	427
GR25453790	450	375	778	427
GR25522290	525	225	630	465
GR25523090	525	300	650	465
GR25523790	525	375	778	465
GR25524590	525	450	854	465
GR25602290	600	225	624	514
GR25603090	600	300	720	514
GR25603790	600	375	780	514
GR25604590	600	450	856	514
GR25605290	600	525	932	514



END CAPS (PP)

Product code	Dimensions		
	DN (mm)	L (mm)	t (mm)
GWR105225*	225	200	10
GWR105300*	300	200	10
GWR105375*	375	200	15
GWR105450	450	200	15
GWR105525	525	200	20
GWR105600	600	200	20



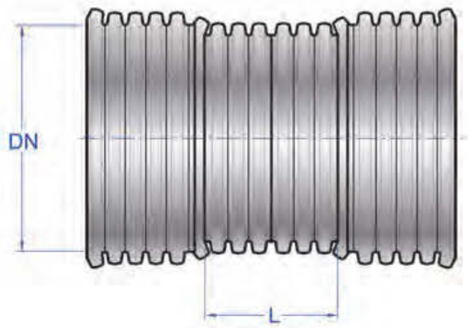
** These sizes are POA only and subject to availability at time of ordering.*

***Note:** All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.1 BlackMAX™ (PP) fittings range (continued)

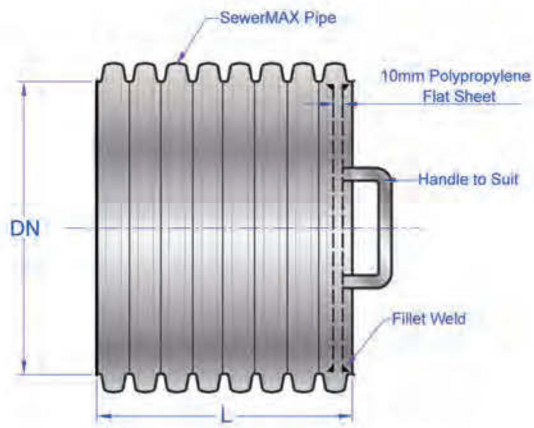
COUPLINGS (PP)

Product code	Dimensions	
	DN (mm)	L (mm)
GR57225*	225	400
GR57300*	300	400
GR57375*	375	400
GR57450	450	400
GR57525	525	400
GR57600	600	400



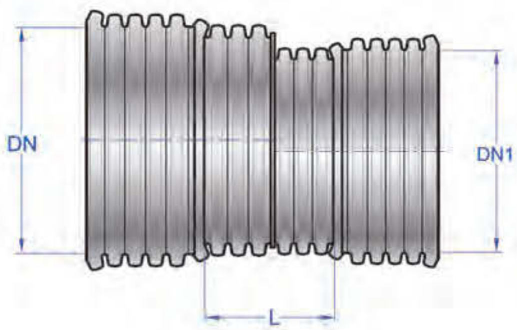
PLUGS (PP)

Product code	Dimensions	
	DN (mm)	L (mm)
GR106225*	225	160
GR106300*	300	180
GR106375*	375	215
GR106450	450	270
GR106525	525	310
GR106600	600	360



LEVEL INVERT TAPERS (PP): Socket x Socket

Product code	Dimensions		
	DN (mm)	DN1 (mm)	L (mm)
GR722215*	225	150[1]	400
GR723015*	300	150[1]	400
GR723022*	300	225	400
GR723715*	375	150[1]	400
GR723722*	375	225	400
GR723730*	375	300	400
GR724522	450	225	400
GR724530	450	300	400
GR724537	450	375	400
GR725222	525	225	400
GR725230	525	300	400
GR725237	525	375	400
GR725245	525	450	400
GR726022	600	225	400
GR726030	600	300	400
GR726037	600	375	400
GR726045	600	450	400
GR726052	600	525	400



[1] DN150 PP pipe spigots are suitable for connection to PVC (DWV) RRJ sockets or couplings. DN150 = 160mm OD.

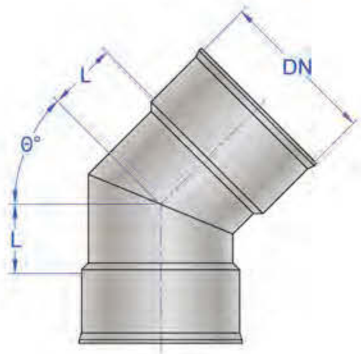
** These sizes are POA only and subject to availability at time of ordering.*

Note: *All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.2 BlackMAX™ (PVC) fittings range

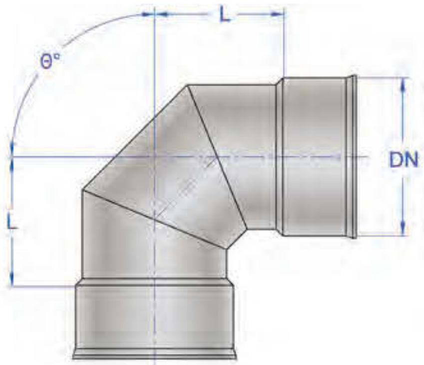
BENDS (PVC): Socket x Socket

Product code	Angle Θ°	Dimensions DN (mm)	L (mm)
GWR0222515	15	225	60
GWR0230015	15	300	125
GWR0237515	15	375	143
GWR0222530	30	225	77
GWR0230030	30	300	147
GWR0237530	30	375	170
GWR0222545	45	225	96
GWR0230045	45	300	169
GWR0237545	45	375	200



BENDS (PVC) x 90º: Socket x Socket

Product code	Dimensions DN (mm)	L (mm)
GWR0222590	225	204
GWR0230090	300	311
GWR0237590	375	373

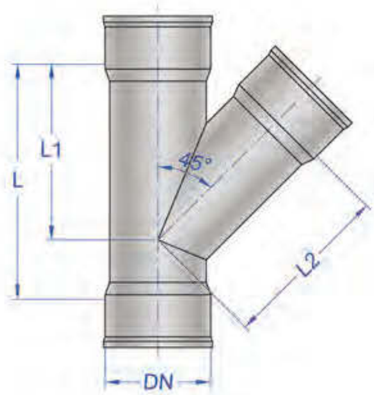


Note: *All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.2 BlackMAX™(PVC) fittings range (continued)

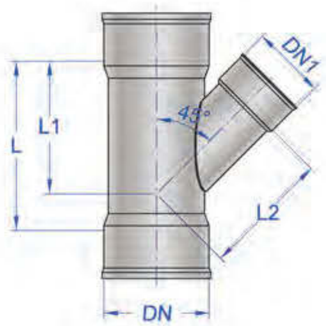
EQUAL JUNCTIONS (PVC) x 45°: Socket x Socket x Socket

Product code	Dimensions			
	DN (mm)	L (mm)	L1 (mm)	L2 (mm)
GWR2422545	225	521	386	386
GWR2430045	300	714	514	514
GWR2437545	375	816	600	600



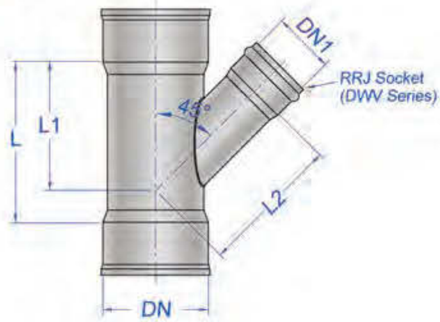
REDUCING JUNCTIONS (PVC) x 45°: Socket x Socket x Socket

Product code	Dimensions				
	DN (mm)	DN1 (mm)	L (mm)	L1 (mm)	L2 (mm)
GWR25302245	300	225	640	483	481
GWR25372245	375	225	630	527	531
GWR25373045	375	300	730	573	590



REDUCING JUNCTIONS (PVC) x 45°: Socket x Socket x RRJ (DWV)

Product code	Dimensions				
	DN (mm)	DN1[1] (mm)	L (mm)	L1 (mm)	L2 (mm)
GWR25221045	225	100	362	306	315
GWR25221545	225	150	393	321	324
GWR25301045	300	100	394	354	361
GWR25301545	300	150	365	390	378
GWR25371045	375	100	530	468	412
GWR25371545	375	150	530	463	451



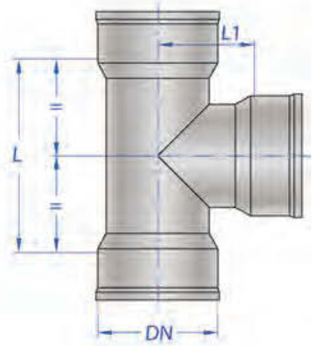
[1] DN100 & DN150 branches are generally supplied as DWV RRJ (rubber ring joint). A branch connection with a SWJ (solvent weld joint) is also available on request. Add an 'S' at the end of the product code when ordering.

Note: *All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.2 BlackMAX™(PVC) fittings range (continued)

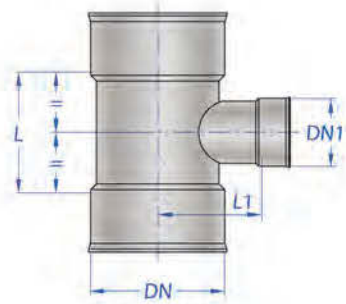
EQUAL TEES (PVC) x 90º: Socket x Socket x Socket

Product code	Dimensions		
	DN (mm)	L (mm)	L1 (mm)
GWR2422590	225	416	208
GWR2430090	300	564	282
GWR2437590	375	660	330



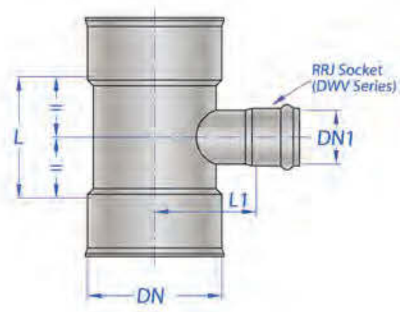
REDUCING TEES (PVC) x 90º: Socket x Socket x Socket

Product code	Dimensions			
	DN (mm)	DN1 (mm)	L (mm)	L1 (mm)
GWR25302290	300	225	244	261
GWR25372290	375	225	265	323
GWR25373090	375	300	464	442



REDUCING TEES (PVC) x 90º: Socket x Socket x RRJ (DWV[1])

Product code	Dimensions			
	DN (mm)	DN1[1] (mm)	L (mm)	L1 (mm)
GWR25221090	225	100	265	189
GWR25221590	225	150	163	193
GWR25301090	300	100	174	241
GWR25301590	300	150	199	245
GWR25371090	375	100	265	274
GWR25371590	375	150	265	288



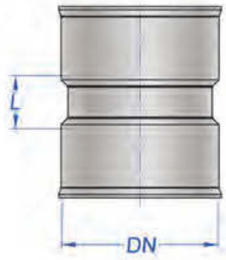
[1] DN100 & DN150 branches are generally supplied as DWV RRJ (rubber ring joint). A branch connection with a SWJ (solvent weld joint) is also available on request. Add an 'S' at the end of the product code when ordering.

Note: *All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.2 BlackMAX™(PVC) fittings range (continued)

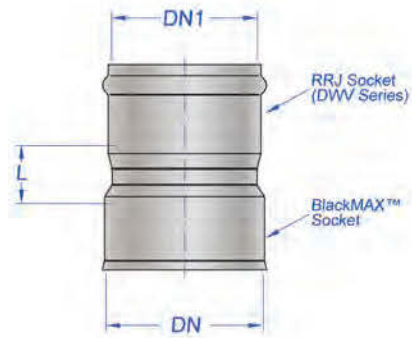
COUPLINGS (PVC): Socket x Socket

Product code	Dimensions	
	DN (mm)	L (mm)
GWR57225	225	116
GWR57300	300	148
GWR57375	375	149



ADAPTORS (PVC): Socket x RRJ (DWV)

Product code	Dimensions		
	DN (mm)	DN1 (mm)	L (mm)
GWR612222	225	225	77
GWR613030	300	300	155
GWR613737	375	375	107

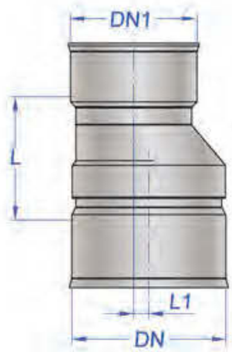


ADAPTORS (PVC): Socket x SWJ (DWV)

Product code	Dimensions		
	DN (mm)	DN1 (mm)	L (mm)
GWR622222	225	225	65
GWR623030	300	300	140
GWR623737	375	375	95

LEVEL INVERT TAPERS(PVC) : Socket x Socket

Product code	Dimensions			
	DN (mm)	DN1 (mm)	L (mm)	L1 (mm)
GWR722215	225	150[1]	460	41
GWR723015	300	150[1]	108	69
GWR723022	300	225	234	33
GWR723715	375	150[1]	168	110
GWR723722	375	225	203	65
GWR723730	375	300	405	43



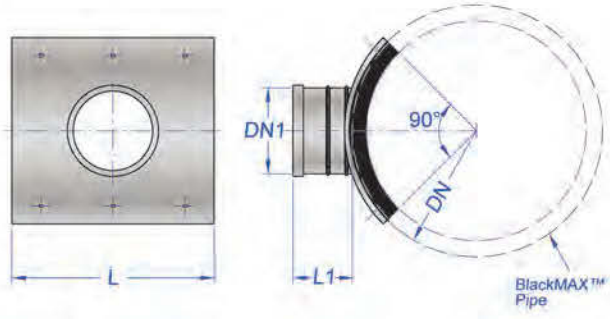
[1] *DN150 sockets are generally supplied as DWV RRJ (rubber ring joint). A SWJ (solvent weld joint) is also available on request. Add an 'S' at the end of the product code when ordering.*

Note: *All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.2 BlackMAX™(PVC) fittings range (continued)

STORMWATER SADDLES (PVC) x RRJ (DWV)

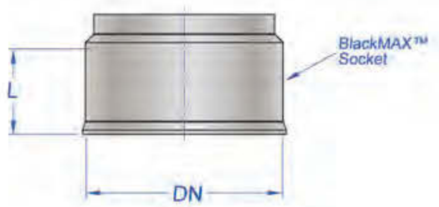
Product code	Dimensions			
	DN (mm)	DN1 (mm)	L (mm)	L1 (mm)
GWR50221090	225	100[1]	255	80
GWR50221590	225	150[1]	255	120
GWR50301090	300	100[1]	275	80
GWR50301590	300	150[1]	275	120
GWR50371090	375	100[1]	315	80
GWR50371590	375	150[1]	315	120
GWR50451090	450	100[1]	390	80
GWR50451590	450	150[1]	390	120
GWR50521090	525	100[1]	360	80
GWR50521590	525	150[1]	360	120
GWR50601090	600	100[1]	410	80
GWR50601590	600	150[1]	410	120



Plan View
Side Elevation

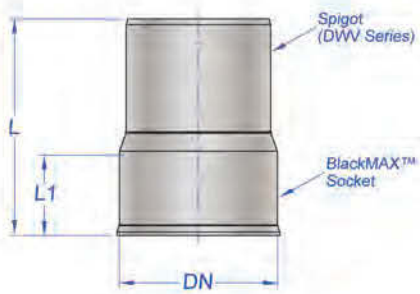
END CAPS (PVC)

Product code	Dimensions	
	DN (mm)	L (mm)
GWR105225	225	145
GWR105300	300	150
GWR105375	375	185



ADAPTORS (PVC): Socket x Spigot (DWV)

Product code	Dimensions		
	DN (mm)	L (mm)	L1 (mm)
GWR602222	225	375	145
GWR603030	300	470	150
GWR603737	375	450	185



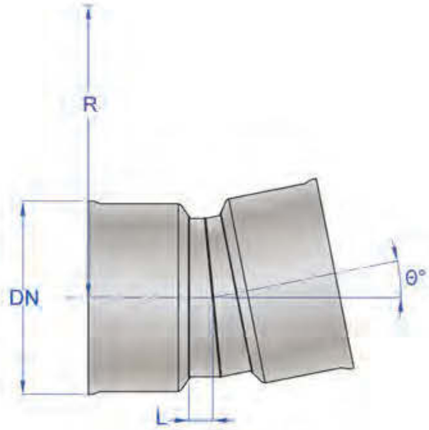
[1] DN100 & DN150 branches are generally supplied as DWV RRJ (rubber ring joint). A branch connection with a SWJ (solvent weld joint) is also available on request. Add an 'S' at the end of the product code when ordering.

***Note:** All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.3 SewerMAX™ (GRP) fittings range

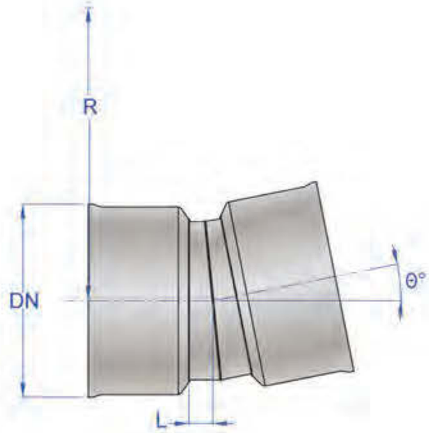
BENDS (GRP) x 15º: Socket x Socket

Product code	Dimensions		
	DN (mm)	L (mm)	R (mm)
GFR0222515	225	60	1535
GFR0230015	300	65	1861
GFR0237515	375	70	2141
GFR0245015	450	75	2711
GFR0252515	525	80	3037
GFR0260015	600	85	3423



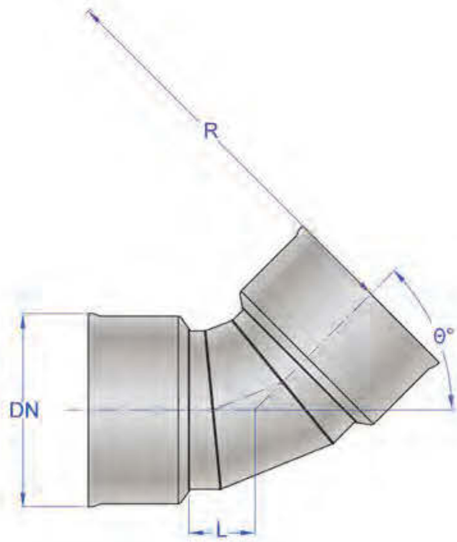
BENDS (GRP) x 30º: Socket x Socket

Product code	Dimensions		
	DN (mm)	L (mm)	R (mm)
GFR0222530	225	76	813
GFR0230030	300	86	992
GFR0237530	375	96	1148
GFR0245030	450	106	1447
GFR0252530	525	116	1627
GFR0260030	600	126	1835



BENDS (GRP) x 45º: Socket x Socket

Product code	Dimensions		
	DN (mm)	L (mm)	R (mm)
GFR0222545	225	191	762
GFR0230045	300	234	891
GFR0237545	375	244	1005
GFR0245045	450	291	1212
GFR0252545	525	312	1323
GFR0260045	600	329	1490

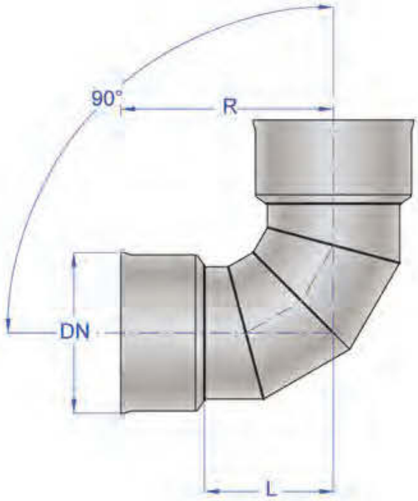


Note: *All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.3 SewerMAX™ (GRP) fittings range (continued)

BENDS (GRP) x 90º: Socket x Socket

Product code	Dimensions		
	DN (mm)	L (mm)	R (mm)
GFR0222590	225	228	370
GFR0230090	300	266	446
GFR0237590	375	302	514
GFR0245090	450	340	622
GFR0252590	525	374	699
GFR0260090	600	410	781

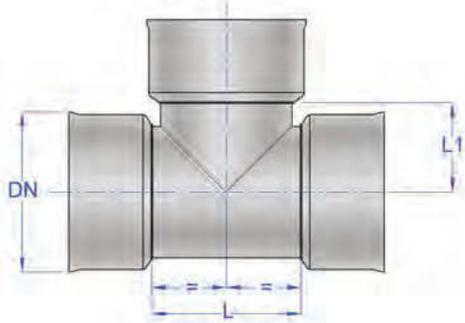


Note: *All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.3 SewerMAX™ (GRP) fittings range (continued)

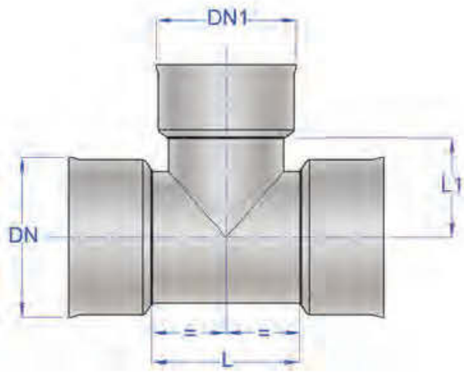
EQUAL TEES (GRP) x 90°: Socket x Socket x Socket

Product code	Dimensions		
	DN (mm)	L (mm)	L1 (mm)
GFR2422590	225	325	270
GFR2430090	300	400	305
GFR2437590	375	475	313
GFR2445090	450	550	369
GFR2452590	525	625	451
GFR2460090	600	700	482



REDUCING TEES (GRP) x 90°: Socket x Socket x Socket

Product code	Dimensions			
	DN (mm)	DN1 (mm)	L (mm)	L1 (mm)
GFR25221090*	225	100*	210	345
GFR25221590*	225	150*	260	345
GFR25301090*	300	100*	210	390
GFR25301590*	300	150*	260	390
GFR25302290	300	225	325	315
GFR25371090*	375	100*	210	345
GFR25371590*	375	150*	260	390
GFR25372290	375	225	325	265
GFR25373090	375	300	400	305
GFR25451090*	450	100*	210	480
GFR25451590*	450	150*	260	480
GFR25452290	450	225	326	395
GFR25453090	450	300	400	358
GFR25453790	450	375	476	530
GFR25521090*	525	100*	210	525
GFR25521590*	525	150*	260	525
GFR25522290	525	225	326	450
GFR25523090	525	300	400	440
GFR25523790	525	375	476	403
GFR25524590	525	450	550	411
GFR25601090*	600	100*	210	620
GFR25601590*	600	150*	260	620
GFR25602290	600	225	326	495
GFR25603090	600	300	400	485
GFR25603790	600	375	476	448
GFR25604590	600	450	550	459
GFR25605290	600	525	626	496



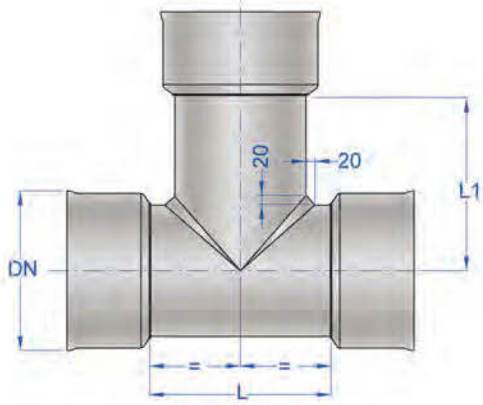
** DN100 & DN150 offtakes are available for PVC & VC connections.*
For DWV RRJ (rubber ring joint) add 'R' at the end of the code
For SWJ (solvent weld joint) add an 'S' at the end of the product code when ordering.
For VC RRJ add a 'V' at the end of the product code.

***Note:** All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.3 SewerMAX™ (GRP) fittings range (continued)

SewerMAX™ DROP JUNCTION (GRP) SWB

Product code	Dimensions		
	DN (mm)	L (mm)	L1 (mm)
GFR37225WB	225	330	320

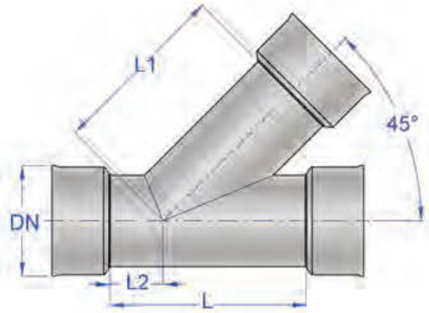


Note: *All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.3 SewerMAX™ (GRP) fittings range (continued)

EQUAL JUNCTION (GRP) x 45°: Socket x Socket x Socket

Product code	Dimensions			
	DN (mm)	L (mm)	L1 (mm)	L2 (mm)
GFR2422545	225	525	445	100
GFR2430045	300	650	573	134
GFR2437545	375	759	645	157
GFR2445045	450	913	765	175
GFR2452545	525	1034	836	187
GFR2460045	600	1165	980	200



REDUCING JUNCTIONS (GRP) x 45°: Socket x Socket x Socket

Product code	Dimensions				
	DN (mm)	DN1 (mm)	L (mm)	L1 (mm)	L2 (mm)
GFR25221045*	225	100*	366	424	25
GFR25221545*	225	150*	432	424	53
GFR25301045*	300	100*	398	643	25
GFR25301545*	300	150*	435	643	25
GFR25302245	300	225	544	498	81
GFR25371045*	375	100*	440	695	25
GFR25371545*	375	150*	479	695	25
GFR25372245	375	225	524	550	25
GFR25373045	375	300	657	625	105
GFR25451045*	450	100*	486	782	25
GFR25451545*	450	150*	522	782	25
GFR25452245	450	225	605	603	25
GFR25453045	450	300	702	678	69
GFR25453745	450	375	805	699	120
GFR25521045*	525	100*	521	803	25
GFR25521545*	525	150*	558	803	25
GFR25522245	525	225	660	658	25
GFR25523045	525	300	715	732	27
GFR25523745	525	375	818	753	79
GFR25524545	525	450	926	819	133
GFR25601045*	600	100*	626	870	25
GFR25601545*	600	150*	662	870	25
GFR25602245	600	225	711	725	25
GFR25603045	600	300	767	800	24
GFR25603745	600	375	815	820	24
GFR25604545	600	450	922	887	77
GFR25605245	600	525	1030	906	132

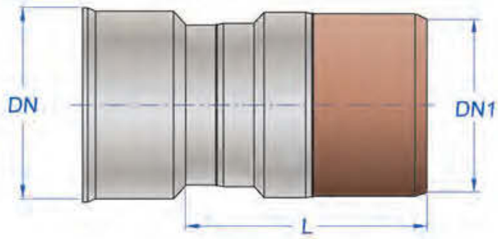
** DN100 & DN150 offtakes are available for PVC & VC connections.*
For DWV RRJ (rubber ring joint) add 'R' at the end of the code
For SWJ (solvent weld joint) add an 'S' at the end of the product code when ordering.
For VC RRJ add a 'V' at the end of the product code.

Note: *All illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.3 SewerMAX™ (GRP) fittings range (continued)

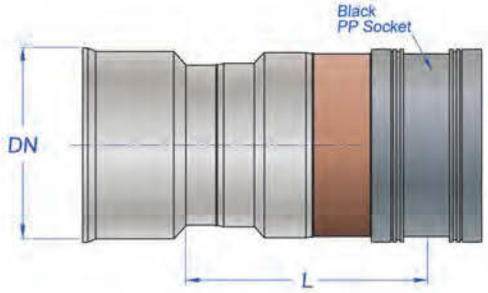
ADAPTOR (GRP): Socket x VC Spigot

Product code	Dimensions		
	DN (mm)	DN1 (mm)	L (mm)
GFR602222VC	225	263	350



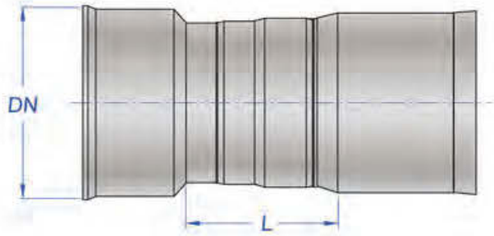
ADAPTOR (GRP): Socket x VC Socket RRJ

Product code	Dimensions	
	DN (mm)	L (mm)
GFR602222VCS	225	350



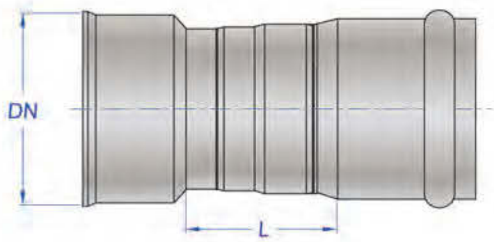
ADAPTOR (GRP): Socket x DWV Solvent Weld Socket

Product code	Dimensions	
	DN (mm)	L (mm)
GFR602222PVCS	225	200



ADAPTOR (GRP): Socket x DWV RRJ Socket

Product code	Dimensions	
	DN (mm)	L (mm)
GFR602222PVCR	225	200



Note: *All Illustrations are not to scale.*
All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.

2.5.4 SewerMAX™ stainless steel clamp range

REPAIR CLAMP - C37018

Product code	DN (mm)	Length (mm)
C37018.22530	225	300 (4 Bolt)
C37018.30030	300	300 (4 Bolt)
C37018.37530	375	300 (4 Bolt)
C37018.45040	450	400 (5 Bolt)
C37018.52540	525	400 (5 Bolt)
C37018.60040	600	400 (5 Bolt)

JOINER CLAMP – C37019

Product code	DN (mm)	Length (mm)
C37019.22520	225	200 (2 Bolt)
C37019.30020	300	200 (2 Bolt)
C37019.37520	375	200 (2 Bolt)
C37019.45030	450	300 (4 Bolt)
C37019.52530	525	300 (4 Bolt)
C37019.60030	600	300 (4 Bolt)

REDUCING JUNCTION – C37017

DN (mm)	Reducing junction (X100 DWV RRJ)	Clamp length	Reducing junction (X150 DWV RRJ)	Clamp length
225	C37017.22530OB100	300 (8 Bolt)	C37017.22540OB150	400 (8 Bolt)
300	C37017.30030OB100	300 (8 Bolt)	C37017.30040OB150	400 (8 Bolt)
375	C37017.37530OB100	300 (8 Bolt)	C37017.37540OB150	400 (8 Bolt)
450	C37017.45040OB100	400 (10 Bolt)	C37017.45060OB150	600 (16 Bolt)
525	C37017.52540OB100	400 (10 Bolt)	C37017.52560OB150	600 (16 Bolt)
600	C37017.60040OB100	400 (10 Bolt)	C37017.60060OB150	600 (16 Bolt)

Note: *All dimensions may vary. Therefore if this is critical please contact Iplex Pipelines for confirmation.*

2.6 BlackMAX™ and SewerMAX™ RUBBER RING JOINT PERFORMANCE

Poor joint performance can lead to major problems with your asset. An inadequate joint can allow tree root intrusion, which can lead to pipe blockages and ground water infiltration. Infiltration through the pipe joint can also cause silting of the pipeline and long-term maintenance issues. For this reason the quality of the joint is critical to the performance of any pipe system.

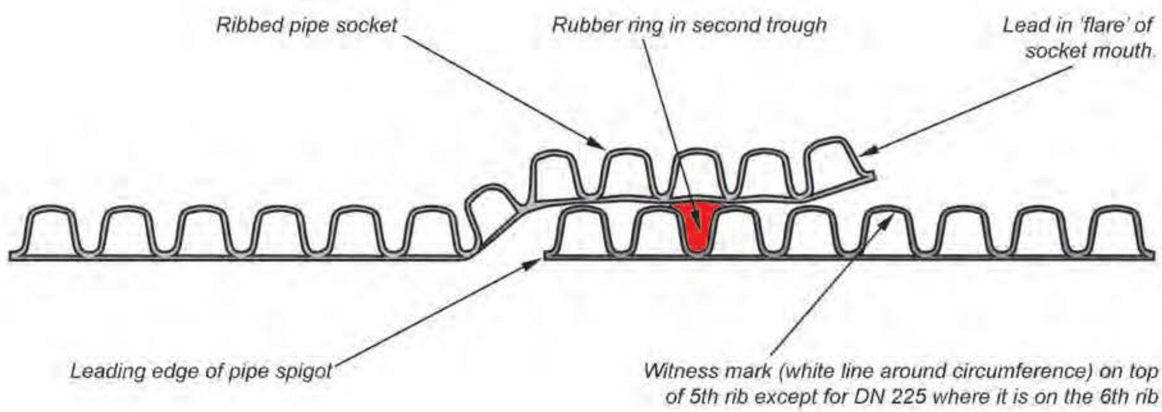
Iplex Pipelines has participated with the CSIRO in a research project to assess the characteristics of various elastomeric seal pipe joints to determine their resistance to infiltration and exfiltration with particular emphasis on tree root intrusions. The result of this work has been applied to the design of the elastomeric seal joint for BlackMAX™ and SewerMAX™. The elastomeric seal is made of SBR, which also has a high degree of resistance to chemical and microbiological attack and is compliant to "*AS1646, Elastomeric seals for water works purposes*".

The BlackMAX™ and SewerMAX™ pipe joint has been designed to meet the performance requirements of "AS/NZS 5065 *Polyethylene and polypropylene pipes and fittings for drainage and sewerage applications*". The standard specifies a pressure test of 85 KPa and a vacuum test of - 85KPa as well as a minimum contact pressure of 0.4MPa between the rubber seal and the pipe wall over a distance of at least 4mm. These conditions have shown to provide high resistance to tree root intrusion for plastic pipes.

2.6.1 Joint details

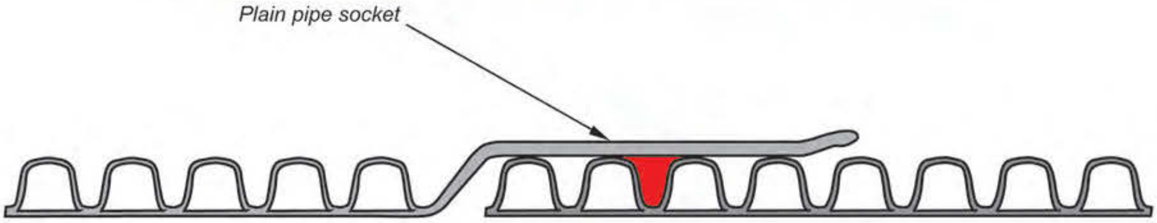
BlackMAX™ and SewerMAX™ pipes are manufactured with a *spigot and socket* rubber ring jointing system. A profiled ring is located in the second trough from the *spigot* end and is compressed as the spigot enters the socket. This jointing system can be used after cutting the pipe anywhere along its length. Joined pipes may be deflected by up to 3 degrees off-line after assembly. See Section 4.4 for details of the jointing procedure.

Figure 2.3 a. DN 225 to DN 525 BlackMAX™ & SewerMAX™ spigot and socket rubber ring joint (cross-section of assembly)



2.6.1 Joint details (continued)

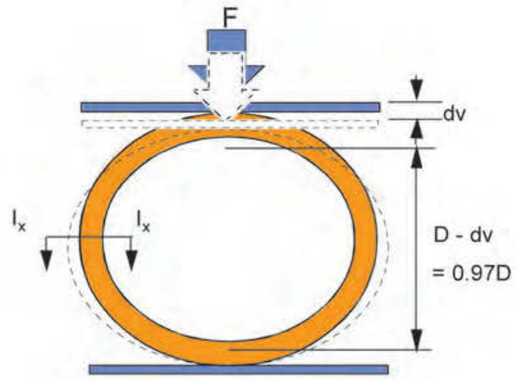
Figure 2.3 b. DN600 (only) BlackMAX™ & SewerMAX™ spigot and socket rubber ring joint (Cross-section of assembly)



Pipes can be cut using a carpentry saw where short lengths are required and rejoined on site

2.7 PIPE STIFFNESS

The ring stiffness of a *flexible* pipe indicates its ability to resist soil loads, external hydrostatic pressure, negative internal pressures, traffic and construction loads. Nominal ring stiffness can be determined by laboratory testing and is expressed in N/m.m - Ref. AS/NZS 2566.1 & AS/NZS 1462.22. BlackMAX™ pipes are manufactured with a stiffness of not less than 8000 N/m.m and are designated as SN8. SewerMAX™ pipes are manufactured with a stiffness of not less than 10000N/m.m and are designated as SN10. The increased stiffness of SewerMAX™ provides a higher factor of safety for deep buried applications such as gravity sewer mains.



The stiffness criterion has been adopted by Australian Standard AS/NZS 2566.1-1998 "*Buried flexible pipelines - Part 1 Structural design*" as being the most appropriate means of classifying flexible pipes manufactured from all types of plastics and metallic materials. It is defined as the force required to achieve the nominated deflection (typically 3% to 5%) on a specific length of pipe and is expressed mathematically as follows:

equation 2.1

$$SN = \frac{Ff}{L.dv}$$

equation 2.2

$$SN = \frac{EI}{D^3} x10^6$$

Where:

SN = nominal stiffness (N/m.m)

E = the apparent pipe material modulus (MPa)

F = force (Newtons)

I = second moment of area (m^4/m)

L = length of test specimen (m)

dv = deflection, ie. diametral deformation (m)

D = pipe diameter at neutral axis of the pipe wall (m)

f = the ovality correction factor, that is $f = 10^{-5}\left(1860 + 2500\frac{dv}{D}\right)$

3.0 DESIGN

3.1 HYDRAULIC PERFORMANCE

New BlackMAX™and SewerMAX™ 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_f	=	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/m³)
ν	=	kinematic viscosity (m²/sec)
2θ	=	angle (radians) subtended at pipe centre by water surface in invert - *see Figure 3.4*
τ	=	average boundary shear stress (Pa)

To assist the designer in selecting the appropriate pipe diameter, flow resistance charts covering BlackMAX™and SewerMAX™ pipes have been provided – see Figures 3.1 and 3.2.

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.

equation 3.1

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

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}m²/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™ and SewerMAX™ 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.

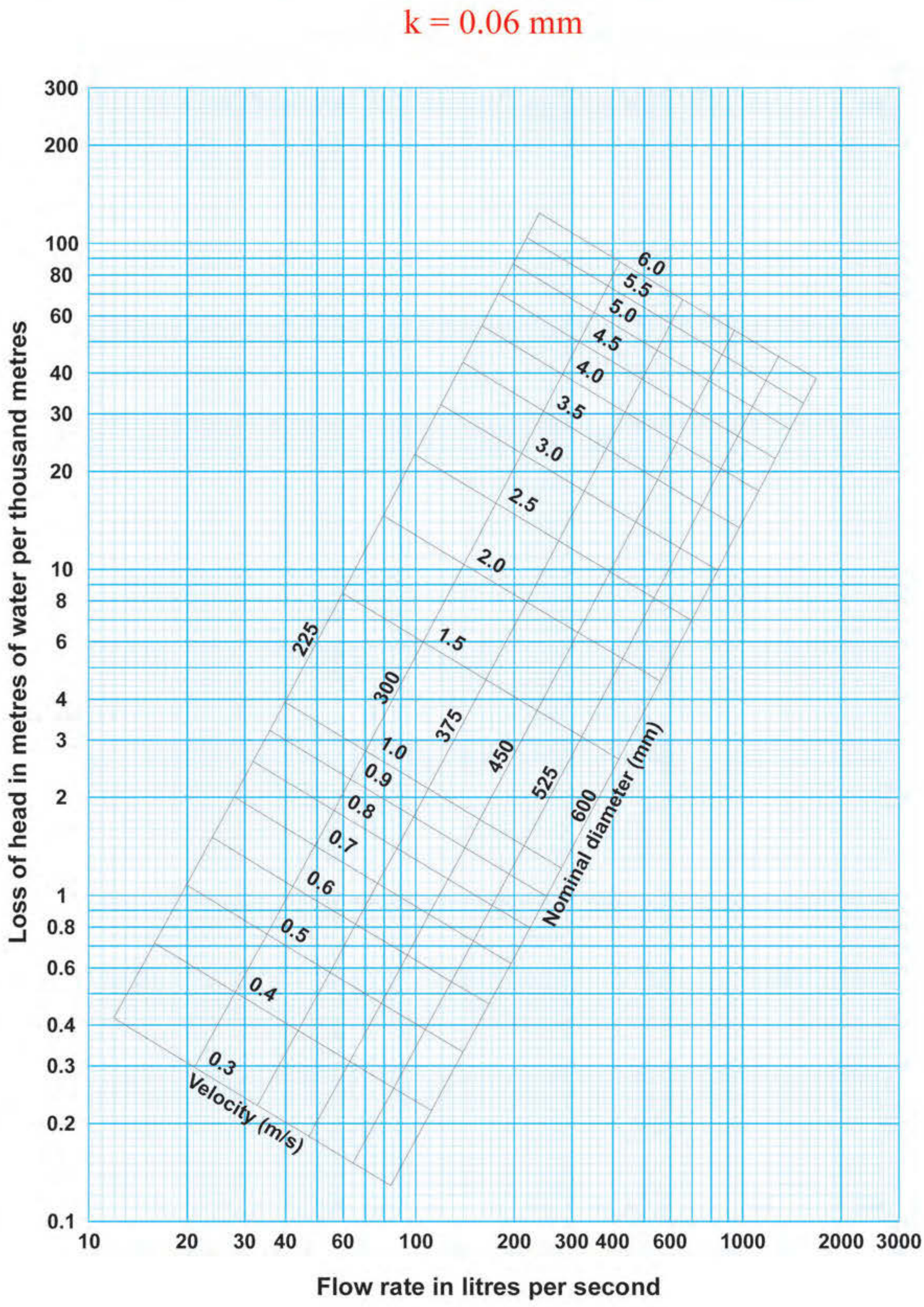
Table 3.1 Typical colebrook white roughness coefficients k for different materials

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 charts 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.

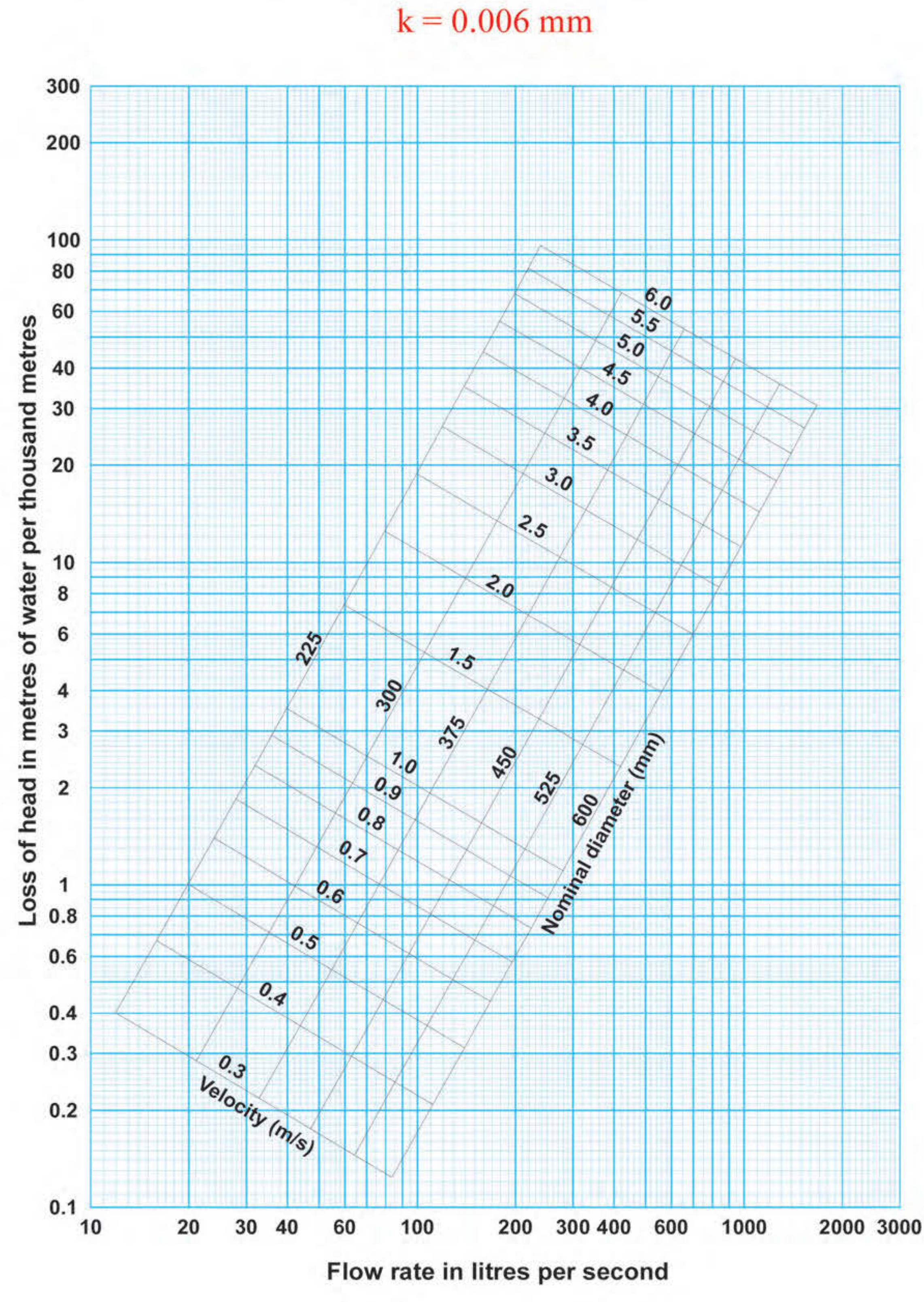
3.1 HYDRAULIC PERFORMANCE (continued)

Figure 3.1 Flow chart used typically for sewerage and drainage applications



3.1 HYDRAULIC PERFORMANCE (continued)

Figure 3.2 Flow chart used typically for water supply applications



3.1 HYDRAULIC PERFORMANCE (continued)

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 3.2

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

For clean polypropylene pipes such as BlackMAX™ and SewerMAX™, 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™ and SewerMAX™ pipes.

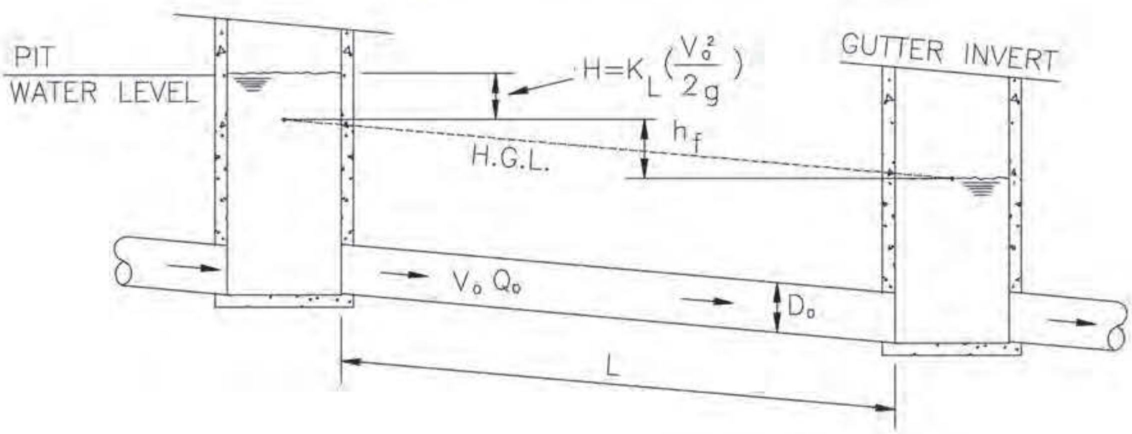
3.1.1 Stormwater drainage design

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 3.3 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 3.3 Head losses through stormwater pits

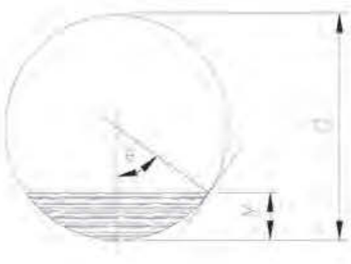


3.1.2 Sewer design

The design of gravity sewers can be complex due to the assumptions, which must be made to cover the wide variations between storm flows and low dry weather flows. Although pipes must be sized to carry high wet weather flows, the size and grade of the pipeline must also meet self-cleansing criteria under dry weather conditions.

Acceptable design methods will vary between authorities and whether the system is to be designed for sewage flows only or combined sewage and stormwater flows. In Australia the separated sewage flow is the usual requirement. Even so these systems often carry considerable stormwater flow in wet weather due to incidental inflow and infiltration of stormwater. For design purposes the normal average sewerage flow of say 0.003 L/s per head of population or *equivalent population* (EP) is increased by a series of empirical factors to allow for peak dry and wet weather flows. The resulting maximum design flow is therefore much higher than the estimated average flow. Sewer pipes are sized to carry the maximum design flow (Q_f) flowing full. In addition a check is made to ensure that in dry weather there will be sufficient flow to ensure a self-cleansing flow at least once daily.

Figure 3.4 Angle of repose of sediment for a self-cleansing flow



Historically, the normal design criterion was that a partial flow with a self-cleansing velocity of 0.6 m/s had to be achieved once a day. Today most design methods are based on the Fluid Boundary Layer Shear Theory. Research on the movement of sand particles on submerged pipe perimeters at low flows show that deposition will occur on the flatter parts of the pipe invert when the slope of the pipe wall is less than $\theta = 35°$, refer to Figure 3.4. The Boundary Layer design theory builds on this fact.

From open channel theory the following expression can be written in terms of average boundary shear stress τ.

equation 3.3

$$\tau = \rho . g . R . S$$

For a circular sewer flowing part full and since $R_f = d/4$, Equation 3.3 can be rewritten as

equation 3.4

$$\tau = \rho . g . {}^{d}\!/_{4} . {}^{R_p}\!/_{R_f} . S$$

It can be assumed if $\tau \geq 1.5$ Pa that the pipe invert will be self-cleansing. Therefore taking this as the value for τ, the minimum self cleansing slope can be determined by re arranging equation 3.4

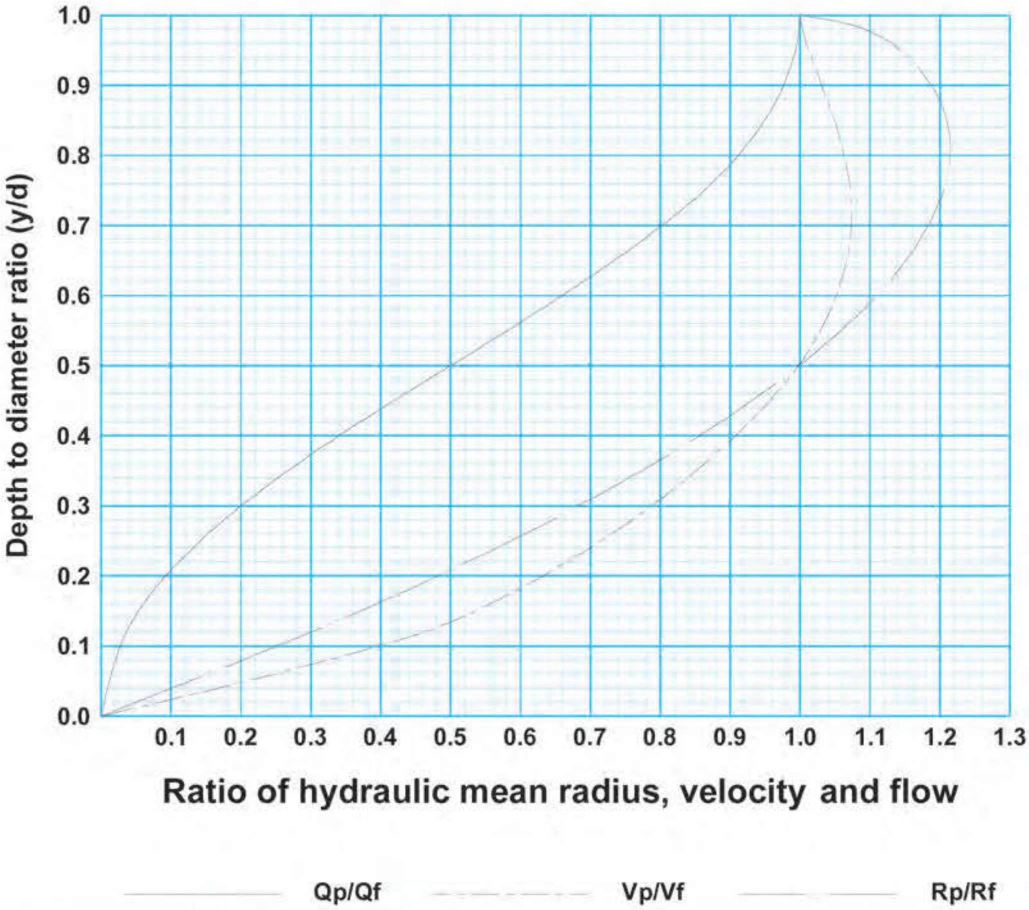
equation 3.5

$$S_{\min} = \frac{4\tau}{\rho . g . d . \left({}^{R_p}\!/_{R_f} \right)}$$

Using geometrical relationships and the Manning's Equation 3.2, the hydraulic elements in Figure 3.5 have been developed to relate the flow, depth and hydraulic mean radius ratios to each other. With the Q_p/Q_f ratio known, the depth to diameter ratio y/d can be found and then from this value the R_p/R_f ratio can be determined by substitution in equation 3.5

3.1.2 Sewer design (continued)

Figure 3.5 Proportional velocity and discharge in part-full pipes



Example

Problem:

A DN450 SewerMAX™ sewer carrier laid at a 0.2% gradient, with an assumed Colebrook White roughness k = 0.06 mm, will carry 170 L/s when flowing full (See Figure 3.1). The probable daily peak dry weather flow is estimated at 35 L/s.

Will this sewer be self-cleansing?

Solution:

The ratio Q_p/Q_f = 35/170 = 0.206
From Figure 3.5, y/d = 0.305 and for this depth the ratio R_p/R_f = 0.705
From Table 2.2, mean pipe internal diameter d = 447mm or 0.447m
Substituting for R_p/R_f in Equation 3.5

$$S_{\min} = \frac{4\,x\,1.5}{1000\,x\,9.81\,x\,0.447\,x\,(0.705)}$$

$$= 0.00192 \text{ or } \underline{0.19\%}.$$

The required grade of 0.19% is slightly less than the proposed 0.2%, therefore this pipeline will be self cleansing.

3.2 STRUCTURAL DESIGN

In engineering terminology, BlackMAX™ and SewerMAX™ pipes are considered to be *flexible pipes*. They are designed to deform or deflect diametrically within specified limits without structural damage after installation.

External soil and live loads on buried flexible pipes will cause a small decrease in vertical diameter and simultaneously an increase in the horizontal diameter. The horizontal movement of the pipe walls into the soil material at the sides develops a passive resistance within the soil to support the external load. The soil type and density and height of water table (if present), all influence structural performance. The greater the effective soil modulus, the less the pipe will deflect and structural stability against buckling is also enhanced.

Information on an appropriate design procedure is given in Australian Standard AS/NZS 2566.1 "*Buried flexible pipelines Part 1 - Structural design*" and its Supplement. Alternatively, Iplex pipe design software, which is based on this standard is available from Iplex Pipelines Australia.

BlackMAX™ pipes have a relatively high pipe stiffness of not less than 8000 N/m.m, classified as SN8 and are suitable for cover heights of 2 to 10 metres. SewerMAX™ pipes provide a higher factor of safety with a minimum stiffness of not less than 10,000 N/m.m and are classified as SN10. SewerMAX™ is suitable for cover heights of 2 to 13 metres.

To properly assess the effect of site conditions on a proposed installation, specific information is needed for structural design.

This includes:

- Pipe diameter
- Cover height
- Properties of Native soil
- Width of Embedment
- Properties of Embedment material
- Height of Water table
- Traffic loading
- Special requirements, such as concrete encasement or grouting

Professional advice should be obtained to determine the appropriate value of the effective soil deformation modulus for a particular installation. It will depend on the native soil type and condition, the pipe embedment material, its degree of compaction and its geometry (e.g. trench width / embedment width). Geotechnical surveys giving soil types and properties, including soil-bearing capacities, SPT (Standard Penetration Test) values at pipe depth and embedment compaction, will be relevant to the design.

The following notation is used in this Section:

a	=	the radius of applied circle of loading (m)
b	=	embedment width each side of pipe at spring line (m)
B	=	trench width at pipe springline (m)
D	=	overall outside diameter of pipe (m)
E_e	=	embedment soil deformation modulus (MPa)
E_n	=	native soil deformation modulus (MPa)
E'	=	combined soil deformation modulus (MPa)
H	=	cover height (m)
h	=	bedding thickness (m)
k	=	overlay thickness (m)
p	=	presumptive (allowable) beaing pressure (kPa)
Δ	=	displacement or settlement (m)
ξ	=	leonhardt correction factor

3.2.1 Geotechnical investigation

The conventional approach to a pipeline route investigation has been to assess the soil conditions at pipe depth by carrying out a drilling and soil sampling program along the alignment. While the intention in the past was often only to determine the presence of rock and to estimate trench stability for construction purposes, this investigation is now used for more detailed geotechnical reporting and includes additional information readily obtained from routine surveys. It includes design data such as the Standard Penetration Test (SPT) blow counts (at pipe depth), identification of native soil type and depth of water table. The designer will also require an assessment of the embedment material surrounding the pipe and the specified compaction procedure.

3.2.2 Derivation of soil deformation modulus values

The correct choice of soil moduli will have significant effects on design decisions. An approximate conversion of SPT blow counts to soil moduli is given in Table 3.2 of Australian Standard AS/NZS 2566.1. However many designers may have more confidence in basing their assessment on the widely available data on foundation design. Often this is contained in records obtained over many years and frequently gives correlations between SPT and allowable soil bearing pressures.

The soil deformation moduli stated in AS/NZS 2566.1 were originally derived from European design practice using soil bearing plate tests. These moduli are generally about half the value of deformation moduli measured using standard laboratory tri-axial tests and should not be confused with these. Using allowable foundation bearing pressures, it is possible to derive the plate load or pipe design soil moduli from the Boussinesq's plate bearing theory for an elastic, homogenous, isotropic solid. That is for a rigid plate and a soil Poisson's ratio of 0.5;

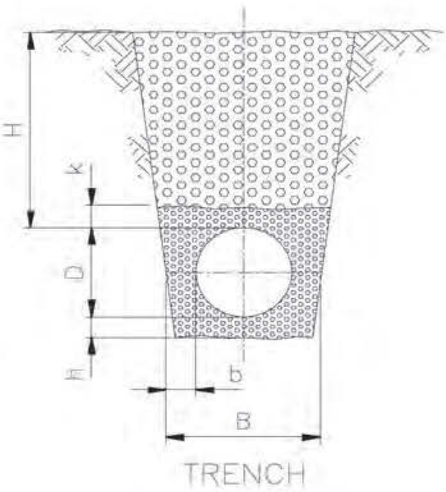
equation 3.6

$$\Delta = \frac{1.18.p.a}{E_n}.10^{-3}$$

For the purposes of obtaining a derivation it can be assumed that the plate is a standard 750mm diameter and the allowable settlement is 15 mm. Equation 3.6 provides a conversion relationship, $E_n = 0.03 \times p$. Table 3.2 , which is based on data published by Sowers[1] (1979), shows the result of applying this factor.

Values of the soil deformation moduli are needed for both the native and embedment soils within a distance of 2.5 x the pipe diameter on each side of the pipe centre-line. The modulus for a given pipe embedment soil (E_e) can be estimated from Table 3.3.

Figure 3.6 Critical dimensions for design and installation



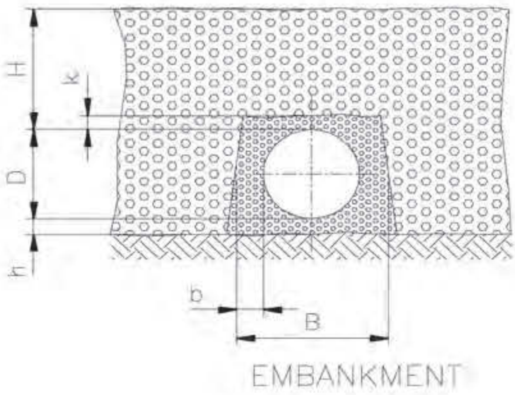


Table 3.2 Typical allowable foundation pressures converted to native soil moduli

Soil description	Standard penetration resistance – blow count over 300 mm	Allowable foundation bearing pressures p (KPa)	Derived soil deformation moduli E_n (using Eqn 3.6) (MPa)
Loose sand, dry	5 - 10	70 -140	2.1 - 4.2
Firm sand, dry	11 - 20	150 - 300	4.5 - 9.0
Dense sand, dry	31 - 50	400 - 600	12 - 18
Loose sand, inundated	5 - 10*	40 - 80	1.2 - 2.4
Firm sand, inundated	11 - 20*	80 - 170	2.4 - 5.1
Dense sand, inundated	31 - 50*	240+	7+
Soft clay	2 - 4	30 - 60	0.9 - 1.8
Firm clay	5 - 8	70 - 120	2.1 - 3.6
Stiff clay	9 - 15	150 - 200	4.5 - 6.0
Hard clay	30+	400+	12+
Heavily fractured or partially weathered rock	50+	500 - 1200	15 - 36

** SPT before inundation*

3.2.3 Effective soil modulus

Knowing the proportion of embedment and native soil in the side support zone, that is the trench width to pipe diameter (B/D) and the ratio of embedment modulus to native soil modulus (E_e/E_n), the *Leonhardt factors* given in Table 3.4 enable an overall effective soil modulus $E^{\prime}$ to be determined using the equation:

equation 3.7

$$E^{\prime} = \xi . E_e$$

Assuming a density of 20 kN/m^3 for the trench fill over the pipe, Table 3.5 will then give an estimate of the maximum safe cover heights.

Alternatively if the embedment widths comply with the following dimensions, pre calculated safe minimum cover heights for a range of native and embedment soils are given in Table 3.6.

DN (mm)	Embedment width
225	OD + 300mm
300	OD + 300mm
375	OD + 400mm
450	OD + 400mm
525	OD + 600mm
600	OD + 600mm

Note: Tables 3.5 and 3.6 have been compiled with reference to AS/NZS 2566.1 using the following assumptions:

1) Water table near surface
2) AUSTROADS HLP 400 traffic loading
3) Fill density of 20 kN/m^3

Table 3.3 Embedment soil moduli

Soil description	Standard dry density ratio (%)	Density index (%)	Deformation moduli E_e (MPa)
Aggregate – single size	-	Uncompacted 50 60 70	5 6 7 10
Aggregate - graded	-	Uncompacted 50 60 70	3 5 7 10
Crushed rock	uncompacted 85 90 95	-	1 3 5 7
Sand and coarse grained soil with less than 12% fines	uncompacted 85 90 95	-	1 3 5 7
Coarse grained soil with more than 12% fines	85 90 95	-	1 3 5

Note: These values are given in AS/NZS 2566.1 Buried flexible pipelines Part 1: Structural design Table 3.2

Table 3.4 Leonhardt correction factor ξ

B/D	E_e / E_n						
	0.2	0.4	0.8	1	2	4	6
1.5	2.4	1.8	1.2	1.0	0.6	0.3	0.2
2.0	1.7	1.5	1.2	1.0	0.6	0.4	0.3
2.5	1.5	1.3	1.1	1.0	0.7	0.5	0.4
3.0	1.2	1.2	1.0	1.0	0.8	0.6	0.5
4.0	1.0	1.0	1.0	1.0	1.0	0.9	0.8
5.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table 3.5 Permissible cover height (metres)

Nominal stiffness	Effective (Combined) soil modulus E' (Calculated knowing E_n, E_e and embedment width B)							
	1.5 MPa	2.0 MPa	2.5 MPa	3.0 MPa	4.5 MPa	6.0 MPa	7.5 MPa	9.0 MPa
SN8	1.9	2.6	3.5	3.8	5.8	7.1	8.4	9.6
SN10	2.4	2.8	3.8	4.5	6.5	7.8	9.1	10.6

For the locations given in Table 3.6 with E' values equal to or greater than shown, BlackMAX™ and SewerMAX™ pipes will be adequate for AUSTROADS highway loadings. As cover heights increase to over 2.5 metres the effect of highway traffic loading on the buried culvert becomes negligible.

Table 3.6 Minimum cover heights (from AS/NZS 2566 Part 1)

Location		Minimum height of cover H (m)*	Minimum value of E' (MPa)
Not subject to vehicular loading		0.30	Not applicable
Subject to vehicular loading	- not in roadways	0.45	2.0
	- in sealed roadways	0.60	2.0
	- in unsealed roadways	0.75	1.5
Pipes in embankment conditions or subject to construction equipment loading		0.75	2.0

** Subject to variation by the regulatory authority.*

***Note*:** Table 3.5 & 3.6 are for BlackMAX™ (SN8) & SewerMAX™ (SN10) pipes with pipe design parameters as follows:

- Vertical deflections ≤ 5%
- Buckling factor of safety of 2.5
- Assuming highway loading

3.2.3 Effective soil modulus (continued)

Worked example

Problem:

A DN600 BlackMAX™ drainage pipeline is proposed for an installation under a major highway. The pipes will be laid in a trench with a standard width of 1200 mm and a cover height of up to 6 metres. The native soil material at pipe depth is a stiff clay and the pipes will be embedded in a 10 mm aggregate compacted to a density index of 70%.

Determine whether BlackMAX™ is suitable?

Solution:

Referring to Table 3.2 as a guide for selection of soil deformation moduli it would be reasonable to use E_n = 4.5 MPa. For the embedment material refer to Table 3.3. For gravels/aggregates compacted to 70% DI, the modulus E_e would be 10.0 MPa.

Therefore:

$E_e / E_n = 10.0/4.5 = 2.22$ and,
$B/D_e = 1200 / 600 = 2.0$

From Table 3.4, The Leonhardt's Correction Factor = 0.58

Using Equation 3.7, The Effective modulus,

$E' = \xi \times E_e$
$E' = 0.58 \times 10$
$E' = 5.8$ MPa

From Table 3.5, by interpolation for E' of 5.8 MPa, the permissible cover height for BlackMAX™ pipes = 6.9 metres and therefore these pipes are suitable.

3.2.4 Effect of construction loads on buried BlackMAX™ and SewerMAX™ (PP) pipes

The recommended minimum (final) cover heights for buried flexible pipelines in different installation conditions are tabulated in Table 4.1 of Australian Standard AS/NZS 2566.2 and are empirically derived from accepted installation practice. They are similar to those used for rigid pipes.

However some authorities have requested information on the performance of flexible pipes under construction loads where the cover heights may be considerably lower. A theoretical evaluation is possible using the design procedure for flexible pipes given in AS/NZS 2566.1 Clause 4.7 "*Superimposed Live Loads*" provided that these covers may be less than the prescribed design minimum. That is at covers less than 400mm where loads are due to compaction equipment, it is reasonable to assume there will be some load dispersion but that this will reduce progressively in a linear fashion to nil as covers reduce from 400mm to zero.

Minimum (construction) cover heights have been calculated using this approach. Assumptions have been made with regard to the native soil modulus, with a value of 3 MPa being considered appropriate. This corresponds to a firm clay with a presumptive foundation bearing pressure of about 100KPa or SPT blow count of 6+ per 300mm. A firm inundated sand would have a similar modulus. The embedment modulus has been taken to be 7MPa from Table 3.2 of AS/NZS 2566.1 as this is

typical of good quality embedment material. The calculated minimum (and maximum) covers for the range of compaction equipment in Table 3.7 are shown in Table 3.8.

On site, the effect of compaction equipment on flexible pipes can be checked by monitoring changes in ring deflection. Details of allowable deflections are given in clause 5.7 of AS/NZS 2566.2. Although higher ring deflections will not damage polypropylene pipes, excessive initial ring deflections, e.g more than 4%, should be avoided as the magnitude of the deflection after installation is often used as the prime indicator of whether the specified side support compaction has been achieved. Compaction of the side support zone before allowing the compaction equipment to operate on the overlay above the pipe will assist in this respect. Where the allowable limit has been exceeded the pipeline installation may be rejected. In these circumstances it may be acceptable to recover and re use the same pipes with increased side support compaction.

Table 3.7 Compaction equipment

Type	Vibratory rammer	Vibratory trench roller (2t)	Excavator compaction wheel	Vibratory roller
Model	BS62Y	-	-	CAT CS653
Number of axles	1	2	1	1
Axle spacings	N/A	970mm	N/A	N/A
Bearing length 'a'	330mm	200mm	200mm	200mm
Bearing length 'b'	330mm	865mm	580mm	2200mm
Wheel load 'P'	33KN	72KN	155KN	218KN

Table 3.8 Summary of cover height calculations for B/D ≥ 1.66*

Pipe stiffness	Minimum covers using compaction equipment in Table 3.7				Allowable maximum covers for soil plus construction loads
	Vibratory rammer	Vibratory trench roller (2t)	Excavator compaction wheel	Vibratory roller	
SN8	230mm	220mm	670mm	470mm	6000mm
SN10	210mm	190mm	630mm	430mm	6500mm

**B = trench width at spring line, D = external pipe diameter*

4.0 INSTALLATION

4.1 TRANSPORTATION AND STORAGE

Although BlackMAX™ and SewerMAX™ pipes are notably resistant to impact, they should not be rolled, dropped, thrown, or allowed to come into contact with sharp objects likely to cause damage.

When pipes are unloaded for storage they should be kept in their packs until required. The storage site should be level and free of obstructions.

If pipes are not crated they should be placed on horizontal supporting timbers at approximately 2 metre centres. These timbers can also be used to separate layers when pipes are stacked individually.

Stack heights should be limited to prevent excessive ovalisation.

Sockets should be protected from distortion during storage by ensuring all of the sockets are placed at alternate ends and protruding from the stack.

Table 4.1 Packing specifications for BlackMAX™ pipes

Nominal pipe diameter DN (mm)	Approximate pack sizes			Pipes per pack	Approximate mass of pack (Without timbers) (kg)	Number of pipes per semi-trailer
	Width (mm)	Height (mm)	Length (mm)			
225	1090	630	6300	8	192	128
300	1090	770	6330	6	262	72
375	920 or 1340	950 or 940	6400	4 or 6	246 or 369	60
450	1080	610	6500	2	176	32
525	1890	690	6500	3	307	18
600	2130	770	6500	3	406	18

Table 4.2 Packing specifications for SewerMAX™ pipes

Nominal pipe diameter DN (mm)	Approximate pack sizes			Pipes per pack	Approximate mass of pack (Without timbers) (kg)	Number of pipes per semi-trailer
	Width (mm)	Height (mm)	Length (mm)			
225	1090	630	3300	8	81	256
300	1090	770	3300	6	120	144
375	920 or 1340	950 or 940	3400	4 or 6	118 or 177	90
450	1080	610	3500	2	76	48
525	1890	690	3500	3	150	27
600	2130	770	3400	3	199	27

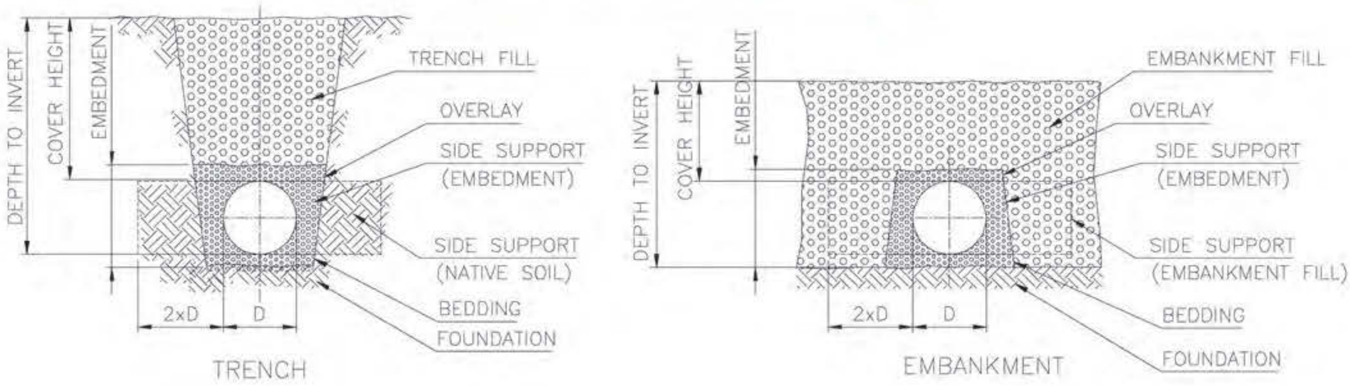
Typical packing method used for road transport

4.2 INSTALLATION GUIDELINES

BlackMAX™ and SewerMAX™ are flexible pipes designed for controlled deflection under vertical soil loads. These loads are then transferred to the soil in the side support zone. The Australian Standard AS/NZS 2566.2 "*Buried flexible pipelines – Part 2 Installation*" provides detailed information on appropriate methods for ensuring the side support zone in particular is correctly constructed.

The most critical aspect for the successful installation of these pipes is the selection and compaction of the embedment, i.e. the material in contact with the pipe. Embedment material should be of a granular nature, which is readily compactable. Crushed rock, aggregate and graded sand are commonly used but occasionally native soils, (eg. beach and mallee sand) may also be suitable provided they are free flowing and readily compacted. Appendices *G* and *H* of AS/NZS 2566.2 provide extensive guidance on the selection and use of a wide range of embedment materials. For best results when using BlackMAX™ and SewerMAX™, the maximum particle size of the pipe embedment should be limited to 5 mm for all sizes up to and including DN 375 and 10 mm for DN450 and larger.

Fig 4 .1 Buried pipeline terminology



4.3 EXCAVATION AND ASSOCIATED WORKS

4.3.1 Trench excavation

Excavate the trench to the line and grade specified. The trench width must be sufficient to permit compaction of the pipe embedment materials with suitable equipment. The minimum pipe trench width required is typically equal to pipe OD + 300mm and OD + 600mm depending on the pipe diameter – see Section 3.2.3 for further information. The trench bottom should be even and free of soil clods and rocks.

4.3.2 Foundation

The native soil in the foundation zone should be carefully excavated to grade permitting the pipeline to be correctly aligned and allowing for bedding material with a minimum thickness of 100 mm beneath the pipe. If the bearing capacity of the foundation soil is thought to be less than 50 KPa it will need to be replaced with a mattress of embedment material. In this situation geotechnical advice should be obtained.

4.3.3 Unstable and wet ground conditions

Wet and/or unstable soil conditions will require precautions to maintain firm and permanent side support for the pipes once installed. Where groundwater is present there may be a risk of the fine soil particles migrating across the interface between the native and embedment soils. It is recommended in this situation that the embedment material should be fully enveloped with geotextile material. Details of soil gradings where this can occur are given in AS/NZS 2566.2.

Pipe installation should be carried out in a trench free of water. Where there is a continuing high rate of ground water inflow, it may be necessary to facilitate drainage of the trench by the use of a porous layer of bedding material in the foundation zone. Generally this will be a coarse granular material, which will need to be fully encapsulated in a geo-textile fabric. It is sometimes described as a drainage *mattress*.

4.3.4 Trench shields

If possible, trench shields or soil boxes should be a close fit against the excavated trench walls and the bottom edges kept above the top of the pipe. If for safety reasons they must extend to the bottom of the trench, compaction of the embedment material after the shields are lifted is necessary to eliminate any voids that may otherwise develop (see Figures 4.2a and 4.2b).

Soil boxes used in open excavations are prone to accumulate loose debris between the box and the trench wall. As this poor quality material can adversely affect the available side support, it is good practice to place high quality embedment material to form part of the side support zone as soon as possible. This will exclude any debris or material which may slough from the trench wall (see Figure 4.3)

Figure 4.2a Shields kept above side support zone

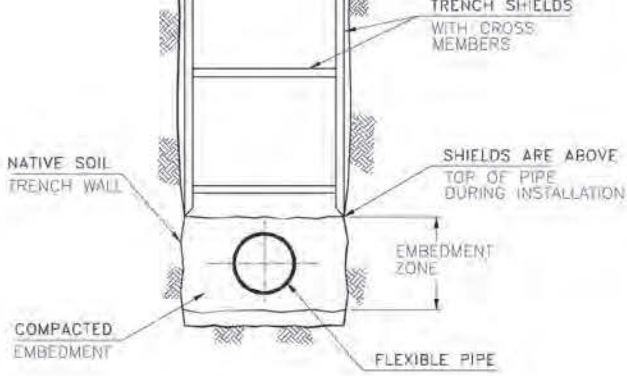


Figure 4.2b Shields in side support zone

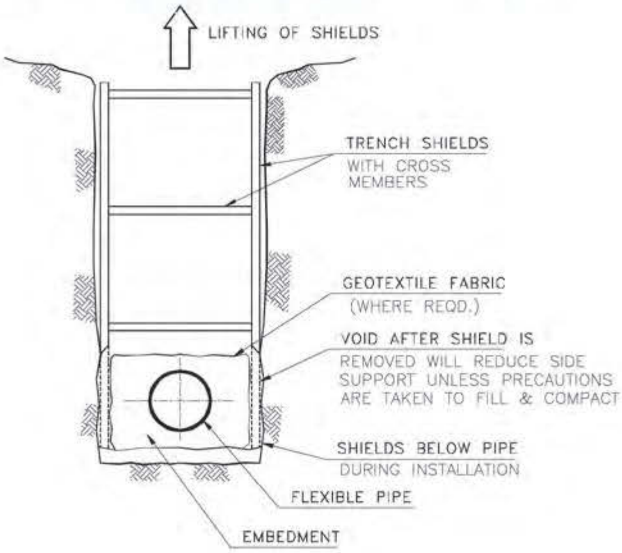
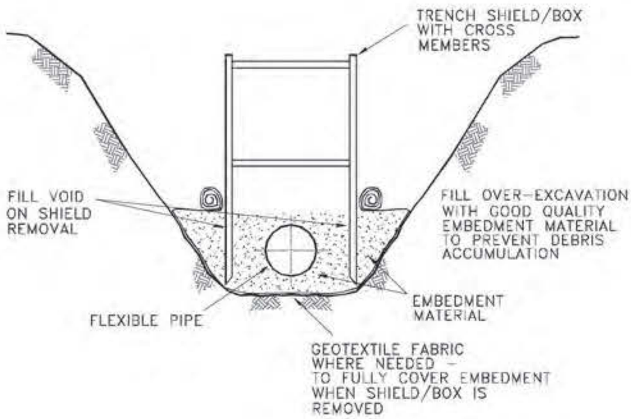


Figure 4.3 Shields in wide trench



4.4 PIPE LAYING

4.4.1 Bedding

The bedding material should be the same as the embedment used to completely surround the pipe. Its purpose is to provide uniform support and load distribution for the pipe barrel, the remaining embedment material and the backfill.

A layer of granular material with a maximum particle size of up to 5 mm for all sizes up to and including DN375 and 10 mm for DN450 and larger pipes should be placed and compacted to ensure a full 100 mm clear thickness below the wall profile. A small depression should be formed under each socket to ensure that the pipe barrel is evenly supported along its whole length. When laid to the specified alignment the pipes should be on the centreline of the trench.

If groundwater is present, the trench should be de-watered so that the pipes can be joined and installed in relatively dry conditions. In low strength soils, additional bedding material may be required as a replacement for unsatisfactory native material in the foundation zone.

4.4.2 Jointing of pipes

Once the trench and bedding has been prepared, pipes can be lowered into the trench with the aid of suitable slings or ropes. (Chains are not to be used). Manual handling and lifting is possible with most diameters of BlackMAX™ and SewerMAX™ pipes. Alternatively an excavator or backhoe can be used with a nylon sling at the pipe mid-point.

Pipes are light-weight and in most cases can be moved by hand.

4.4.2 Jointing of pipes (continued)

The following procedure is recommended when installing BlackMAX™ and SewerMAX™ rubber ring jointed pipes:

1 Clean the pipe socket and spigot grooves, making sure both are free of foreign material. Install the rubber ring by stretching it over the spigot so that it sits in the second groove from the end of the pipe. Ensure the rubber ring is evenly fitted by running hands and fingers around its full circumference.

2 Although pipes may show some out-of-roundness due to storage loads, this is usually minimal. Where it is present, it is advantageous to orientate the larger pipe diameter in the vertical plane. This will ease the jointing process and helps offset any deflection after backfilling.

3 Apply Iplex jointing lubricant liberally to the inside of the socket and lead-in flare. Avoid lubricating the ring itself to ensure it does not pick up dirt while the joint is being made. (*Under no circumstances should mineral oils or greases be used, as these compounds will cause long-term degradation of the rubber seal. In an emergency common soap can be used*).

A 'witness' mark is made on the pipe at a distance equal to the coupling length 'Pw' from the pipe end (see Table 2.2). The rubber ring should be fitted in the second trough from the spigot end.

Joining pipes with a crowbar using a solid bridging piece of timber to protect the pipe

4 The normal convention is to lay pipes by starting from the down-stream end with the socket facing in the up-stream direction. After laying, pipes should be held in position to line and grade by placing sufficient embedment material over each pipe before joining the next one.

5 Insert the leading edge of the spigot into the socket mouth. It is essential that pipes be in a straight line before attempting to make the joint.

6 Apply an even jointing force using a crowbar thrusting on a timber-bridging piece protecting the end of the pipe.

7 Push home to the spigot witness mark.

8 Where pipes are cut on site for short length adjustments or connections to fittings, it is important to place a new witness mark at the end of the spigot at a distance shown in Figure 2.1. Then repeat steps 1 to 7.

4.5 PIPE SIDE SUPPORT & OVERLAY

4.5.1 Embedment – Haunching and side support

Generally material used in the embedment zone should be uniform selected non cohesive soils. Information regarding selection is given in Appendices G and H of AS/NZS 2566.2.

The embedment must be evenly compacted between the pipe and the surrounding native soil given that the complete side support zone extends horizontally beyond the pipe for a distance of approximately twice the pipe diameter at pipe depth. Care must be taken not to disturb the pipe alignment when compacting the embedment material.

Where trench shields or boxes are used, special care is necessary to fill any voids resulting from their removal and must be filled with the same compacted embedment material.

If there is a possibility of migration of fines between the embedment and native soil, geotextile fabric should be used at the interface to completely envelope the embedment including the bedding. Refer to section 4 of AS/NZS 2566.2 and Appendix J for further information.

Granular embedment should be properly compacted to ensure there is adequate side support for the pipe

Attention to the quality and degree of compaction of embedment material placed on each side of a BlackMAX™ or SewerMAX™ pipeline is fundamental to its structural integrity. Table 4.3 shows the default values given in AS/NZS 2566.2 for the appropriate degrees of relative compaction of the embedment bedding and side support zone.

4.5.2 Overlay

The embedment material should extend to a cover height of 150 mm above the pipe. This provides protection from the placement of overburden material and the operation of compaction equipment.

Table 4.3 Minimum relative compactions (from AS/NZS 2566.2 Table 5.5)

Soil type	Test method	Trafficable areas		Non trafficable areas	
		Embedment material %	Trench / embankment fill material %	Embedment material %	Trench / embankment fill material %
Cohesion-less	Density Index	70	70	60	Compaction to suit site requirements
Cohesive	Standard Dry Density Ratio, or Hilf Density Ratio	95	95	90	

4.6 TRENCH & EMBANKMENT FILL (above pipes)

Backfilling pipelines may involve the use of excavated material providing the thickness of the overlay is adequate. Care must be taken to avoid the inclusion of large stones, rocks or hard clumps that may cause point loading on the pipeline.

Overburden compaction using large vibrating power compactors should be avoided until there is an adequate height of fill over the pipes (Refer to Section 3.2.4). This will vary depending on the capacity of the machine but generally at least 0.5 metres is desirable.

4.6.1 Monitoring diametral deflections

Once the back filling operation is complete, the adequacy of the embedment and compaction and the use of correct backfilling techniques may be assessed by measuring the vertical deflection within the pipe. The deflection check described in Section 5.2 is useful in the initial construction period as this provides an opportunity for benchmarking appropriate compaction procedures.

Maximum allowable *initial* deflection values are given in AS/NZS 2566.2 for differing time intervals after completion of the fill operation e.g. the maximum allowable deflection at 24 hours is 3.5 % and maximum allowable deflection at 30 days is 5.0%. Refer to Table 5.3.

Note: *During compaction of backfill in the pipe embedment zone, an increase in the vertical diameter and decrease in the horizontal diameter may occur. This is not detrimental providing the magnitude of the horizontal diametral deformation does not exceed the prescribed allowable deflections. See Section 5.2 for test procedure.*

4.7 BORE CASING

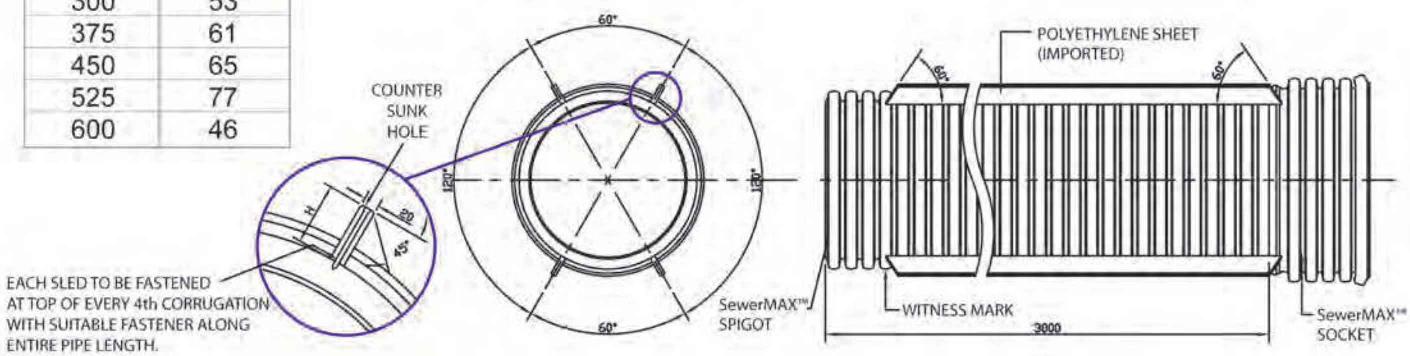
When BlackMAX™ or SewerMAX™ pipe is installed under roadways, casing may be required to prevent damage to structures due to soil erosion or settlement in the pipe zone caused by line failure or leakage. Casing is also required to accommodate regulations or requirements imposed by the public or private owners of property in which the pipe is installed, and where open excavation would be impossible or prohibitively expensive.

When BlackMAX™ or SewerMAX™ pipe is installed in casings; skids should be used to prevent damage to the pipe and socket joints during installation. Skids should properly position the pipe in the casing. Figure 4.4 shows a typical skid arrangement for SewerMAX™ pipe.

Skids should extend for the full length of the pipe, with the exception of the socket and spigot (up to

Figure 4.4 Typical skid arrangement for SewerMAX™ pipe

DN (MM)	H (MM)
225	45
300	53
375	61
450	65
525	77
600	46



the witness mark) required for joint assembly. Skids must provide sufficient height to permit clearance between the socket and casing wall. Casings are normally sized to provide an inside diameter which is at least 50mm greater than the maximum outside diameter of the pipe socket, or skids.

Skids can be fabricated from Polyethylene sheet and should be fastened securely to the pipe as shown in figure 4.4. Alternatively wooden skids can also be used with suitable strapping. Use approved pipe lubricant between the skids and casing for ease of installation. Upon completion of pipe insertion, grouting of the void in accordance with design requirements can be accomplished.

4.7.1 Grouting

Where it is necessary to pressure grout an annulus between the pipe and enveloping conduit, for example where SewerMAX™ pipe has been used to reline a deteriorated sewer, it is important to ensure that the grout is introduced into the annulus as evenly as possible. The pipe must be properly chocked to resist flotation, deformation and bending. In addition the hydrostatic grout pressure should not exceed 70 KPa to ensure there is an adequate factor of safety against buckling instability. If necessary the effect of grout pressures can be nearly halved by filling the pipeline with water. Alternatively it may be possible to stage the grouting process in two or three *lifts*, allowing the grout to solidify in the annulus below the spring-line before the top section is filled. This method is illustrated in Appendix K of AS/NZS 2566.2.

4.8 JOINTING TO RIGID STRUCTURES & LATERAL PIPES

4.8.1 Relative settlement

Where BlackMAX™ pipes are connected to concrete structures there is unlikely to be any need for short *rocker* pipes due to the high straining (ductile) capability of polypropylene. This will allow the pipes to accommodate differential settlement without damage.

4.8.2 Pipe/Concrete interface

BlackMAX™ and SewerMAX™ pipes can be directly embedded into concrete maintenance holes, pits or other concrete structures. If a water-tight seal is required as in the case of sewerage installations, an approved hydrophilic *rubber* compound in strip form should be used.

The following procedure outlines the steps to be followed when using the Hydrotite Water Seal with SewerMAX™ pipes connecting into concrete manholes.

1. Prior to fixing the Hydrotite seal to the SewerMAX™ pipe, ensure the contact surface is free of dust, grime or any foreign matter.

2. Select the rib nominated in Table 4.4 for the pipe diameter that will give approximately 75mm of cover (min 50mm) to the Hydrotite when encased in the concrete wall. See figure 4.5.

3. Lightly roughen the pipe surface where the Hydrotite is to be affixed with some fine sandpaper.

4. Remove the protective tape from the self-adhesive backing on the Hydrotite and fix the Hydrotite around the circumference of the pre prepared rib on the pipe. Start with the centre of the pipe and work around until you are approximately ¾ around the rib.

5. Apply a thin film of Loctite adhesive to each end of the Hydrotite and, stretching the two ends, butt them together then hold for approximately 30 seconds, until adhesive sets. Lower the Hydrotite to the rib surface.

6. With the heel of the hand press the Hydrotite firmly onto the surface of the pipe rib.

7. Place pipe end with the Hydrotite seal into the pit ready for concrete to be placed around the joint. Before concrete is poured it should be positioned in the pipe /concrete interface zone at a minimum distance of 75 mm inside the formwork to ensure all potential water paths are intercepted.

Note: *Standard work practices should be observed when using the adhesives or similarsubstances.*

Table 4.4 Rib selection for placement of hydrotite seal.

Pipe diameter (DN)	Rib no	Typical minimum wall thickness of concrete structures
225	3	150mm
300	3	150mm
375	2	150mm
450	2	150mm
525	2	150mm
600	2	200mm

Figure 4.5 Typical connection to structure: SewerMAX™ pipe & concrete maintenance hole

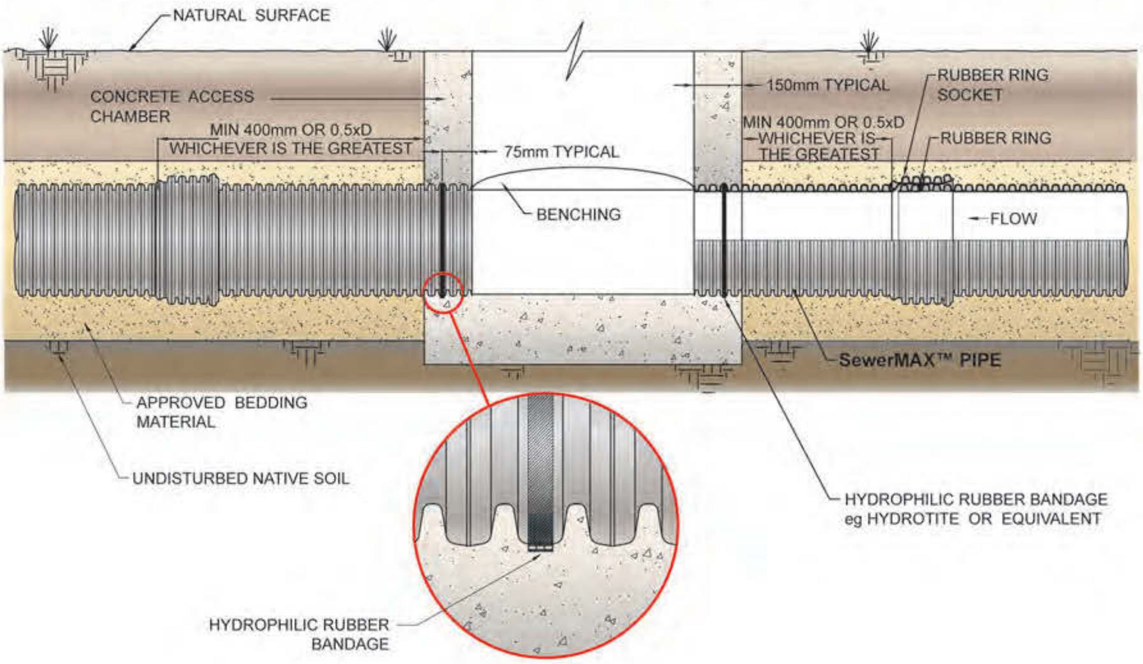
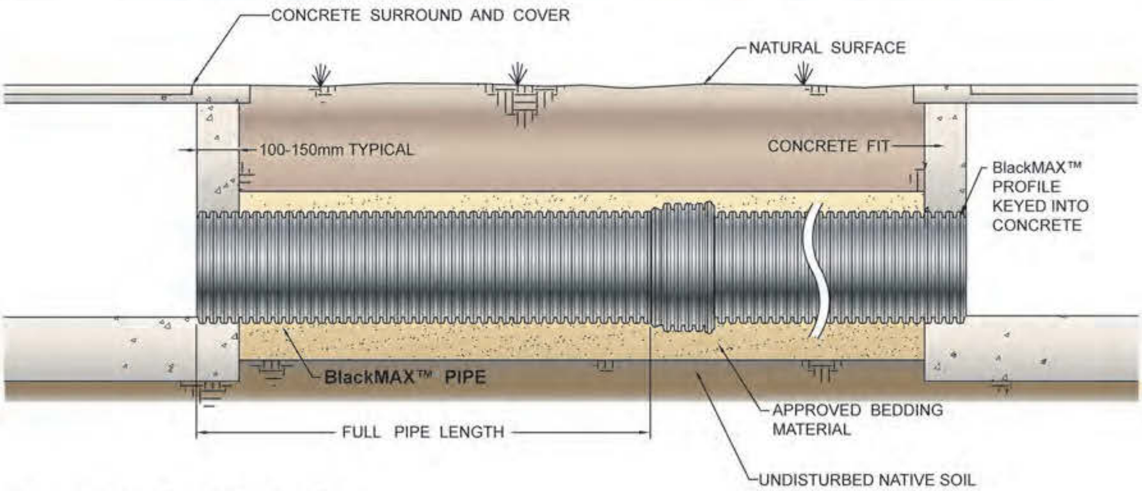
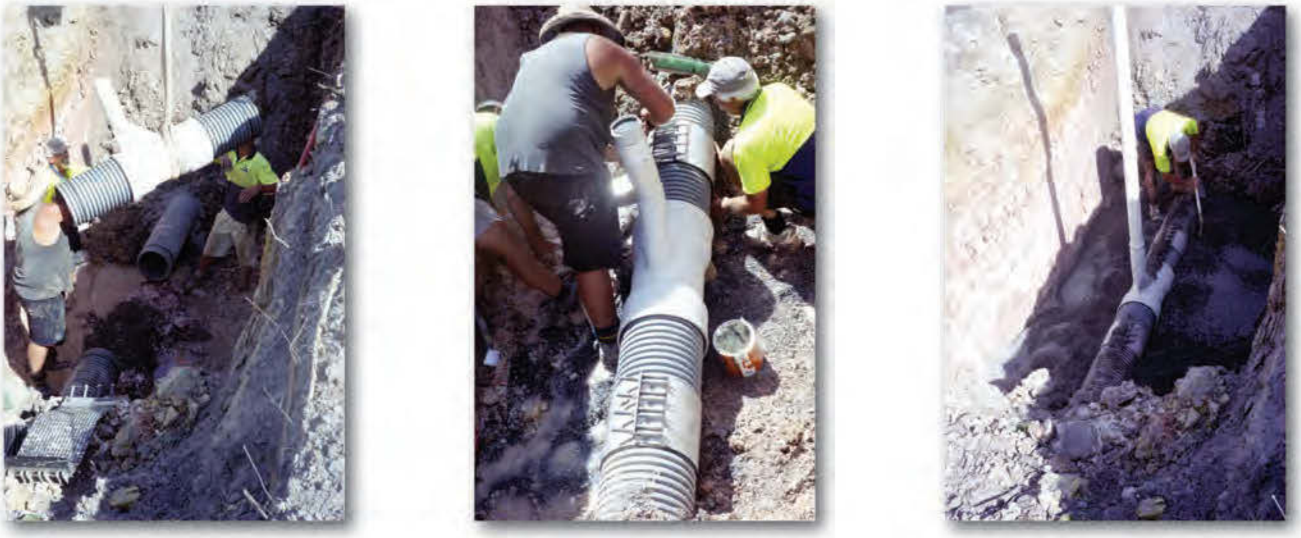


Figure 4.6 Typical connection to structure: BlackMAX™ pipe & concrete storm-water pit



Note: *All illustrations are not to scale.*

4.8.3 Connections for incoming sidelines



Cutting in a sewer junction using stainless steel mechanical joints

SewerMAX™ Junctions

A standard range of SewerMAX™ junctions is available for lateral side connections, providing a leak tight sewer system. Junctions can be manufactured from either PVC or GRP/composite materials with socket ends suitable for rubber ring jointing to SewerMAX™ pipes. The branch-off takes are normally at 45° to the main body with sockets suitable for connection with most materials. For e.g SewerMAX™, PVC or VC pipes. (Refer to section 2.5)

The method for connecting to existing sewer mains is given in Iplex Pipelines Drawing No IMWS-103. "*Minor Works Sewer, Post Installation of SewerMAX™ Junction for Incoming Connections*" and is similar to the methods shown in the "*Sewerage Code of Australia WSA 02-2002*".

Alternatively where a cut-in is not appropriate, a stainless steel Junction can be used eliminating the need for cutting in a new junction. Refer to Iplex Pipelines drawing No IMWS-101 "*Minor Works Sewer, Post Installation Stainless Steel Junction with SewerMAX pipe*".

4.8.4 Stormwater saddles

Note: *Illustration is not to scale.*

BlackMAX™ stormwater saddlles with DN100 or DN150 DWV PVC branch off-takes are available for incoming lateral side connections. These saddles have a solid elastomeric gasket profiled to suit the pipe corrugations. The procedure for installing the stormwater saddle is as follows: -

1. Place the saddle at the required position on the pipe. (*Note, the profile gasket will guide the saddle onto the pipe and ensure the saddle sits correctly.*)

2. Using the saddle as a template, inscribe a circle on the pipe with a marker corresponding with the sideline diameter.

3. Remove the saddle and position the pilot drill of the hole-saw at the centre of the circle and cut the hole.

4. If specified, apply a bead of butyl mastic on the underside of the saddle.

5. Place the saddle in position and secure with the fasteners supplied.

4.9 REPAIR METHODS

If a BlackMAX™ or SewerMAX™ pipe is damaged after installation one of the following repair methods may be used. The condition of the damaged pipe will determine which method should be adopted.

4.9.1 Minor repairs

If the damage is limited to a minor hole in the pipe wall, then it may be repaired by using a repair clamp (Refer to section 2.5.4). The repair clamp may be wrapped around the pipe at the point of damage with minimal disturbance to the pipeline. The gasket is preformed to match the external pipe wall profile and provides a watertight seal.The condition of the damaged area is critical when making the repair. The pipe surface profiles must be clean and free of dirt and mud. The procedure for installation is as follows:

1. Loosen all nuts on the clamp, but do not remove from the studs. Slide the locking plate towards the nuts and open the clamp.

2. Position the clamp centrally over the damaged area ensuring that no foreign matter will be trapped between the mating surfaces. Special attention should be paid to cleaning the *grooves* in the pipe profile.

3. Wrap the clamp around the pipe and bring both ends together by using the locking washer plate.

4. Lock into place and squeeze the lugs together while tightening the nuts by hand. Prior to tightening the nuts with a wrench ensure the damaged area is correctly centred under the clamp.

5. Tighten the nuts to the required torque as indicated by the installation instructions for the clamp.

6. Compact the specified embedment material in the embedment zone and backfill the remainder of the excavation to the required standard of compaction.

4.9.2 Major repairs

If the pipe is severely damaged then the damaged section will have to be removed and replaced with a new pipe section of the same length. The pipe ends can be rejoined using two jointing clamps (Refer to section 2.5.4). The jointing clamp is comprised of a stainless steel shell with a smooth rubber sleeve and utilises two SewerMAX™ sealing rings to make the connection. The installation procedure is as follows:

1. Locate and expose the whole length of the damaged pipe.

2. Remove the damaged section only by cutting with a hand saw or circular saw

3. Clean and trim intact pipe ends leaving these ends smooth and square.

4. Cut a length of replacement pipe to suit the distance between the prepared ends less the length of a single profile.

5. Fit the SewerMAX™ rubber rings on each pipe spigot end. These rings should be placed in the second groove away from each pipe end.

6. Fit the clamps symmetrically over each join and tighten the bolts to the torque as labelled.

5.0 FIELD ACCEPTANCE TESTING

Field-testing is used for identifying installation problems such as damaged pipes, poor embedment compaction and jointing deficiencies. Where a fully water tight system is required as in the case of sewers, a properly structured leakage testing program is usually required to obtain acceptance. However this is not usually needed in the case of underground stormwater drains. A diametral deflection check as the principle indicator can easily make an assessment of the structural integrity of a SewerMAX™ pipe/soil system.

5.1 LEAKAGE TESTING

A leakage check on a buried pipeline can be completed using any one of the following methods:

- Hydrostatic Pressure Test
- Vacuum Test
- Low Pressure Air Test
- Infiltration Test

The air and vacuum tests are usually more convenient as they do not require water. An infiltration observation or test measurement is a further option where a pipeline is installed well below the water table.

5.1.1 Hydrostatic (exfiltration) testing

The pipeline should be filled with water to a height of not less than 1 m above the natural ground level at the highest point of the test length but not exceeding 6 m at the lowest point of the test length. A minimum of 2 hours should elapse to allow temperatures to stabilise. Then during a minimum time span of 30 minutes any fall in water level in the test vessel must not exceed the hourly allowance amount shown in Table 5.1.

If this is not achieved the pipeline shall be carefully examined visually for leaks, and any defects repaired. The pipeline should then be retested.

Table 5.1 Hydrostatic pressure test leakage limits

DN	Make- up allowance* (Litres /m / hour)	DN	Make- up allowance* (Litres /m / hour)
225	0.11	450	0.21
300	0.14	525	0.25
375	0.18	600	0.28

** Based on an allowance of 0.5 litres per hour per mm diameter per km (Reference, AS/NZS2566.2)*

5.1.2 Low pressure air (exfiltration) testing

The test length of pipeline should be generally restricted to lengths between maintenance holes (the most convenient places for fixing temporary bulkheads).

The procedure for low-pressure air testing of larger diameter pipelines is potentially hazardous because of the large forces exerted during testing. Temporary bulkheads must resist these forces and the serious safety consequences should there be an accidental bulkhead blow-out.

The procedure is as follows:

1. Pump in air slowly until a pressure of 28KPa above any external ground water pressure is reached (*but do not in any case exceed 50KPa gauge*).
2. Maintain the pressure for at least 3 minutes.
3. If no leaks are detected during this phase, shut off the air supply.

The low pressure air test for a test length of pipeline is satisfactory if the test pressure does not drop more than 7KPa, within the time period shown in Table 5.2 from air supply shut-off. In any case should there be no discernible pressure loss after 1 hour has elapsed, the test can be considered satisfactory and terminated.

If the pipeline fails the test, re-pressurise to 28KPa and check for leaks. This may be assisted by the use of leak detecting equipment. Leaks in shallow installations with joints exposed may be detected by pouring a concentrated solution of soft soap and water over joints and fittings. Repair and then repeat the test.

5.1.3 Infiltration testing

Where a freestanding water table exists at a level of at least 1.5 m above the pipeline and 150 mm above any lateral connections, the absence of infiltration can remove the need for either of the previous pressure tests. In all cases where infiltration is observed the source should be investigated and the leak plugged. Where the size of the catchment and number of side connections precludes this approach then the inflow should be measured over a 24 -hour period and the principal informed for determination of the acceptable allowable inflow. Generally this should not exceed 5 litres/mm diameter/km length/day.

Table 5.2 Minimum allowable times for test (for 7 KPa pressure drop)

	Minimum allowable time* (minutes) for test length shown		
DN	**50m**	**100m**	**150m**
225	4	5	8
300	6	9	14
375	7	14	22
450	10	21	31
525	14	28	42
600	18	37	55

**These times may be halved where a pressure drop of 3.5 kPa is used.*

5.2 STRUCTURAL ASSESSMENT

5.2.1 Deflection testing

Deflection measurements are often used as an additional quality control device to indirectly assess the relative compactions achieved during installation and whether the required structural performance has been achieved. A visual line-of-site inspection will usually indicate any abnormal deflections. The reason for these should be investigated. An acceptance test requiring a pull-through *Go or No go* proving tool may be specified to ensure that the actual short-term vertical deflection does not exceed the allowable vertical deflection given in Table 5.3.

Where required, a prover of the allowable deflected internal diameter less a further tolerance of 2.5 millimetres, should be pulled through the pipeline by hand or means of a hand operated winch.

5.2.2 Prover design

Suitable types of provers are described in AS/NZS 2566.2. A lightweight vaned type with a minimum of eight vanes between 1.0 and 1.3 pipe diameters in length may be used. The acceptable prover diameter should be determined after giving consideration to the effect of different time periods after completion of construction. These are given in Table 5.3.

Where a prover cannot pass along the test length, the cause of the obstruction should be ascertained, e.g. by remote TV investigation, and appropriate remedial construction undertaken. This may require the exposure of the affected section of the pipeline and the re-compaction of the side support material probably without removing pipes. That is SewerMAX™ pipes are not usually damaged by excessive deflections and a visual inspection should be sufficient to determine if any pipe replacement is required.

Table 5.3 Maximum allowable prover diameters for nominated times after completion of the backfill

		24 hours	3 days	7 days	14 days	30 days	3 months	1 year
Adjustment Factor		0.7	0.75	0.85	0.95	1	1.1	1.2
Deflection (%)		3.5	3.8	4.3	4.8	5.0	5.5	6.0
DN	Pipe ID							
225	225	215	214	213	212	211	210	209
300	299	286	285	284	282	282	280	279
375	373	357	357	355	353	352	350	348
450	447	429	428	426	423	422	420	418
525	522	501	500	497	495	493	491	488
600	596	573	571	568	565	564	561	558

Pipelines

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