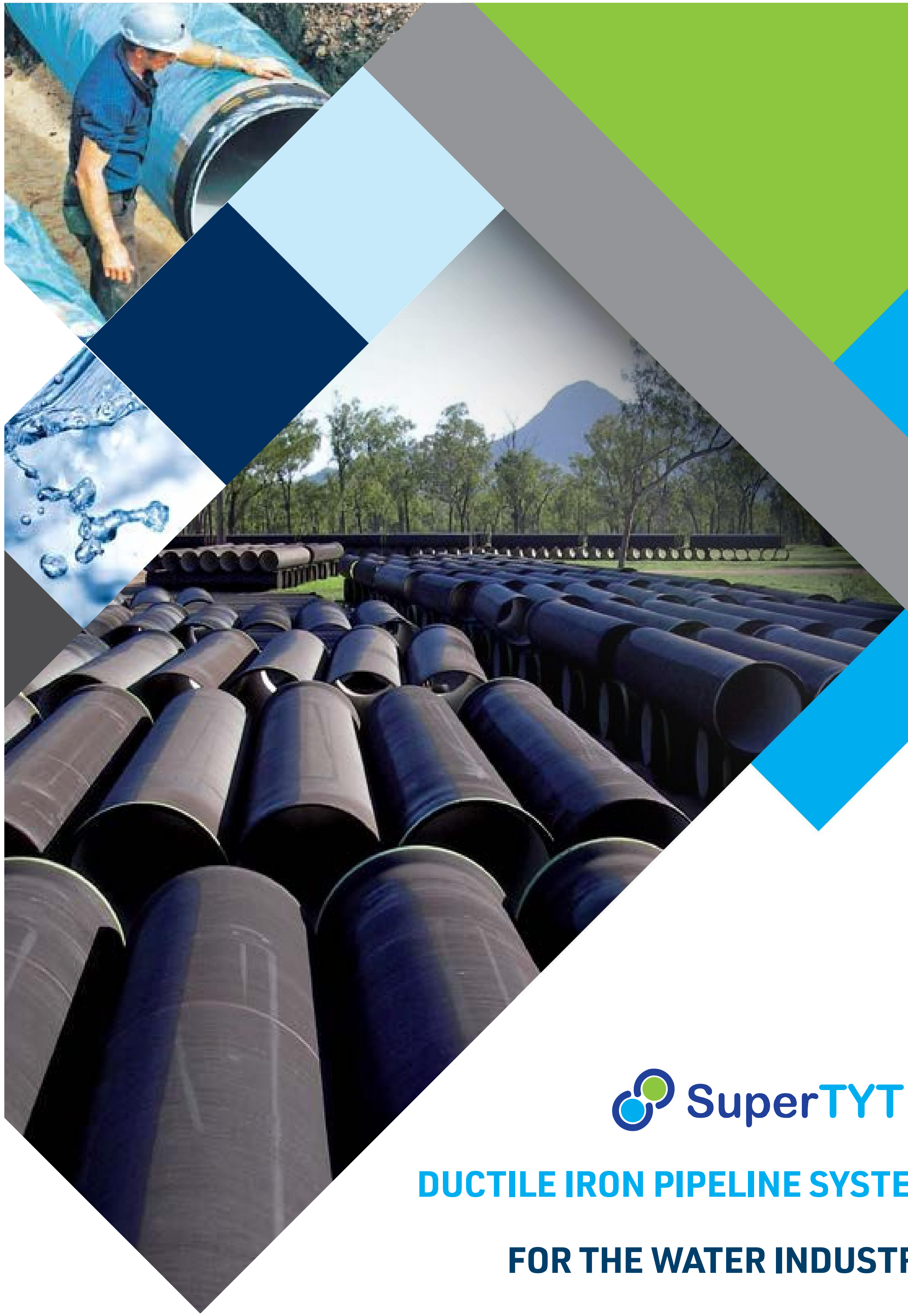


SuperTYT

DUCTILE IRON PIPELINE SYSTEM

FOR THE WATER INDUSTRY

FOREWORD

Our communities today depend heavily on the continuity of water and sewerage systems in both the domestic and industrial fields.

For any application, an engineer requires a pipeline which will meet operating conditions without undue risk of damage or failure. These conditions embrace the flow requirements, operating pressure, external loads due to earth pressure, transient loads due to vehicles as well as risks of damage during handling, transport and installation.

The inherent properties of ductile iron combined with easily applied corrosion protection systems ensure that ductile iron pipelines provide solutions to the widest range of conditions encountered in water supply systems, as well as many other industry applications.

SCOPE

Ductile iron pipelines are used for the transmission of water, wastewater, drainage, effluents, slurries and various other fluids.

This manual deals essentially with water industry applications. It has been compiled to assist pipeline designers, specifiers and operators.

It is not intended to be a comprehensive treatise on all aspects of ductile iron pipeline design but a compendium of information, data, useful guidelines and procedures.

SUPERTYT - FORMERLY TYCO WATER

Tyco Water now trades as SuperTYT one of Australia's leading suppliers of ductile iron pipeline systems.

Tyco Water provided premium pipeline products and services to the market.

Our focus on, and commitment to, the water industry is stronger than ever thus ensuring that the level of service our customers have grown to expect is not only maintained but exceeded under our new name SuperTYT.

MANUFACTURING AND SOURCING

SuperTYT sources DI pipes and fittings manufactured in accordance to its strict quality control procedures from approved suppliers.

All manufacturing facilities that manufacture the SuperTYT branded products are produced to the relevant International and British Standards under systems accredited to ISO 9001.

QUALITY ASSURANCE

As part of the Supplier Assessment Scheme, each manufacturing facility is also required to partake in independent Quality Management Systems and Product Certification assessments. Certification is accredited by reputable independent authorities.

Documented procedures are followed for all aspects of a plant's operation from receipt of order through design, purchasing, manufacture, inspection and delivery. Adherence to these procedures is determined by internal Quality Assurance audits conducted by trained auditors.

To consistently satisfy our customers' expectations, SuperTYT places great importance on the maintenance of product quality through the operation of Quality Systems in accordance with ISO 9001.

SuperTYT is committed to continuous improvement through its 'Operational Excellence' philosophy and deployment of Six Sigma, Lean and DFSS principles throughout the company. This involves employees at all levels and disciplines in the operations.

SuperTYT

DUCTILE IRON PIPELINE SYSTEM

CONTENTS

DUCTILE IRON PIPELINE SYSTEM
COMPONENT DATA

TECHNICAL SPECIFICATION DATA

STANDARDS

THE MAJOR REFERENCE STANDARDS FOR THE DESIGN OR SPECIFICATION OF DUCTILE IRON PIPELINES ARE LISTED BELOW.

BS EN 545
Ductile iron pipes, fittings, accessories and their joints for water pipelines.

BS EN 598
Ductile iron pipes, fittings, accessories and their joints for sewerage applications.

BS ISO 2531
Ductile iron pipes, fittings and accessories for pressure pipelines.

BS EN 197-1
Composition, specifications and conformity criteria for common cements.

BS ISO 8179
External zinc-based coating.

BS EN 681-1
Elastomeric seals (gaskets) used in water and drainage applications.

BS EN 1092-2
Flanges with PN designated.

BS EN 14901
Epoxy coating of ductile iron fittings.

BS 3416
Specification for bitumen-based coatings for cold application.

CLASS DESIGNATION

Class designation is related to wall thickness only and the system of notation follows that established in BS EN 545: Ductile Iron Pipes and Fittings for Pressure Pipelines.

The nominal pipe wall thickness for Class K pipes and fittings is determined as a function of the nominal diameter by the formula, with minimum of 6mm for pipes and 7mm for fittings.

$a = K (0.5 + 0.001 DN)$

where

a is the nominal wall thickness in millimetres

DN is the nominal pipe size

K is the coefficient selected from a series of whole numbers ... 7, 9,10,12,14, which corresponds to the class of pipe K9, etc.

Increases in pipe wall thickness are obtained by modification to the internal diameter, the external diameter remaining constant for each nominal size of pipe.

The minimum iron wall thickness of Class C Pipes is given as a function of the nominal size (DN) and the pressure class value (C) . Please see page 10.

MINIMUM WALL THICKNESS

MINIMUM WALL THICKNESSES ARE AS FOLLOWS.	
Type of Casting	Minimum Wall Thickness (MWT)
Pipes centrifugally cast in metal moulds (Class K Series)	If a ≤ 6mm then MWT equal to: a - 1.3 If a > 6 mm then MWT equal to: a - (1.3 +0.001 DN)
Pipes centrifugally cast in metal moulds (Class C Series)	Please see page 10
Pipes & fittings cast in sand moulds	If a ≤ 7mm then MWT equal to: a - 2.3 If a > 7 mm then MWT equal to: a - (2.3 +0.001 DN)

DN is the nominal size in millimetres.
'a' is the nominal wall thickness in millimetres.
No limit for the plus tolerance has been set.
Fitting thickness will be normally supplied either K12 (without branches) e.g. Bends or K14 (with branches) e.g. Tees.

In-line dimensional checking

TOLERANCE ON OUTSIDE DIAMETER

The tolerance on the outside diameter of Push-in Flexible pipes is as follows.

NOMINAL DIAMETER	O.D. TOLERANCE
DN	mm
80 - 150	+1.0, -2.7 to 2.9
200 - 350	+1.0, -3.0 to 3.4
400 - 500	+1.0, -3.5 to 3.8
600 - 800	+1.0, -4.0 to 4.5
900 -1000	+1.0, -4.8 to 5.0

This tolerance is limited to a distance of 4 metres from the spigot end of a standard 6m pipe.

PIPE LENGTHS

PUSH-IN FLEXIBLE PIPE

The standard manufacturing length of a spigot and socket pipe provides an effective length of 6m when laid.

The tolerance on the effective length of pipes is +/- 100mm.

FLANGED JOINT PIPE

Pipe flanged at both ends is available up to a maximum length of 5.8m. The tolerance on pipe with flanged ends ± 10 mm.

TOLERANCE ON STRAIGHTNESS OF SPUN PIPES

Pipes shall be straight with a maximum deviation of 0.125% of their length.

TOLERANCE ON MASS

The permitted tolerances on the standard masses for pipes centrifugally cast in metal moulds are as follows.

NOMINAL SIZE	TOLERANCE
Up to DN 200	
inclusive	±8%
Above DN 200	±5%

HARDNESS

When tested in accordance with the Standard, the Brinell hardness of the outside surface of the pipe is not to exceed 230 HBW and the Brinell hardness of the outside of fittings is not to exceed 250 HBW.

MECHANICAL PROPERTIES

The tensile test is in accordance with the requirements of the Standard.

TYPE OF CASTING	NOMINAL SIZE	MINIMUM TENSILE STRENGTH MPA	MINIMUM 0.2% PROOF STRESS MPA	MINIMUM BREAKING ELONGATION %
Pipes centrifugally cast in metal moulds	80 - 1000	420	300	10
Pipes and fittings cast in sand moulds	80 - 1000	420	300	5

The proof stress is only measured when specially agreed between the purchaser and manufacturer and is carried out under the conditions specified by the purchaser at the time of enquiry and order.

WORKS PROOF AND LEAK TIGHTNESS TEST PRESSURES

The hydrostatic test for pipes and fittings is carried out prior to lining and coating. The test pressure is maintained for 15 seconds to test for leak, sweat or other defects.

NOMINAL SIZE	WORKS HYDROSTATIC TEST PRESSURE FOR CENTRIFUGALLY CAST PIPE (CLASS K9 OR ABOVE)	WORKS HYDROSTATIC TEST PRESSURE FOR FITTINGS	WORKS HYDROSTATIC TEST PRESSURE FOR FLANGED PIPE
DN	MPa	MPa	MPa
80 - 300	5.0	2.5	2.5
350 - 600	4.0	1.6	1.6
700 - 1000	3.2	1.0	1.0

The hydrostatic test pressures specified in this table are intended primarily to detect casting flaws and bear no relation to the safe working pressures for the pipes or fittings. The application of higher test pressures to fittings is precluded owing to the risk of distortion resulting from the high restraining load which would have to be imposed on the fittings by the standard test apparatus.

LINING

When cement lining is specified by the purchaser, the mortar consists of well graded aggregate and cement in a ratio not exceeding 2:1, aggregate to cement. Water to cement ratio is the least that will produce a workable mortar mix depending on the mix proportions and the diameter of pipe to be lined.

The thickness of the sulphate resisting cement lining for all classes of pipe and fittings is as follows.

NOMINAL SIZE OF PIPE OR FITTING	NOMINAL THICKNESS	TOLERANCE NEGATIVE ONLY GIVEN	MAXIMUM CRACK WIDTH
DN	mm	mm	mm
80 - 300	4.0	-1.5	0.4
350 - 600	5.0	-2.0	0.5
700 - 1000	6.0	-2.5	0.6

Unlined pipes are not internally coated unless specified by the purchaser.

COATING

Unless otherwise specified by the purchaser, all pipes are coated externally with metallic zinc covered by a finishing paint layer.

INSPECTION

Pipes and fittings are subject to a quality assurance system regularly audited by **British Standards Institution.**

If the purchaser wishes to inspect the pipes, such an inspection is undertaken at the works of the manufacturer. The equipment and labour necessary to carry out the inspection is provided by the manufacturer.

The inspector may witness the sampling, preparation and testing of the test pieces, checking of dimensions and weights and hydrostatic testing.

Should the purchaser or his representative not be present for the implementation of these operations at the time agreed, the manufacturer is entitled to proceed with the inspection without the purchaser or his representative being present.

MARKING

Each pipeline component has the following marks legibly cast, stamped or painted on.

PIPES

1 SuperTYT logo.
2 Nominal size.
3 Class designation.
4 Year of manufacture.
5 Day cast.
6 Batch number.
7 Standards reference.

FITTINGS

1 SuperTYT or S-TYT logo.
2 Nominal size.
3 Date of manufacture.
4 'Ductile' or 'DI'.
5 For bends, relevant angle.
6 Standards reference.

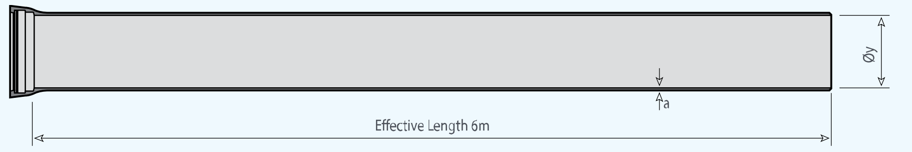
PIPE DATA

CLASS K9 PUSH-IN FLEXIBLE JOINT DUCTILE IRON PIPE

NORMAL APPLICATION

Flexible pressure pipelines carrying water, sewage and other liquids.

For thickness of cement lining see page 8.



NOMINAL SIZE	MEAN EXTERNAL DIAMETER Øy	CEMENT LINED MEAN INTERNAL DIAMETER	NOMINAL WALL THICKNESS a	ALLOWABLE OPERATING PRESSURE*	ALLOWABLE MAXIMUM OPERATING PRESSURE**	ALLOWABLE SITE TEST PRESSURE†
DN	mm	mm	mm	MPa	MPa	MPa
80	98	78.0	6.0	6.4	7.7	9.6
100	118	98.0	6.0	6.4	7.7	9.6
150	170	150.0	6.0	6.4	7.7	9.6
200	222	201.4	6.3	6.2	7.4	7.9
250	274	252.4	6.8	5.4	6.5	7.0
300	326	303.6	7.2	4.9	5.9	6.4
350	378	352.6	7.7	4.5	5.4	5.9
400	429	402.8	8.1	4.2	5.1	5.6
450	480	452.8	8.6	4.0	4.8	5.3
500	532	504.0	9.0	3.8	4.6	5.1
600	635	605.2	9.9	3.6	4.3	4.8
700	738	704.4	10.8	3.4	4.1	4.6
800	842	806.6	11.7	3.2	3.8	4.3
900	945	907.8	12.6	3.1	3.7	4.2
1000	1048	1009.0	13.5	3.0	3.6	4.1
>1000 Refer to your SuperTYT representative						

* Allowable Operating Pressure – Internal pressure, excluding surge, which the pipeline can safely withstand in permanent service.

** Allowable Maximum Operating Pressure – Maximum internal pressure including surge, which the pipeline can safely withstand in service.

† Allowable Site Test Pressure – Maximum hydrostatic pressure applied on site to a newly installed pipeline, for a relatively short duration.

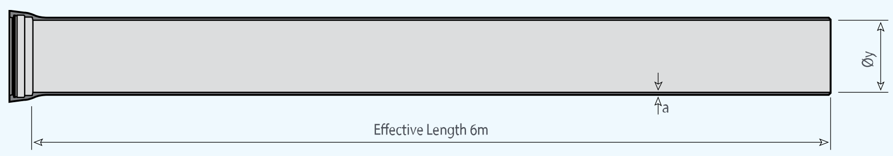
PIPE DATA

CLASS K12 PUSH-IN FLEXIBLE JOINT DUCTILE IRON PIPE

NORMAL APPLICATION

Flanged pressure pipe with screw-on flanges, specialised high pressure pipework and slurry lines.

For wall thickness formula see page 6.



NOMINAL SIZE	MEAN EXTERNAL DIAMETER Øy	CEMENT LINED MEAN INTERNAL DIAMETER	NOMINAL WALL THICKNESS a	ALLOWABLE OPERATING PRESSURE*	ALLOWABLE MAXIMUM OPERATING PRESSURE**	ALLOWABLE SITE TEST PRESSURE†
DN	mm	mm	mm	MPa	MPa	MPa
80	98	76.0	7.0	6.4	7.7	9.6
100	118	95.6	7.2	6.4	7.7	9.6
150	170	146.4	7.8	6.4	7.7	9.6
200	222	197.2	8.4	6.4	7.7	9.6
250	274	248.0	9.0	6.4	7.7	9.6
300	326	298.8	9.6	6.4	7.7	9.6
350	378	347.6	10.2	6.4	7.7	9.6
400	429	397.4	10.8	6.1	7.3	7.8
450	480	447.2	11.4	5.7	6.8	7.3
500	532	498.0	12.0	5.5	6.6	7.1
600	635	598.6	13.2	5.1	6.1	6.6
700	738	697.2	14.4	4.8	5.8	6.3
800	842	798.8	15.6	4.6	5.5	6.0
900	945	899.4	16.8	4.4	5.3	5.8
1000	1048	1000.0	18.0	4.3	5.2	5.7
>1000	Refer to your SuperTYT representative					

* Allowable Operating Pressure – Internal pressure, excluding surge,which the pipeline can safely withstand in permanent service.

** Allowable Maximum Operating Pressure – Maximum internal pressure including surge, which the pipeline can safely

†Allowable Site Test Pressure – Maximum hydrostatic pressure applied on site to a newly installed pipeline, for a relatively short duration.

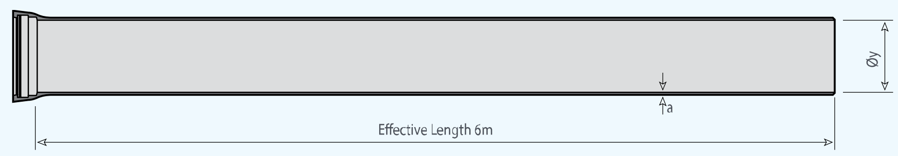
PIPE DATA

CLASS C SERIES PUSH-IN FLEXIBLE JOINT DUCTILE IRON PIPE

NORMAL APPLICATION

Flexible pressure pipelines carrying water, sewage and other liquids.

For thickness of cement lining see page 8.



MINIMUM WALL THICKNESS mm						
DN	Class 25	Class 30	Class 40	Class 50	Class 64	Class 100
80			3.0	3.5	4.0	4.7
100			3.0	3.5	4.0	4.7
150			3.0	3.5	4.0	5.9
200			3.1	3.9	5.0	7.7
250			3.9	4.8	6.1	9.5
300			4.6	5.7	7.3	11.2
350		4.7	5.3	6.6	8.5	13.0
400		4.8	6.0	7.5	9.6	14.8
450		5.1	6.8	8.4	10.7	16.6
500		5.6	7.5	9.3	11.9	18.3
600		6.7	8.9	11.1	14.2	21.9
700	6.8	7.8	10.4	13.0	16.5	
800	7.5	8.9	11.9	14.8	18.8	
900	8.4	10.0	13.3	16.6		
1000	9.3	11.1	14.8	18.4		
>1000	Refer to your SuperTYT representative					

* Allowable Operating Pressure – Internal pressure, excluding surge,which the pipeline can safely withstand in permanent service.

** Allowable Maximum Operating Pressure – Maximum internal pressure including surge, which the pipeline can safely

†Allowable Site Test Pressure – Maximum hydrostatic pressure applied on site to a newly installed pipeline, for a relatively short duration.

PIPE DATA

K12 FLANGED DUCTILE IRON PIPE

NORMAL APPLICATION

Flanged pressure pipelines carrying water, sewage and other liquids.

For thickness of cement lining see page 8.

FLANGED JOINT PIPE

MINIMUM AND MAXIMUM PIPE LENGTH OF INTEGRALLY CAST-ON FLANGES		
NOMINAL SIZE	MIN	MAX
DN	mm	mm
80	200	1000
100	200	1000
150	200	1200
200	200	1200
250	200	1200
300	200	1500
350	200	1500
400	200	1800
450	200	1800
500	250	2000
600	250	2000
700	300	2000
800	300	2000
900	200	2000
1000	200	2000

Refer to your SuperTYT representative for other flanged pipes lengths.
All lengths are approximates

Flanged pipes are now in world-wide general use. Flanged jointed pipe should not be used to support itself as a structure in pumping station pipework or similar. Sufficient support brackets should be used to prevent flanges taking moments due to self-weight.

FLANGES

Pipe flanges manufactured from ductile iron may be PN16 or PN25.

FLANGE THREAD SEALANT

An epoxy resin is used as the flange thread sealant. Unaffected by water, sewage and aqueous industrial waste, it cures to a hard clear corrosion resistant and corrosion protective solid. The resin is resistant to water absorption and will not impart colour, odour, taste or toxic constituents to potable water.

PIPE BARRELS

Ductile iron pipe barrels are normally supplied as Class K12. Pipe barrels of other Classes are available. The approximate Maximum length of pipe with factory Weld-on flanges and Screw-on flanges are 5.7m and 5.8m respectively.

MINIMUM PIPE LENGTH OF DOUBLE FLANGED PIPE WITH WELD-ON AND SCREW-ON FLANGES		
NOMINAL SIZE	WELD-ON FLANGE	SCREW-ON FLANGE
DN	mm	mm
80	300	150
100	300	150
150	400	150
200	400	200
250	500	200
300	500	200
350	600	200
400	600	200
450	600	200
500	600	250
600	850	250
700	850	300
800	850	300
900	850	300
1000	850	300

Refer to your SuperTYT representative for other flanged pipe lengths.
All lengths are approximates

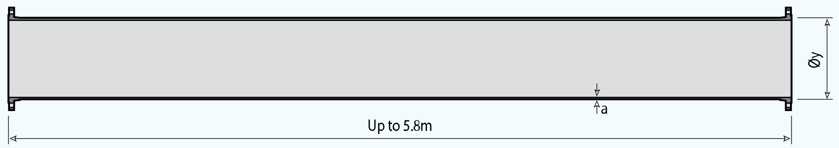
PIPE DATA

K12 FLANGED DUCTILE IRON PIPE SPECIFICATION

NORMAL APPLICATION

Flanged pressure pipelines carrying water, sewage and other liquids.

For thickness of cement lining see page 8.



NOMINAL SIZE	MEAN EXTERNAL DIAMETER Øy	CEMENT LINED MEAN ID	NOMINAL WALL THICKNESS FOR CLASS K12 PIPE BARREL a	ALLOWABLE OPERATING PRESSURE*		ALLOWABLE MAXIMUM OPERATING PRESSURE**		ALLOWABLE SITE TEST PRESSURE†	
				PN16	PN25	PN16	PN25	PN16	PN25
DN	mm	mm	mm	MPa	MPa	MPa	MPa	MPa	MPa
80	98	76.0	7.0	1.6	2.5	2.0	3.0	2.5	3.5
100	118	95.6	7.2	1.6	2.5	2.0	3.0	2.5	3.5
150	170	146.4	7.8	1.6	2.5	2.0	3.0	2.5	3.5
200	222	197.2	8.4	1.6	2.5	2.0	3.0	2.5	3.5
250	274	248.0	9.0	1.6	2.5	2.0	3.0	2.5	3.5
300	326	298.8	9.6	1.6	2.5	2.0	3.0	2.5	3.5
350	378	347.6	10.2	1.6	2.5	2.0	3.0	2.5	3.5
400	429	397.4	10.8	1.6	2.5	2.0	3.0	2.5	3.5
450	480	447.2	11.4	1.6	2.5	2.0	3.0	2.5	3.5
500	532	498.0	12.0	1.6	2.5	2.0	3.0	2.5	3.5
600	635	598.6	13.2	1.6	2.5	2.0	3.0	2.5	3.5
700	738	697.2	14.4	1.6	2.5	2.0	3.0	2.5	3.5
800	842	798.8	15.6	1.6	2.5	2.0	3.0	2.5	3.5
900	945	899.4	16.8	1.6	2.5	2.0	3.0	2.5	3.5
1000	1048	1000.0	18.0	1.6	2.5	2.0	3.0	2.5	3.5

* Allowable Operating Pressure
– Internal pressure, excluding surge, which the pipeline can safely withstand in permanent service.

** Allowable Maximum Operating Pressure
– Maximum internal pressure including surge, which the pipeline can safely withstand in service.

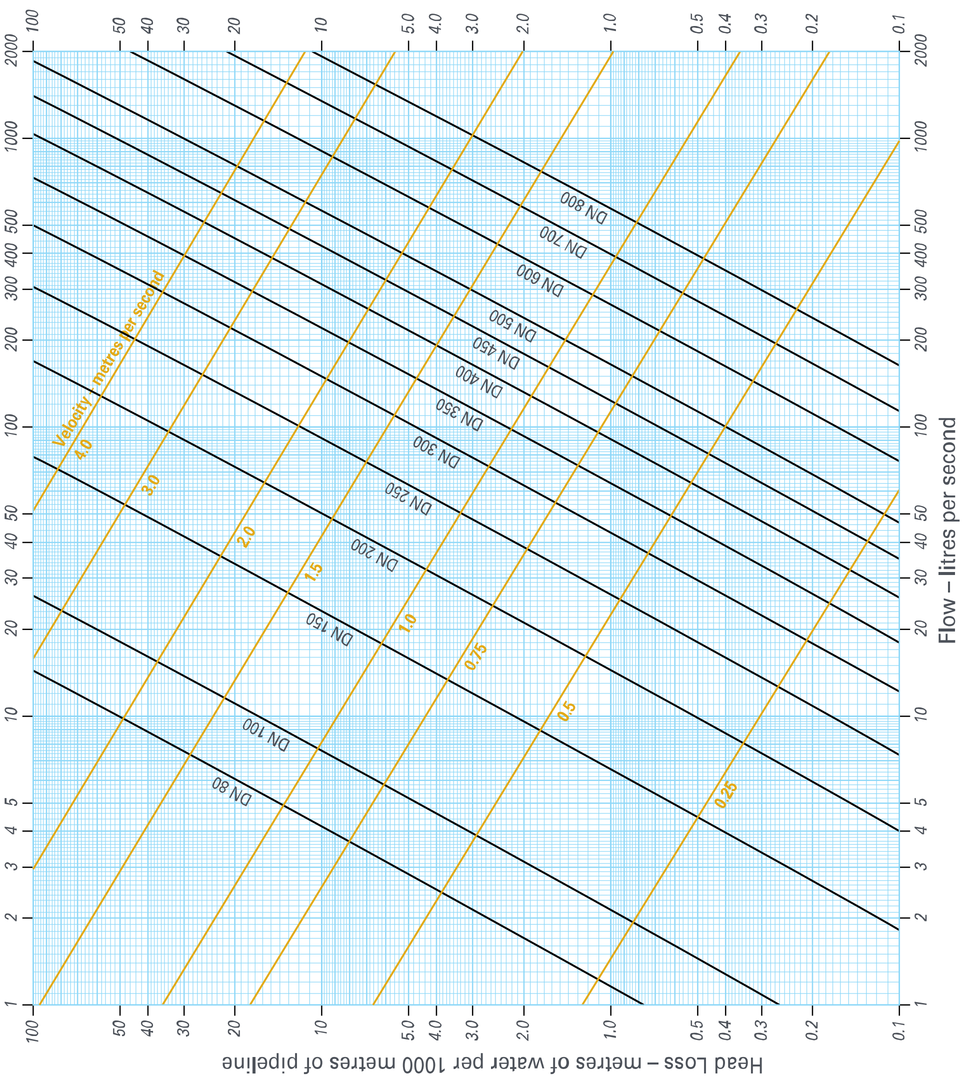
† Allowable Site Test Pressure
– Maximum hydrostatic pressure applied on site to a newly installed pipeline, for a relatively short duration.

PIPE FLOW FRICTION CHARTS

CLASS K9 DUCTILE IRON PIPELINES CEMENT LINED

Colebrook-White coefficient
(k) = 0.03mm.

Values based on mean internal diameters.



JOINT DATA

PUSH-IN FLEXIBLE JOINTS

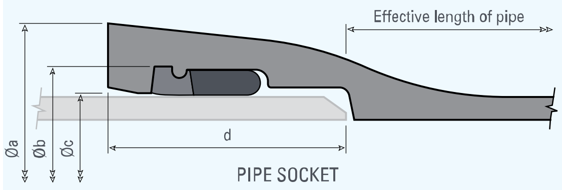
The Push-in Flexible joints are an extremely strong and efficient flexible joint for water, sewerage, slurry and effluent pressure pipelines. It has a single jointing component which is a specially shaped rubber gasket, comprising a 'heel' of hardened rubber which locates in a groove in the pipe socket and a 'bulb' of softer rubber, firmly bonded to the 'heel', which effects the required seal. The joint is suitable for 'in ground' and 'above ground' pipelines.

The joint can be deflected and permits axial movement to compensate for thermal expansion and contraction. The leak-tightness of the Push-in Flexible joint has been proven by exhaustive laboratory tests and confirmed by experience in the field.

Tests have been carried out on all sizes of joints used with Push-in Flexible pipe to pressures well in excess of twice recommended maximum working pressure for the pipeline. These tests were conducted on joints while deflected and offset. Vacuum tests have also been conducted at minus 700 mm of mercury (-0.93 bar / -9.5 metres head of water).

Anchorage must be provided at blank ends, tees and other changes of direction to prevent the withdrawal of the spigot end under the effect of internal pressure. Details of support and anchorage for flexible jointed pipelines are given on pages 34 to 39.

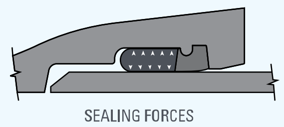
MINIMUM ALLOWABLE PUSH-IN FLEXIBLE JOINT DEFLECTIONS	
Nominal Size	Allowable Joint Deflection
DN	
80 - 300	3°30'
350 - 600	2°30'
700 - 1000	1°30'



PUSH-IN FLEXIBLE JOINT DIMENSIONS mm				
Nominal Size	Dimensions			
DN	a	b	c	d
80	140	123.0	100.5	85
100	163	143.0	120.5	88
150	217	195.0	172.5	94
200	278	250.0	224.5	100
250	336	301.5	276.5	105
300	393	356.5	328.5	110
350	448	408.0	380.5	110
400	500	462.0	431.5	110
450	540	514.0	482.5	120
500	604	568.0	534.5	120
600	713	673.4	637.5	120
700	824	788.0	740.5	150
800	943	894.0	844.5	160
900	1052	1000	947.5	175
1000	1158	1105	1050.5	185

PUSH-IN FLEXIBLE GASKETS

Push-in Flexible gaskets are manufactured to 'SuperTYT Water Solutions's Specification for Push-in Flexible Gaskets' and take into account ISO and British standards. Gaskets are approved to the requirements of SuperTYT Water Solutions' specification.



Only Push-in Flexible gaskets should be used with ductile iron pipelines. The Push-in Flexible gasket is normally manufactured from EPDM synthetic elastomer compound complying with BS EN 681-1.

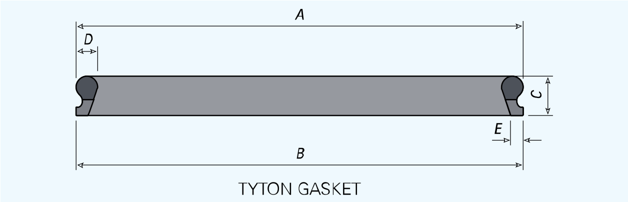
'Bulb' elastomers are primarily designed for environmental resistance and long term sealing performance. Long term sealing performance is related to 'stress relaxation', a measure over time of the maintenance of elastic properties of the elastomer.

'Heel' elastomers are designed for environmental resistance and the anchoring function.

SuperTYT Water Solutions's Push-in Flexible EPDM gaskets are suitable for contact with drinking water in accordance with 'BS 6920 – Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of water.

PUSH-IN FLEXIBLE GASKET DIMENSIONS					
Nom. Size	Dimensions				
DN	A	B	C	D	E
80	123	126	26	16	10
100	144	146	26	16	10
150	198	200	26	16	10
200	254	256	30	18	11
250	308	310	32	18	11
300	364	366	34	20	12
350	418	420	34	20	12
400	473	475	38	22	13
450	526	528	38	23	13
500	581	583	42	24	14
600	690	692	46	26	15
700	803	809	55	33.5	20
800	913	919	60	35.5	21
900	1020	1026	65	37.5	22
1000	1127	1133	70	39.5	23

The extremely strong and efficient Push-in Flexible push-in joint



PUSH-IN FLEXIBLE GASKETS APPLICATION			
Application	Max. Service Temperature °C	Bulb Elastomer	Elastomer Designation
Potable Water	80	Ethylene Propylene Rubber	EPDM
Sewage[1]	80	Ethylene Propylene Rubber	EPDM
Oils/Solvents[2]	25	Nitrile Rubber	NBR
Hot effluents – Water	80	Ethylene Propylene Rubber (peroxide)	EPDM
Hot effluents – Aromatic[2]		Fluoroelastomer,	HK

Notes:
1 Compounds do not include root inhibitor.
2 Specialist advice required.

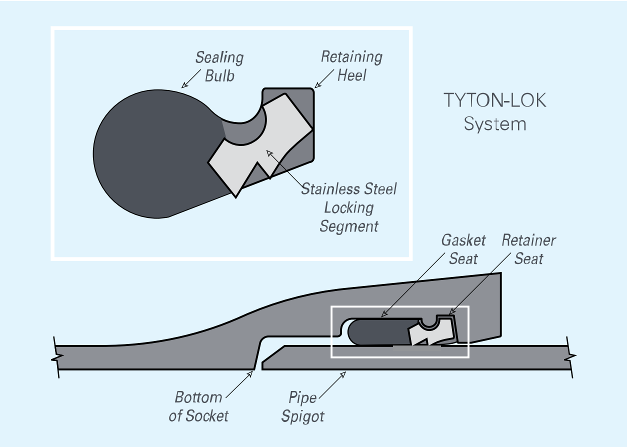
RESTRAINED JOINT SYSTEMS

A restrained joint system offers many advantages for the pipeline designer, amongst which are:

- ability to dispense with traditional concrete thrust blocks. This is especially important:
- in congested service corridors where space is at a premium
- and future interference by other utilities can be contemplated.
- when commissioning of a pipeline is urgent, as there is no need for delay until a concrete thrust block 'cures'.
- in areas where the logistics of providing concrete are difficult.
- capability of providing thrust restraint in poor soil conditions.
- provision of an alternativeto flanged joints in buried situations.
- additional security for strategic mains.

PUSH-IN FLEXIBLE RESTRAINED JOINT SYSTEM

The Push-in Flexible gasket is based on the proven Push-in Flexible rubber ring joint system with one additional feature. By utilising stainless steel locking segments within the gasket itself, the Push-in Flexible gasket transforms the normal Push-in Flexible spigot and socket joint into a restrained joint.



WORKING PRESSURES

The Push-in Flexible system is available in sizes DN 80 – DN 400 and is rated up to a recommended working pressure of 1.6 MPa.

Refer to SuperTYT Water Solutions for more details

FLANGED JOINTS

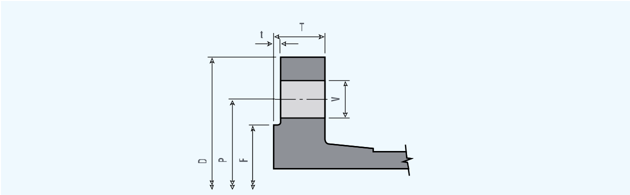
Flanged joints are completely rigid and should not be used for applications where movement of the pipeline is expected, unless special provision is made to accommodate it by, for example, the inclusion of expansion joints.

A pipeline totally constructed from flanged pipework is considered to be self-anchoring and therefore external anchorages are not required at changes of direction and at blank ends.

The joint is used mainly for 'above ground' applications, e.g. pumping stations, water and sewage treatment plants and for industrial pipework. It is also used to facilitate the installation and removal of valves in spigot and socket pipelines and for valve by-pass arrangements.

Particular attention should be paid to pipelines where flanged joint pipe and fittings are to be combined with Push-in Flexible pipe and fittings. In this case, thrust blocks should not be omitted from flanged bends, tees and blank ends before ensuring that there is a sufficient anchoring length of flanged pipe in the ground to prevent the flanged joint and push-in joint sections separating at the change-over points due to the effects of internal pressure.

Flanges are attached to pipes by screwing the pipe and flange with mating threads. These are filled with a recommended epoxy resin before tightening to a predetermined torque. Machining of the flanges is carried out after tightening to ensure ends are parallel and flat. Screwed and integrally cast flanges are available on request. Flanges on fittings are integrally cast in sand moulds with the body of the fitting.



PN16 FLANGES

Nominal Size	Flange Dimensions					Bolting Details		
	Diameter	Thickness	Diameter of Raised Face	Height of Raised Face	Pitch Circle Diameter	Number of Holes	Diameter of Holes	Fastener Size and Thread
DN	D	T	F	t	P	N	V	
80	200	19.0	132	3	160	8	19	M16
100	220	19.0	156	3	180	8	19	M16
150	285	19.0	211	3	240	8	23	M20
200	340	20.0	266	3	295	12	23	M20
250	400	22.0	319	3	355	12	28	M24
300	455	24.5	370	4	410	12	28	M24
350	520	26.5	429	4	470	16	28	M24
400	580	28.0	480	4	525	16	31	M27
450	640	30.0	548	4	585	20	31	M27
500	715	31.5	609	4	650	20	34	M30
600	840	36.0	720	5	770	20	37	M33
700	910	39.5	794	5	840	24	37	M33
800	1025	43.0	901	5	950	24	40	M36
900	1125	46.5	1001	5	1050	28	40	M36
1000	1255	50	1112	5	1170	28	43	M39

PN25 FLANGES

Nominal Size	Flange Dimensions					Bolting Details		
	Diameter	Thickness	Diameter of Raised Face	Height of Raised Face	Pitch Circle Diameter	Number of Holes	Diameter of Holes	Fastener Size and Thread
DN	D	T	F	t	P	N	V	
80	200	19.0	132	3	160	8	19	M16
100	235	19.0	156	3	190	8	23	M20
150	300	20.0	211	3	250	8	28	M24
200	360	22.0	274	3	310	12	28	M24
250	425	24.5	330	3	370	12	31	M27
300	485	27.5	389	4	430	16	31	M27
350	555	30.0	448	4	490	16	34	M30
400	620	32.0	503	4	550	16	37	M33
450	670	34.5	548	4	600	20	37	M33
500	730	36.5	609	4	660	20	37	M33
600	845	42.0	720	5	770	20	40	M36
700	960	46.5	820	5	875	24	43	M39
800	1085	51.0	928	5	990	24	49	M45
900	1185	55.5	1028.5	5	1090	28	49	M45
1000	1320	60	1140	5	1210	28	56	M52

SuperTYT

PUSH-IN FLEXIBLE JOINT PIPELINE FITTINGS

Push-in Flexible pipeline fitting dimensions shown are in accordance with the Standard.

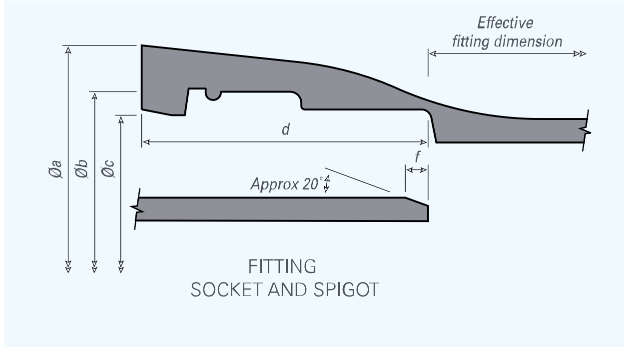
Double socketed fittings are normally used in Push-in Flexible pipelines.

Spigotted fittings may be used in some applications, although their use is mainly limited to installation after construction, where existing pipes are cut and connected to the fitting using couplings.

TEST AND OPERATING PRESSURES

Works hydrostatic leak tightness test pressures for fittings are shown on page 8.

Allowable operating pressures for socketed ductile iron fittings are the same as for Class K9 ductile spun iron pipe in the corresponding nominal sizes.



PUSH-IN FLEXIBLE JOINT FITTINGS DIMENSIONS mm

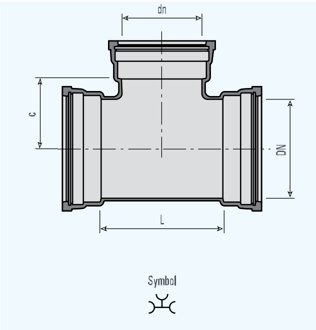
Nominal Size	Dimensions				
DN	a	b	c	d	f
80	140	123.0	100.5	85	6
100	163	143.0	120.5	88	9
150	217	195.0	172.5	94	9
200	278	250.0	224.5	100	9
250	336	301.5	276.5	105	9
300	393	356.5	328.5	110	9
350	448	408.0	380.5	110	9
400	500	462.0	431.5	110	9
450	540	514.0	482.5	120	9
500	604	568.0	534.5	120	9
600	713	673.4	637.5	120	9
700	824	788.0	740.5	150	9
800	943	894.0	844.5	160	9
900	1052	1000	947.5	175	15
1000	1158	1105	1050.5	185	15

REMARKS

1. **In general, fittings will be supplied with Series A as standard dimension. If fittings are not listed in Series A, Series B will be supplied as standard fitting dimensions and are marked with a English character "B" beside the fitting items for identification.**
2. **If the fittings are out of British Standard range, unless there is an agreement between the purchaser and seller, manufacturer's design length will be supplied as standard dimension and are marked with a English character "M" beside the fitting items for identification.**
3. **By agreement between the purchaser and seller, special size fittings may be supplied**

FITTINGS - DUCTILE IRON - FLEXIBLE JOINT

PUSH-IN FLEXIBLE TEES SOCKET - SOCKET x SOCKET



NOMINAL SIZE	DIMENSION	
dn	L	c
DN 80		
80	170	85
DN 100		
80	170	95
100	190	95
DN 150		
80	170	120
100	195	120
150	255	125
DN 200		
80	175	145
100	200	145
150	255	150
200	315	155
DN 250		
80	180	170
100	200	170
150	260	175
200	315	180
250	375	190
DN 300		
M80	180	195
100	205	195
150	260	200
200	320	205
250	375	210
300	435	220
DN 350		
M80	185	220
M100	210	225
M150	265	230
M200	320	235
M250	380	240
M300	440	245
M350	495	250

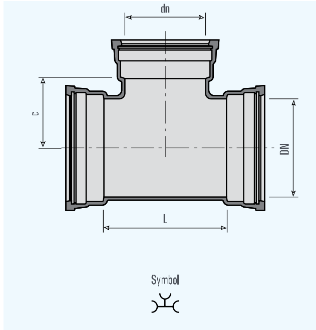
NOMINAL SIZE	DIMENSION	
dn	L	c
DN 400		
M80	190	245
M100	210	245
M150	270	250
M200	325	255
M250	385	260
M300	440	270
M350	500	275
M400	560	280

NOMINAL SIZE	DIMENSION	
dn	L	c
DN 450		
M80	190	270
M100	215	270
M150	270	275
M200	330	285
M250	390	290
M300	445	295
M350	505	300
M400	560	305
M450	620	310
DN 500		
M80	205	295
M100	215	295
M150	275	300
M200	330	310
M250	390	315
M300	450	320
M350	505	325
M400	565	330
M450	620	335
M500	680	340
DN 600		
M80	200	345
M100	220	345
M150	280	350
M200	340	360
M250	395	365
M300	455	370
M350	510	375
M400	570	380
M450	630	385
M500	685	390
M600	800	400

For sizes above DN 1000 refer to your SuperTYT representative.

PUSH-IN FLEXIBLE TEES SOCKET - SOCKET x SOCKET

NOMINAL SIZE	DIMENSION	
dn	L	c
DN 700		
M80	225	400
M100	230	400
M150	285	400
M200	345	405
M250	400	415
M300	460	420
M350	520	425
M400	575	430
M450	635	435
M500	690	440
M600	810	450
M700	925	460
DN 800		
M80	250	450
M100	270	460
M150	330	460
M200	380	460
M250	410	465
M300	465	470
M350	525	475
M400	580	480
M450	640	485
M500	700	490
M600	815	500
M700	930	510
M800	1045	525

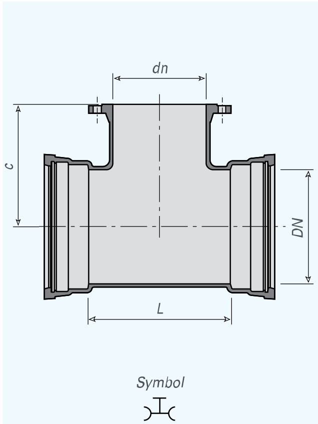


NOMINAL SIZE	DIMENSION	
dn	L	c
DN 900		
M80	255	505
M100	270	505
M150	320	505
M200	355	505
M250	415	515
M300	470	520
M350	530	525
M400	590	530
M450	645	535
M500	705	540
M600	820	550
M700	935	560
M800	1050	575
M900	1170	585
DN 1000		
M80	260	555
M100	280	555
M150	335	555
M200	360	555
M250	420	565
M300	480	570
M350	535	575
M400	595	580
M450	650	585
M500	710	590
M600	825	600
M700	940	610
M800	1060	625
M900	1175	635
M1000	1290	645

For sizes above DN 1000 refer to your SuperTYT representative.

PUSH-IN FLEXIBLE TEES SOCKET - SOCKET X FLANGE

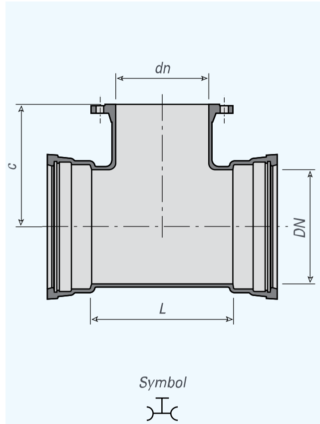
NOMINAL SIZE	DIMENSION	
dn	L	c
DN 80		
80	170	165
DN 100		
80	170	175
100	190	180
DN 150		
80	170	205
100	195	210
150	255	220
DN 200		
80	175	235
100	200	240
150	255	250
200	315	260
DN 250		
80	180	265
100	200	270
150	260	280
200	315	290
250	375	300
DN 300		
80	180	295
100	205	300
150	260	310
200	320	320
B250	380	330
300	435	340
DN 350		
B80	185	325
100	205	330
B150	270	340
200	325	350
B250	385	360
M300	440	370
350	495	380



NOMINAL SIZE	DIMENSION	
dn	L	c
DN 400		
80	185	355
100	210	360
150	270	370
200	325	380
B250	385	390
300	440	400
M350	500	410
400	560	420
DN 450		
B100	215	390
B150	270	400
B200	330	410
B250	390	420
B300	445	430
B400	560	450
B450	620	460
DN 500		
M80	M205	415
100	215	420
M150	275	430
200	330	440
M250	390	450
M300	450	460
M350	505	470
400	565	480
M450	620	490
500	680	500

PUSH-IN FLEXIBLE TEES SOCKET - SPCKET X FLANGE

NOMINAL SIZE	DIMENSION	
dn	L	c
DN 600		
M80	200	475
M100	220	480
M150	280	490
200	340	500
M250	395	510
M300	455	520
M350	510	530
400	570	540
M450	630	550
M500	685	560
600	800	580
DN 700		
M80	225	505
M100	230	510
M150	285	520
200	345	525
M250	400	535
M300	460	540
M350	520	550
400	575	555
M450	635	565
M500	690	570
M600	810	585
700	925	600
DN 800		
M80	250	565
M100	270	570
M150	330	580
200	350	585
M250	410	595
M300	465	600
M350	525	610
400	580	615
M450	640	625
M500	700	630
600	1045	645
M700	930	660
800	1045	675



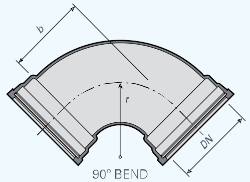
NOMINAL SIZE	DIMENSION	
dn	L	c
DN 900		
M80	225	625
M100	270	630
M150	355	630
200	355	645
M250	415	655
M300	470	660
M350	530	670
400	590	675
M450	645	685
M500	705	690
600	1170	705
M700	935	720
M800	1050	735
900	1170	750
DN 1000		
M80	260	685
M100	360	690
M150	360	700
200	360	705
M250	420	715
M300	480	720
M350	535	730
400	595	735
M450	650	745
M500	710	750
600	1290	765
M700	940	780
M800	1060	795
M900	1175	810
1000	1290	825

For sizes above DN 1000 refer to your SuperTYT representative.

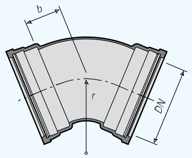
PUSH-IN FLEXIBLE BENDS SOCKET - SOCKET

NOMINAL SIZE	DIMENSION
DN	b
90° BENDS	
80	100
100	120
150	170
200	220
250	270
300	320
M350	370
M400	420
M450	470
M500	520
M600	620
M700	720
M800	820
M900	920
M1000	1020

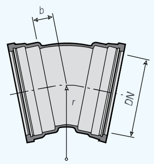
NOMINAL SIZE	DIMENSION
DN	b
22½° BENDS	
80	40
100	40
150	55
200	65
250	75
300	85
350	95
400	110
450	120
500	130
600	150
700	175
800	195
900	220
1000	240



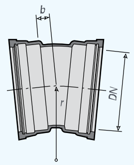
90° BEND



45° BEND



22.1/2° BEND



11.1/4° BEND

Symbol

NOMINAL SIZE	DIMENSION
DN	b
45° BENDS	
80	55
100	65
150	85
200	110
250	130
300	150
350	175
400	195
450	220
500	240
600	285
700	330
800	370
900	415
1000	460

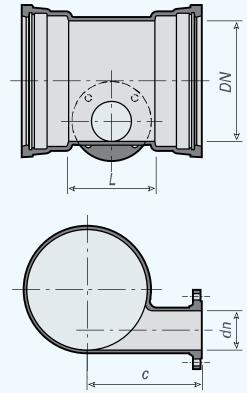
NOMINAL SIZE	DIMENSION
DN	b
11¼° BENDS	
80	30
100	30
150	35
200	40
250	50
300	55
350	60
400	65
450	70
500	75
600	85
700	95
800	110
900	120
1000	130

For sizes above DN 1000 refer to your SuperTYT representative.

PUSH-IN FLEXIBLE TEES INVERT SCOUR

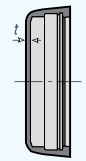
NOMINAL SIZE	DIMENSION		
DN	dn	L	c
M200	80	175	235
M250	80	180	265
M300	80	180	295
M350	100	205	330
M400	100	210	360
M450	100	215	390
M500	100	215	420
M600	100	220	480
M700	150	345	520
M700	200	345	525
M800	150	350	580
M800	200	350	585

For sizes above DN 800 refer to your SuperTYT representative.



INVERT SCOUR TEE

Symbol



CAP

Symbol

PUSH-IN FLEXIBLE CAPS

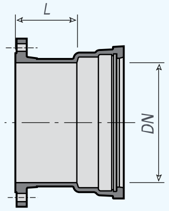
NOMINAL SIZE	DIMENSION
DN	t
M80	18
M100	18
M150	18
M200	18
M250	19.5
M300	23
M350	24
M400	25
M450	26
M500	27
M600	29.5
M700	31
M800	33
M900	35
M1000	37

For sizes above DN 800 refer to your SuperTYT representative.

PUSH-IN FLEXIBLE CONNECTORS

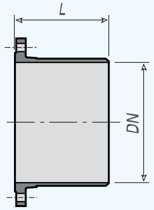
NOMINAL SIZE	DIMENSION
DN	L
FLANGE - SOCKET	
80	130
100	130
150	135
200	140
250	145
300	150
350	155
400	160
450	165
500	170
600	180
700	190
800	200
900	210
1000	220
FLANGE - SPIGOT	
80	350
100	360
150	380
200	400
250	420
300	440
350	460
400	480
450	500
500	520
600	560
700	600
800	600
900	600
1000	600

For sizes above DN 1000 refer to your SuperTYT representative.



FLANGE - SOCKET

Symbol



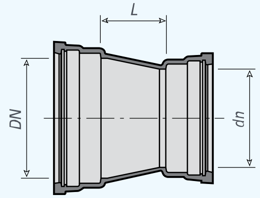
FLANGE - SPIGOT

Symbol

SuperTYT

PUSH-IN FLEXIBLE TAPERS

NOMINAL SIZE	DIMENSION	
DN	dn	L
100	80	90
150	80	190
150	100	150
200	100	250
200	150	150
250	150	250
250	200	150
300	150	350
300	200	250
300	250	150
350	200	360
350	250	260
350	300	160
M400	200	460
400	250	360
400	300	260
400	350	160
M450	250	460
M450	300	360
450	350	260
450	400	160
M500	250	560
M500	300	460
500	350	360
500	400	260
M500	450	160
M600	300	660
M600	350	560
600	400	460
M600	450	360
600	500	260
M700	450	580
700	500	480
700	600	280
M800	500	680
800	600	480
800	700	280



SOCKET - SOCKET

Symbol

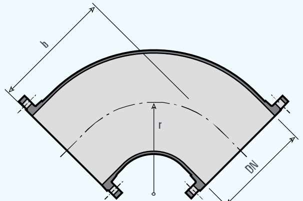
NOMINAL SIZE	DIMENSION	
DN	dn	L
900	M80	1720
900	M100	1680
900	M150	1580
900	M200	1480
900	M250	1380
900	M300	1280
900	M350	1180
900	M400	1080
900	M450	980
900	M500	880
900	M600	680
900	700	480
900	800	280
1000	M80	1920
1000	M100	1880
1000	M150	1780
1000	M200	1680
1000	M250	1580
1000	M300	1480
1000	M350	1380
1000	M400	1280
1000	M450	1180
1000	M500	1080
1000	M600	880
1000	M700	680
1000	800	480
1000	900	280

For sizes above DN 1000 refer to your SuperTYT representative.

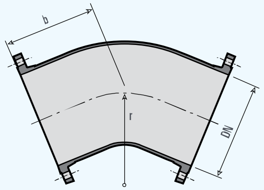
FITTINGS - DUCTILE IRON - FLANGED JOINT

FLANGED BENDS

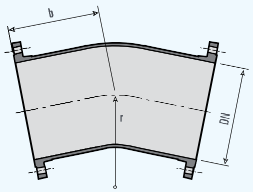
NOMINAL SIZE	DIMENSION
DN	b
90° BENDS	
80	165
100	180
150	220
200	260
250	350
300	400
350	450
400	500
450	550
500	600
600	700
700	800
800	900
900	1000
1000	1100
45° BENDS	
80	130
100	140
150	160
200	180
250	350
300	400
350	298
400	324
450	350
500	375
600	426
700	478
800	529
900	581
1000	632



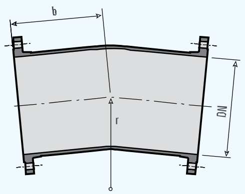
90° BEND



45° BEND



22½° BEND



11¼ BEND

Symbol

NOMINAL SIZE	DIMENSION
DN	b
22½° BENDS	
80	105
100	110
150	109
200	131
250	190
300	210
350	210
400	239
M450	349
M500	375
M600	426
M700	478
M800	529
M900	581
M1000	632
11¼° BENDS	
80	113
100	115
150	113
200	132
250	165
300	175
350	191
400	205
M450	349
M500	375
M600	426
M700	478
M800	529
M900	581
M1000	632

For sizes above DN 1000 refer to your SuperTYT representative.

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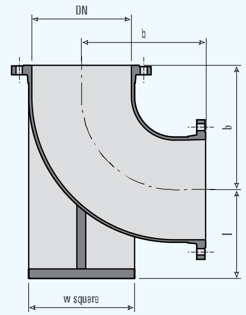
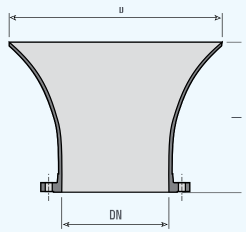
FLANGED DUCKFOOT BENDS

NOMINAL SIZE	DIMENSION		
DN	b	l	w
80	165	110	180
100	180	125	200
150	220	160	250
200	260	190	300
250	350	225	350
300	400	255	400
350	450	290	450
400	500	320	500
450	550	355	550
500	600	385	600
600	700	450	700
M700	800	515	800
M800	900	580	900
M900	1000	645	1000
M1000	1100	710	1100





FLANGED BELLMOUTHS

NOMINAL SIZE	DIMENSION	
DN	l	b
M80	130	150
M100	135	175
M150	150	230
M200	170	290
M250	185	345
M300	205	405
M350	220	460
M400	240	520
M450	255	575
M500	275	635
M600	310	750
M700	345	865
M800	380	980
M900	415	1095
M1000	450	1210

For sizes above DN 1000 refer to your SuperTYT representative.

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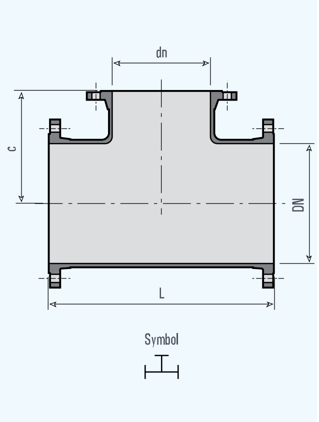
FLANGED TEES

NOMINAL SIZE	DIMENSION	
dn	L	c
DN 80		
80	330	165
DN 100		
80	360	175
100	360	180
DN 150		
80	440	205
100	440	210
150	440	220
DN 200		
80	520	235
100	520	240
150	520	250
200	520	260
DN 250		
B80	405	265
100	700	275
B150	485	280
200	700	325
250	700	350
DN 300		
B80	425	295
100	800	300
B150	505	310
200	800	350
B250	620	330
300	800	400



NOMINAL SIZE	DIMENSION	
dn	L	c
DN 350		
B80	445	325
100	850	325
B150	530	340
200	850	325
B250	645	360
M300	850	425
350	850	425
DN 400		
B80	470	355
100	900	350
B150	550	370
200	900	350
B250	665	390
B300	725	400
M350	900	450
400	900	450
DN 450		
100	950	375
B150	570	400
200	950	375
B250	690	420
B300	745	430
M350	950	475
B400	860	450
450	950	475

For sizes above DN 800 refer to your SuperTYT representative.

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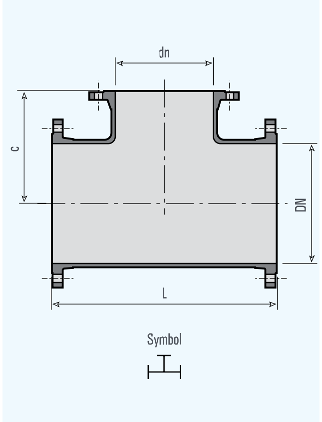
FLANGED TEES

NOMINAL SIZE	DIMENSION	
dn	L	c
DN 500		
100	1000	400
M150	1000	400
200	1000	400
M250	1000	400
M300	1000	500
M350	1000	500
400	1000	500
M450	1000	500
500	1000	500
DN 600		
200	1100	450
M250	1100	450
M300	1100	550
M350	1100	550
400	1100	550
M450	1100	550
M500	1100	550
600	1100	550
DN 700		
200	650	525
M250	705	533
M300	760	540
M350	815	548
400	870	555
M450	925	563
M500	980	570
M600	1200	585
700	1200	600
DN 800		
200	690	585
M250	745	593
M300	800	600
M350	855	608
400	910	615
M450	965	623
M500	1020	630
600	1350	645
M700	1350	660
800	1350	675



NOMINAL SIZE	DIMENSION	
dn	L	c
DN 900		
M80	598	627
M100	620	630
M150	675	640
200	730	645
M250	785	655
M300	840	660
400	950	675
M450	1005	685
M500	1060	690
600	1500	705
M700	1500	735
M800	1500	735
900	1500	750
DN 1000		
M80	638	685
M100	660	690
M150	715	700
200	770	705
M250	825	715
M300	880	720
M350	935	730
400	990	735
M450	1045	745
M500	1100	750
600	1650	765
M700	1650	765
M800	1650	795
M900	1650	825
1000	1650	825

For sizes above DN 1000 refer to your SuperTYT representative.

FLANGED TAPERS CONCENTRIC

NOMINAL SIZE	DIMENSION	
DN	dn	L
CONCENTRIC		
M80	50	200
80	65	200
M100	50	300
M100	65	300
100	80	200
M150	80	400
M150	100	300
M200	80	150
M200	100	600
200	150	300
M250	150	600
250	200	300
M300	150	600
M300	200	600
300	250	300
M350	250	600
350	300	300
M400	200	700
M400	250	650
400	300	300
400	350	300
M450	250	700
M450	300	650
M450	350	600
450	400	300
M500	250	750
M500	300	700
M500	350	650
500	400	600
M500	450	300
M600	300	800
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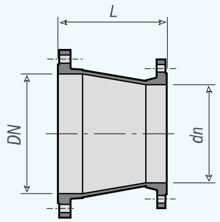
M600	400	700
M600	450	650
600	500	600
M700	450	750
M700	500	700
700	600	600



FLANGE - FLANGE
CONCENTRIC

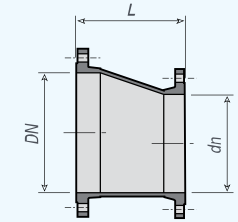
Symbol

NOMINAL SIZE	DIMENSION	
DN	dn	L
ECCENTRIC		
M800	500	800
M800	600	700
800	700	600
M900	450	950
M900	500	900
M900	600	800
M900	700	700
900	800	600
M1000	500	1000
M1000	600	900
M1000	700	800
M1000	800	700
1000	900	600

For sizes above DN 800 refer to your SuperTYT representative.

FLANGED TAPERS ECCENTRIC

NOMINAL SIZE	DIMENSION	
DN	dn	L
ECCENTRIC		
M80	50	200
80	65	200
M100	50	300
M100	65	300
100	80	200
M150	80	400
M150	100	300
M200	80	150
M200	100	600
200	150	300
M250	150	600
250	200	300
M300	150	600
M300	200	600
300	250	300
M350	250	600
350	300	300
M400	200	700
M400	250	650
400	300	300
400	350	300
M450	250	700
M450	300	650
M450	350	600
450	400	300
M500	250	750
M500	300	700
M500	350	650
500	400	600
M500	450	300
M600	300	800
M600	350	750
M600	400	700
M600	450	650
600	500	600
M700	450	750
M700	500	700
700	600	600



FLANGE - FLANGE
ECCENTRIC

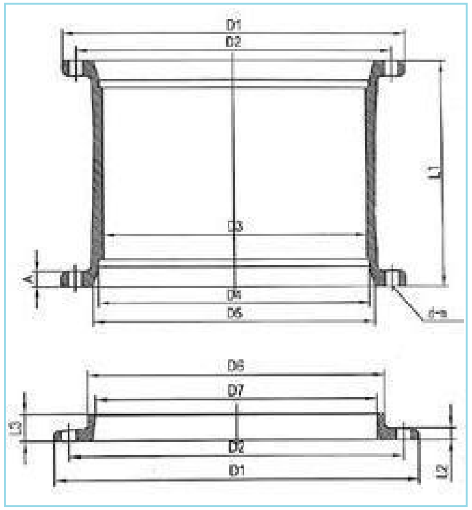
Symbol

NOMINAL SIZE	DIMENSION	
DN	dn	L
ECCENTRIC		
M800	500	800
M800	600	700
800	700	600
M900	450	950
M900	500	900
M900	600	800
M900	700	700
900	800	600
M1000	500	1000
M1000	600	900
M1000	700	800
M1000	800	700
1000	900	600

For sizes above DN 800 refer to your SuperTYT representative.

MECHANICAL JOINT COLLAR

NOMINAL SIZE	L1	D1	D2	D3	D4	D5	A	d	N	D6	D7	L3	L2
80	325	205	165	104	112	130	18	19	4	126	102	35	16
100	325	234	188	121	130	148	19	23	4	146	122	35	16
150	330	288	242	173	182	200	20	23	6	198	174	36	17
200	340	341	295	225	234	252	20	23	6	250	226	37	18
250	385	395	349	277	286	304	21	23	8	302	278	38	19
300	400	455	409	329	342	360	22	23	8	354	330	39	20
350	405	508	462	382	394	412	23	23	10	406	382	40	21
400	410	561	515	433	445	463	23	23	12	457	433	41	22
450	435	614	568	484	496	514	24	23	12	509	485	42	23
500	440	667	621	536	548	566	25	23	14	560	536	43	24
600	450	773	727	639	651	669	26	23	14	663	639	44	25
700	520	892	838	743	758	780	28	27	16	773	743	45	26
800	550	999	942	847	862	884	29	27	20	877	847	47	28
900	590	1123	1057	950	965	987	31	33	20	980	950	48	29
1000	620	1231	1160	1054	1068	1090	32	33	20	1083	1054	49	30



For sizes above DN 1000 refer to your SuperTYT representative.

DUCTILE IRON PIPELINE SYSTEMS
DESIGN GUIDELINES

The process of designing pipeline systems can be complex and requires the skills of a professional, expert in the field.

The following guidelines, although not an exhaustive list, should be considered during various stages in the design and construction process.

PIPES BUILT INTO STRUCTURES

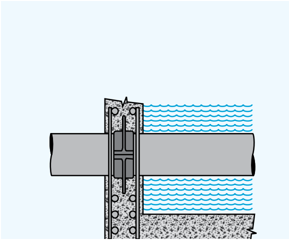
There are a number of design considerations to be taken into account where pipes are built into structures.

WATER BARRIER

Where a pipe passes through the concrete wall of a tank holding liquid and the pipe is below the water level, a means of preventing the liquid leaking between the outside of the pipe and the surrounding structure is required. If the type of installation is such that there is no end thrust tending to push the pipe through the structure, a split puddle flange may be used to provide the water barrier.

Split puddle flanges are designed for use on the bodies of pipes produced by the centrifugal casting method, i.e. spigot and socket pipes or flanged pipes. Prior to assembly, mating surfaces are coated with a sealing compound.

ANCHORAGE



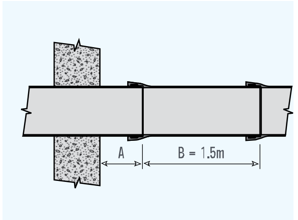
Split thrust flanges used to withstand horizontal thrusts are located in a machined groove cut on the outside surface of the pipe.

Appropriate steel reinforcement should be located in the concrete structure around the thrust flange to take the thrust forces transferred to the concrete wall by the flange.

FLEXIBILITY

Where a buried pipeline passes through a rigid structure and differential settlement of the structure and the adjacent ground is anticipated, two flexible joints should be introduced immediately adjacent to the face of the structure.

It is recommended that dimension A be as short as possible consistent with making the joint, and that dimension B be 1.5m.



Trench incorporating gradient anchors

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ANCHORAGE OF PIPELINES

All pressure pipelines having unanchored flexible joints require anchorage at changes of direction, tees, valves and at blank ends to resist the thrusts developed by internal pressure.

STATIC THRUSTS

Internal pressure thrusts act in the directions indicated. Additional dynamic thrusts are created by moving water, which are usually negligible unless the flow velocity is extremely high.

The magnitude of static thrusts may be calculated as follows:

Blank ends and junctions = 10^3APkN

The above formula also applies to closed valves unpressurised on the downstream side.

Bends = 10^3AP 2Sinθ/2 kN

Main reducing in cross section area from A_1 to A_2 at a taper

= $10^3P(A_1-A_2)$ kN

where

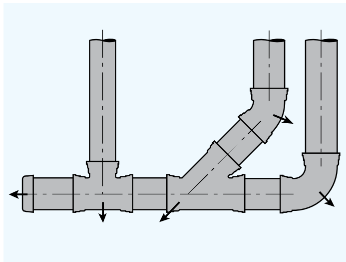
A = cross-sectional area. m^2

(in the case of Push-in Flexible pipe, the external diameter of the barrel should be used in the calculation)

P = internal pressure. MPa

θ = angle of deviation of bend

The following table gives the values of these thrusts at standard fittings.



Direction of thrust for various fittings

THRUST DEVELOPED PER MPA INTERNAL PRESSURE APPROX.

NOM. SIZE	BLANK ENDS AND JUNCTION	BENDS			
		90°	45°	22.1/2°	11.1/4°
DN	kN	kN	kN	kN	kN
80	8	11	6	3	1
100	11	15	8	4	2
150	23	32	17	9	4
200	39	55	30	15	8
250	59	83	45	23	12
300	83	118	64	33	16
350	112	159	86	44	22
400	145	204	111	56	28
450	181	256	138	71	35
500	222	314	170	87	44
600	317	448	242	124	62
700	428	605	327	167	84
800	557	787	426	217	109
900	702	992	537	274	138
1000	863	1220	660	337	169

ANCHOR BLOCKS

Anchorage to resist the thrusts must be designed taking full account of the maximum pressure the main is to carry in service or on site test and the safe bearing pressure of the surrounding soil.

Where possible concrete anchor blocks should be of such a shape as to allow sufficient space for the remaking of joints.

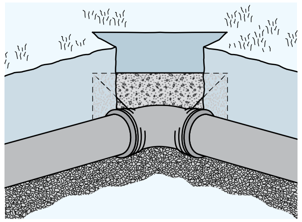
HORIZONTAL THRUST – BURIED MAINS

The thrust developed must be transferred to the undisturbed earth of the trench wall by anchor blocks poured against the appropriate area of earth face. Horizontal anchor blocks distribute thrust forces over the total bearing area of the block in order that the safe bearing pressure of the trench wall is not exceeded, thus ensuring the stability of the pipeline under test and working pressures.

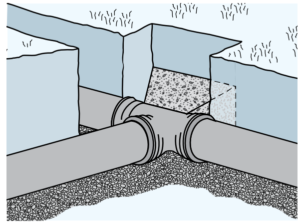
Typical values for the safe bearing pressure of different undisturbed soils are given below based on a horizontal thrust at a minimum depth of 0.6m.

SOIL TYPE	SAFE BEARING PRESSURE KN/M²
Soft Clay	24
Sand	48
Sand and Gravel	72
Sand and Gravel bonded with Clay	96
Shale	240

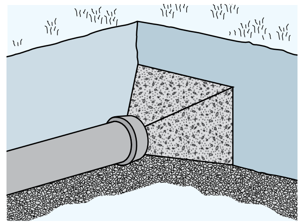
Bends



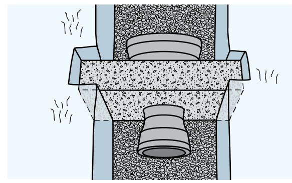
Tees



Dead ends



Tapers



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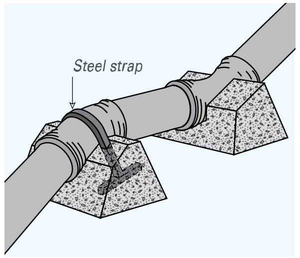
VERTICAL THRUST – BURIED MAINS

Downward vertical thrusts are transferred to the undisturbed ground by anchor blocks in the same manner as horizontal thrusts. Upward vertical thrusts are counteracted by the mass of the concrete anchoring block. If the water table in the area is likely to reach the level of the anchor block, the submerged mass of the block should be taken. If the natural ground is of sufficient strength i.e. rock, special anchor blocks can be cast into the rock to resist vertical upward thrust forces.

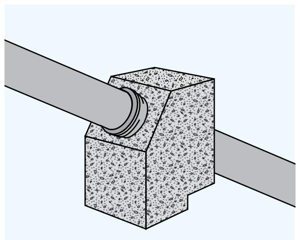


Vertical bends

GRADIENT THRUST – BURIED OR 'ABOVE GROUND' MAINS

Pipes laid at gradients steeper than 1 in 6 generally require anchorage. Flexible jointed pipelines laid on steep slopes require restraint to prevent relative movement of individual pipes due to the component of the mass of pipe and contents acting along the direction of the gradient.

Buried pipelines develop frictional resistance between the backfilling material and the pipeline which counteracts a proportion of the sliding thrust. The table below gives an indication of the spacing of anchor blocks for buried or 'above ground' pipelines for different gradients.



Gradient anchorage

GRADIENT	SPACING OF ANCHOR BLOCKS. M
1 in 2	6
1 in 3	12
1 in 4	12
1 in 5	18
1 in 6	24

EXAMPLE

Determine the lateral bearing area and anchor block size for a horizontal 90˚ bend on a DN 250 ductile iron rising main. The ground is shale and the maximum site test pressure is 4.5 MPa.

From the table of thrusts developed at standard fittings:

Thrust at a DN 250 90˚ bend for 4.5MPa internal pressure is

4.5 x 91 = 409.5 kN.

The safe bearing pressure for shale is 240 kN/m^2.

Bearing area of anchor block is

409.5/240 = 1.7m^2

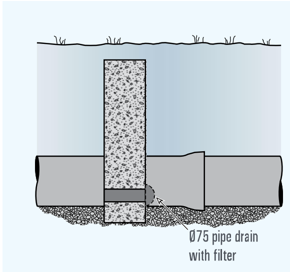
Select anchor block say

1.7m x 1.0m.

Singapore construction

BULKHEADS

Concrete bulkheads may be required in some situations to prevent scouring of bedding and backfill through trench drainage and consequent trench collapse. These situations mainly arise when laying pipelines on steep grade (>1 in 6), across roadways or beside building structures. The bulkheads should be placed at the discretion of the construction engineer. Suitable drainage lines should pass through the bulkhead to facilitate natural water drainage along the trench.

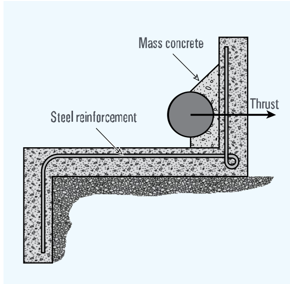


Concrete bulkhead to be 150mm thick for full width of trench and to height and spacing required to prevent scouring of trench by drainage waters

POOR GROUND CONDITIONS

In trench conditions where the allowable bearing pressure of the side wall soil is insufficient to support thrusts or in embankment conditions where undisturbed ground is unavailable, specially designed anchor blocks should be installed.

For large diameter pipes in the higher pressure range, reinforced concrete chair-shaped anchors may be used. The bending and tensile stresses are taken by the steel reinforcement in the direction of thrust while the weight of the earth on the base helps to counteract the overturning effect.



Reinforced concrete anchor block for poor ground conditions

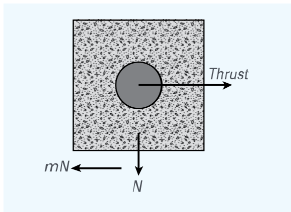
Concrete mass frictional anchor blocks may be preferred in some situations. The resistance force is given by:

R = µN

where

µ = friction coefficient = 0.2 to 1.0

N = weight of concrete anchor block



Mass concrete anchor block

AGGRESSIVE GROUND CONDITIONS

The corrosion behaviour of ductile iron pipe varies considerably depending on ground and soil conditions, and in almost all circumstances failure will not eventuate until corrosion pitting has penetrated the full thickness of the pipe wall. 'Aggressive' ground conditions are defined as those which would lead to corrosion failures within a specified period of time after installation of the pipeline – say 50 years. In these conditions corrosion mitigation measures, such as the use of loose polyethylene sleeving, can prevent premature corrosion failures.

CORROSIVE ENVIRONMENTS

As a guide, the following environments would normally require corrosion protection in order to achieve satisfactory long term performance of a ductile iron pipeline:

1. Areas of waterlogged soil, such as swamps and inter-tidal salt marshes.
2. Highly alkaline soils.
3. Cinder fill.
4. Areas of decaying vegetation.
5. Presence of stray electric direct currents.

In addition to these environments, attention should be paid to the connection of copper service pipes to ductile iron pipes buried in 'moist' coastal soils. In this situation some form of insulation is required between the copper service pipe and ductile iron pipe to prevent galvanic action.

ASSESSMENT SYSTEMS

Over the years, several systems have been developed for the assessment of soil corrosivity, based upon empirical and theoretical considerations.

The most reliable system currently available is the system incorporated in the American Standard ANSI/AWWA C105/A21.5. Results from the testing of soil resistivity (preferably saturated soil resistivity), soil pH, redox potential, presence of sulphides and drainage are used to determine whether the soil is aggressive to ductile iron and protection is required.

Soil resistivity and soil pH are used to indicate the salt content of the soil, and redox potential, presence of sulphides and drainage are used to determine the likelihood of anaerobic soil conditions.

This grit blasted ductile iron pipe was buried for over 11 years in aggressive soil. The left hand side of pipe was polyethylene sleeved, the right hand side left bare.

Upon consideration of these five criteria, the points assigned are totalled and if the sum exceeds 10, some form of protection is indicated.

The soil sample used in the 10 point evaluation should be taken at pipe depth rather than at the surface. Soil corrosivity readings can vary substantially from the surface to pipe depth.

SOIL TEST EVALUATION FOR DUCTILE IRON PIPE. 10 POINT SYSTEM*

SOIL CHARACTERISTICS		POINTS
Resistivity† ohm. cm	<700	10
	700-1000	8
	1000-1200	5
	1200-1500	2
	1500-2000	1
	>2000	0
pH	0 - 2	5
	2 - 4	3
	4 - 6.5	0
	6.5 - 7.5	0‡
	7.5 - 8.5	0
	>8.5	3
Redox Potential	+50 to +100 mv	3.5
	0 to +50 mv	4
	Negative	5
Sulphides	Positive	3.5
	Trace	2
	Negative	0
MOISTURE		
Poor drainage, continuously wet		2
Fair Drainage, generally moist		1
Good Drainange, genreally dry		0

* Ten points - corrosive to Ductile Iron pipe. Protection is indicated.

† Based on single probe at pipe depth or water-saturated soil box, because these methods are designed to obtain the lowest - and most accurate - resistivity reading.

‡ If sulphides are present and low or negative redox-potential results are obtained, 3 points should be given for this range.

LOOSE POLYETHYLENE SLEEVING

The inherent corrosion resistance of the ductile iron pipe and fittings with standard coating provides adequate protection except in aggressive soils where additional protection in the form of loose polyethylene sleeving is recommended.

Loose polyethylene sleeving is used as the principle means of providing corrosion protection for ductile iron pipelines in aggressive soils throughout the world. The sleeving isolates the pipe from the surrounding soil, restricting material and ionic flow between the surface of the pipe and the surrounding soil. The presence of moisture in the cavity between pipe and soil is not important providing:

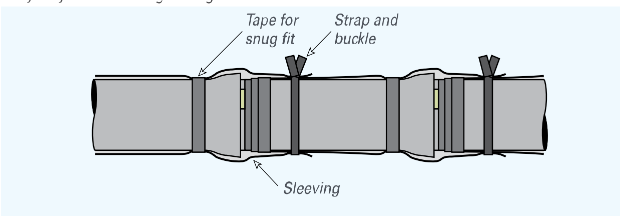
- no soil is trapped inside the sleeving
- the water inside the sleeving is stagnant and not flowing
- the sleeving is adequately 'sealed' to prevent ingress of oxygen.

SUPERTYT'S POLYETHYLENE SLEEVING

SuperTYT's polyethylene sleeving is manufactured in accordance with the requirements of BS 6076 – 'Polyethylene Sleeving for Ductile Iron Pipelines' and has the following advantages.

- perforations in lengths for easy tear-off.
- the water industry has adopted blue as the preferred colour coding for water applications. Since the vast majority of ductile iron pipes are used in water applications.
- end flanges on the roll to protect against damage and allow easy roll-out.
- printing to identify it as a special protection system in aggressive soils to pipelayers and maintenance personnel.

Polyethylene sleeving configuration



The advantages of loose polyethylene sleeving over more conventional coatings can be summarised thus:

1. Comparative ease of sleeving application.
2. Elimination of possible damage to the protection system during transportation.
3. Relative movement of the loose film with soil movement minimises the risk of tearing whilst in service.
4. Damage to sleeving can be easily repaired during installation.
5. Cathodic protection is not required.
6. The technique is relatively inexpensive.

POLYETHYLENE SLEEVING SPECIFICATION

Polyethylene sleeving for the corrosion protection of ductile iron pipe should be supplied in accordance with the requirements of BS 6076. These requirements can be achieved by compliance with the following.

Property	Requirement
Colour	Blue
Nominal thickness	Minimum 200µm
Ultimate tensile	Minimum 50N on
strength	weathered film
Elongation	Minimum 1000%
	on weathered film
Impact Resistance	Greater than 900g
	on weathered film
Tear Resistance	Greater than 25N
	on weathered film

ABOVE GROUND PIPELINES

The following recommendations assume that no additional bending moments above those due to self weight of the pipe and its contents are present.

PUSH-IN FLEXIBLE PIPELINES

NORMAL CONDITIONS

It is recommended that above ground installations of Push-in Flexible Joint pipelines be provided with one support per pipe, the supports being positioned behind the socket of each pipe.

This results in a normal maximum distance between supports of 6m. Figure 1.

Pipes should be fixed to the supports with mild steel straps, so that axial movement due to expansion or contraction resulting from temperature fluctuation, is taken up at individual joints in the pipeline. In addition joints should be assembled with the spigot end withdrawn 5 to 10mm from the bottom of the socket to accommodate these thermal movements.

Pipes supports in this way are capable of free deflection and axial movement at the joints which accommodates small movements of the pipe supports.

Purpose designed anchorage must be provided to resist the thrusts developed by internal pressure at bends, tees, etc. When determining the actual position of the support centres, it should be remembered the lengths of pipes are subject to manufacturing tolerances.

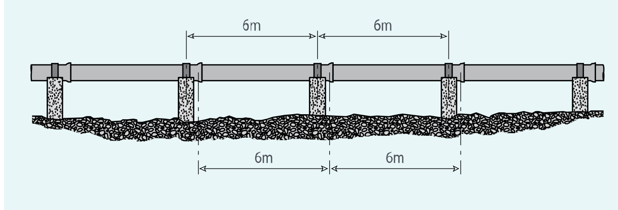


Figure 1. Normal maximum distance between supports of 6.0m

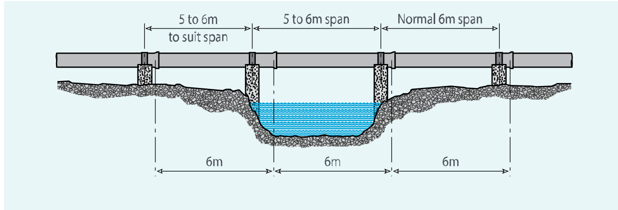


Figure 2. Unsupported spans slightly larger than 6.0m

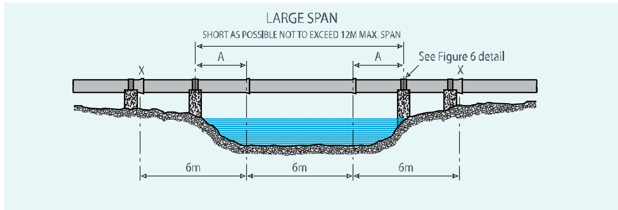


Figure 3. Unsupported spans between 6 and 12m

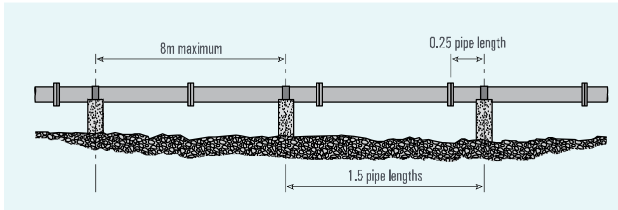


Figure 4. Standard 5.8m long flanged pipes with screwed-on flanges installed as a continuous beam

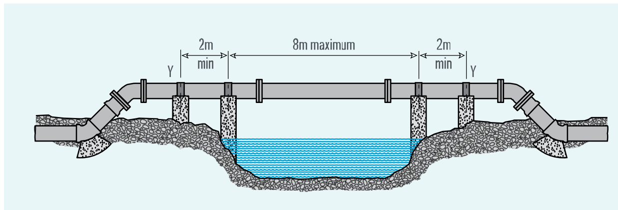


Figure 5. Standard 5.8m long flanged pipes with screwed-on flanges installed as a beam with fixed ends

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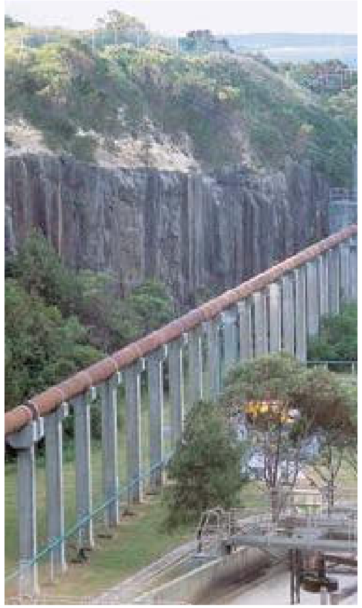
SPECIAL CONDITIONS

UNSUPPORTED SPANS SLIGHTLY LARGER THAN 6M

If necessary, unsupported spans of 6m can be obtained by positioning the pipe supports relative to the pipe joints as indicated in Figure 2.



800mm pipeline on columns, supported at 6 metre centres

UNSUPPORTED SPANS BETWEEN 6 AND 12M

Where a support cannot be provided at every pipe, e.g. at stream crossings etc, unsupported spans of up to 12m can be installed by positioning supports relative to joints as indicated in Figure 3.

The length of dimension A should not exceed one quarter of the total span length.

Cut pipes, fittings, valves, etc, which are adjacent to the span, must be positioned outside the joints marked X and the length between the joints X-X must be equal to 3 full length pipes, i.e., 18m.

FLANGED JOINT PIPELINES

Flanged pipes are subjected to stresses caused by internal pressure and stresses due to local bending moments created by tightening of the bolts.

Flanged pipes installed as self supporting spans are subjected to additional stresses due to bending moments caused by their own weight and the weight of their contents.

The length of unsupported spans of flanged piping is limited by the need to confine stresses due to the combined effects of internal pressure, bolt tightening and bending moments, within safe limits.

The following recommendations are for standard 5.8m long pipes and take account of the above factors.

STANDARD 5.8M LONG FLANGED PIPES WITH SCREWED-ON FLANGES INSTALLED AS A CONTINUOUS BEAM

The recommended maximum unsupported span is 8m. The initial support should be located one quarter of a pipe length from the first flanged joint and subsequent supports located at 1.5 pipe length intervals as shown in Figure 4.

STANDARD 5.8M LONG FLANGED PIPES WITH SCREWED-ON FLANGES INSTALLED AS A BEAM WITH FIXED ENDS (STREAM CROSSINGS)

The recommended maximum unsupported span at stream crossings, etc, is 8m. The relative positions of pipe joints and pipe supports should be as shown in Figure 5.

The supports of all flanged pipe-work spans must accurately align to ensure each support carries its share of the weight of the pipeline and they must be stable and unyielding since movement of the supports will induce additional bending moments in the pipeline.

The straps must prevent any lateral movement or lifting of the main but not restrict axial expansions and contractions of the main caused by temperature fluctuations.

FIXING DETAILS

The strap and bolts shown below are suitable for retaining the pipe in position on the supports. They are not designed to carry the thrusts due to unbalanced loads at bends and other fittings. In these circumstances each case should be considered on its merits and the bolt size and strap design determined accordingly, e.g., the straps marked Y in Figure 5.

NOMINAL SIZE OF PIPE	T	W	D	L	C	SIZE OF BOLT
DN	mm	mm	mm	mm	mm	mm
80 - 150	6	40	13	45	25	M12
200 - 300	6	50	16	50	30	M16
350 - 600	10	65	19	65	35	M20
700 - 1000	10	90	25	75	42	M24

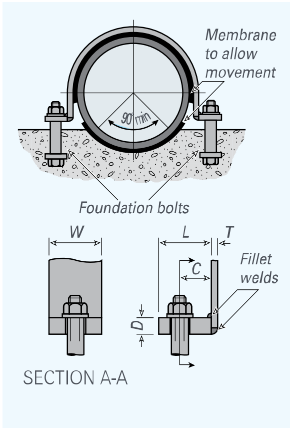


Figure 6. Fixing details

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DUCTILE IRON PIPELINE SYSTEMS
HANDLING AND INSTALLATION

Construction procedures are generally in accordance with the British Standard BS 8010

- Code of Practice for Pipelines:

Part 1, Pipelines on Land, General

Section 2.1, Ductile Iron Pipelines

The successful and economical installation of a pipeline relies on many factors and prior to laying, contractors should check that:

1. Access and storage areas are available for pipe delivery.
2. Pipe delivered is of the correct diameter shown on the drawings.
3. Gaskets, lubricant and polyethylene sleeving (where required) have been delivered.
4. Required fittings have been delivered.
5. Size and location of thrust blocks is known (or locations of joint restraint).
6. Pipe site testing requirements are known.

Pipe packs being loaded for shipping to the Pacific region

HANDLING RECOMMENDATIONS

Ductile iron pipes are not susceptible to breakage by impact loading but bad handling can result in damaged linings and in severe cases, in bruising and deformation of the spigot which could affect the sealing of the joint. Damage to pipes and joint components may be caused by:

- Insecure load on truck or wagon
- Improper use of handling equipment
- Use of unsuitable handling equipment
- Incorrect stacking methods
- Improper storage of joint components
- Unloading on uneven or sloping ground

Damage can be avoided by paying attention to the following points.

TRANSPORTATION

All pipes must be secured by chains to the truck to prevent movement during transit. Suitable protection such as rubber or carpet should be placed between the chains and the outer pipes of the top row.

The use of straight sided loading allows full advantage to be taken of the carrying capacity of the vehicle. Pipes should be loaded onto vehicles using scalloped hardwood timbers of sufficient thickness to ensure no metal to metal contact occurs between rows of pipes.

INSPECTION

On receipt, pipes should be inspected for damage to:

1. The pipe itself
2. Cement mortar linings
3. Jointing surfaces

and any proposed remedial work undertaken as soon as possible.

UNLOADING

OFFLOADING BY CRANE

Pipe masses, type of stacking, outreach required and the site conditions are the important factors to take into account when determining the suitability of lifting equipment. The machine used must be of the type which retains the load safely in the event of a power failure.

Personnel engaged in offloading operations are recommended to wear protective clothing wherever possible.

THE LIFTING OPERATION

It is necessary when using mechanical handling equipment to employ sufficient personnel to carry out the operation efficiently and safely.

Where the crane operator does not have a clear view of the load, he should be guided by the person supervising the operation.

The pipes should be lifted smoothly, without sudden jerking motions, and pipe movement should be controlled by the use of guide ropes. This is necessary for safety and also to prevent damage caused by pipes bumping together or against surrounding objects.

Lifting and placing must be carried out in such a way that the stability of the stack, crane or vehicle is not affected. Chains securing the pipes to the truck should not be released before ensuring the truck is positioned on level ground.

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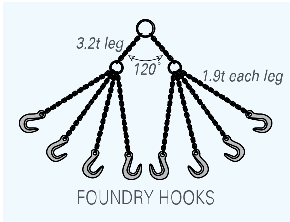
All-terrain forklifts may also be used to unload provided consideration is given to pipe size, weight limitations and site conditions.

When lowering pipes, timber battens placed on the ground about 900mm from each end of the pipes should be used to absorb shock and to prevent damage to the coating.

CHAINS AND HOOKS

The recommended method of attaching pipes to the crane is by means of supporting chains with lifting hooks. The hooks should be of suitable shape to ensure positive engagement when entered into the ends of the pipes and they should pass over any protective packing fitted around the pipe ends by the manufacturer.

Use 2 hooks to lift DN 700 and DN 800 pipes. When the pipes are cement-mortar lined, the hooks should be padded using a piece of rubber hose or similar material to protect the lining.



Recommended hook design.

SLINGS

Long slings or a spreader bar should be used to unload packs of pipes. Short slings are not recommended as they may deform the pack causing the intermediate timbers to break. When it is necessary to use the central sling method for lifting single pipes, a broad webbing sling is recommended. For lifting larger pipes twin slings should be used.

Other types of slings should be used with care; chain slings may slip and are potentially dangerous; it is difficult to detect broken strands in plastic covered wire mesh slings and hemp rope slings can deteriorate rapidly due to weathering or misuse.

OFFLOADING WITHOUT CRANE

Where lifting gear is not available and the mass permits, pipes may be offloaded by rolling them down a ramp formed of timber skids extending from the truck side to the ground. During this operation it is essential to apply steadying ropes to prevent the pipes from rolling down at excessive speed and striking other pipes or objects on the ground. These ropes should be attached to the vehicle, passed under and around the ends of the pipe to be moved, then taken back over the top to purchase away from the ramp, so that the ropes can be paid out steadily to
control the descending pipe.

PIPE STACKING

The site for a depot should have a firm foundation for stacks of pipes, and a suitable approach road for vehicles. Stacks should be so arranged as to provide adequate vehicular and pedestrian access.

During stacking and removal operations, safe access to the top of the stack is essential. In bad weather conditions when pipe surfaces may become slippery, consideration should be given to the use of lightweight stagings placed on top of the stacks.

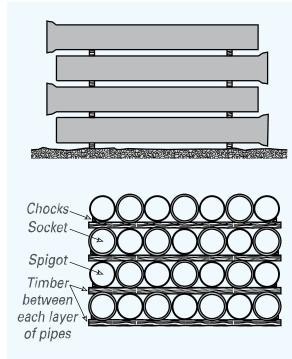
Ductile iron pipes should always be stacked on a base of raised wooden battens. The battens should be of sound timber free from protrusions and at least 100mm thick x 75mm wide. The battens should be positioned approximately 900mm from each end of the pipes. Stacks should be pre-chocked as they are assembled.

A. PARALLEL STACKING USING WOODEN ROLLING BOARDS

For this method of stacking, two timber battens are placed across the pipes between each tier approximately 900mm from the pipe ends.

The sockets of each alternate pipe should be reversed and the battens should be of sufficient thickness to avoid metal to metal contact.

Pipes may be rolled into position along the battens, thus facilitating stacking or removal from the end of the stack. An adequate number of chocks should be wedged under the outer pipes of each tier and nailed to the timber bearers to ensure stability.



B. SQUARE STACKING

By positioning each tier of pipes with their axes at right angles to those in the preceding tier, a stable and compact stack can be formed.

The sockets of alternate pipes in each tier should be reversed. No timber is used between successive tiers and the sockets at each end of the preceding tier act as chocks, locking the tiers in position. Extra care should be exercised when lowering pipe into position. As no timber base is required a flat stacking area is necessary to avoid undue stress on the bottom tier.

C. PRE-BUNDLED PIPE STACKS

Pipes supplied in bundles with intermediate scalloped timbers are suitable for on-site stacking without provision of additional timber battens. Consideration should be given to maximum stacking heights.

RECOMMENDED STACKING HEIGHTS

The heights of stacks are determined by consideration of:

1. The stresses on the lowest layer of pipes in the stack.
2. The total lift given by the available crane.
3. The facilities available to ensure stable stacking.

Taking all these factors into consideration, the following maximum stacking heights are recommended.

NOMINAL SIZE DN	RECOMMENDED MAXIMUM NUMBER OF LAYERS IN STACK
80	12
100	12
150	12
200	10
250	10
300	8
350	7
400	6
450	5
500	5
600	4
700	3
800	3
900	2
1000	2

Pipe packs ready for export

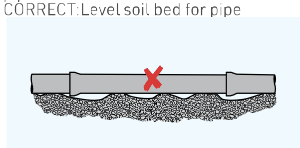
TRENCHING

The trench should be cut as narrow as practicable. Recommended minimum trench widths are shown below. Additional excavation is necessary at each joint to provide sufficient room for the joint to be properly made and to ensure that the pipe rests on the barrel and not on the socket. The preparation of the trench bottom, to give an even bed for the barrel of the pipe and the proper alignment of the pipe, is of great importance.

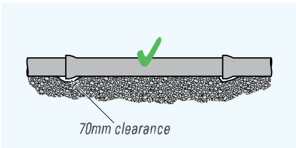
PIPE LAID ON NATURAL EARTH BED

INCORRECT: Uneven bedding causes extra stresses to be developed in the pipeline.

CORRECT: Level soil bed for pipe



with excavated pockets at joints.



NOMINAL SIZE DN	MINIMUM TRENCH WIDTH MM
80	380
100	400
150	450
200	500
250	550
300	600
350	650
400	700
450	800
500	850
600	950
700	1050
800	1150

In rocky ground the trench should be excavated at least 100mm deeper than required and then made up to the required level by the addition of well compacted soft granular material.

Pipeline laid on well compacted, soft, granular material

Where a change in direction is being made by utilising the lateral deflection allowable at the joints, the trench should be cut sufficiently wide to allow the joint to be made in line and then the pipe laterally deflected.

Where trench depths or soil conditions are such that there is a possibility of trench wall collapse then suitable means of shoring or battering of the trench walls must be carried out.

DEPTH OF COVER

In general terms, the trench is excavated to a depth dependent upon the diameter of pipe being laid. This depth is a compromise between providing adequate cover over the pipe whilst allowing ready access for maintenance purposes.

Other considerations when determining a suitable depth of cover include:

- loading on pipe, e.g., pipes usually have greater depth of cover when subject to vehicular loading.
- cover over tapping cock, valve etc.
- location of other services.
- future road regrading.
- removal of top soil, e.g., in ploughed fields or through erosion.
- high-pressure pipelines may require greater depth of cover.

The minimum depth of cover recommended is 300mm assuming none of the above considerations requires the pipeline to be laid at greater depth.

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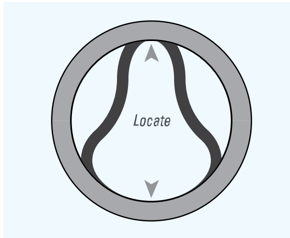
JOINTING AND ASSEMBLY

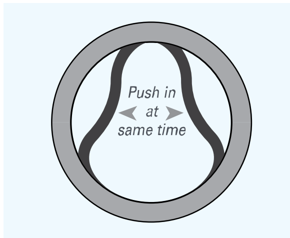
The Push-in FlexibleJoint has long been regarded as the benchmark for rubber ring jointing systems for the water industry. Its unique design offers quick and effective assembly under all conditions.

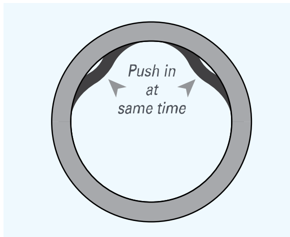
JOINTING INSTRUCTIONS FOR PUSH-IN FLEXIBLE JOINT PIPE

INSERTION OF GASKET

The gasket should be wiped clean, flexed, as shown, and then placed in the socket with bulb leading.







When inserting gaskets, flexing in two places may be necessary. The groove in the gasket must be located on the retaining bead in the socket, and the retaining heel of the gasket firmly bedded in its seat so that the heel of the gasket is not proud of the mouth of the pipe.

LUBRICATION

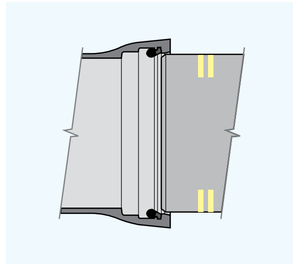
A thin film of lubricant is applied to the inside surface of the gasket which will be in contact with the entering spigot. In addition, a thin film of lubricant should be applied to the chamfer and 25mm of the barrel.

RECOMMENDED QUANTITIES FOR PUSH-IN FLEXIBLE JOINT LUBRICANT ISSUE	
Pipe DN	Push-In Joints / 500g Can
80	35
100	29
150	23
200	14
250	10
300	9
350	7
400	6
450	5
500	5
600	4
700	3
800	3
900	2
1000	2

Use BS 6920 lubricant, for example : **WRAS** approved lubricant

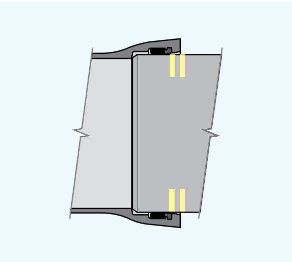
INITIAL ENTRY OF SPIGOT

The spigot of the pipe being jointed must be aligned and entered carefully into the adjacent socket until it makes contact with the gasket. Final assembly of the joint is completed from this position.



COMPLETELY ASSEMBLED JOINT

Joint assembly is completed by forcing the spigot end of the entering pipe past the gasket, which is thus compressed, until the first painted stripe on the end of the pipe disappears and the second is approximately flush with the socket face.



If the joint is difficult to assemble, the spigot should be removed and rotated through 90˚ before attempting to assemble a second time. If the joint is still difficult to assemble, the spigot should be removed and the position of the gasket examined.

DEFLECTION

The joints can be deflected in any direction up to 3˚30' for pipes up to DN 300 and up to 2˚30' for DN 350 to DN 600 and 1˚30' for DN 700 to DN 1000

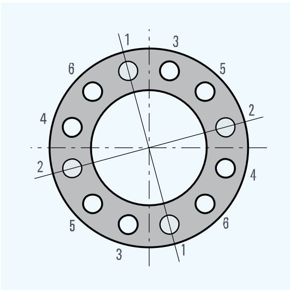
All spigots must be chamfered. When making a joint, pipes should always in line and if required, deflection made after making the joint.

Pipeline construction in Sri Lanka

JOINTING INSTRUCTIONS FOR FLANGED JOINTS

1. Ensure that face of flange is clean from dirt or particles of foreign matter.
2. Clean nuts and bolts.
3. Insert four location bolts in the positions shown on the diagram below.
4. Position insertion gasket on the location bolts.
5. Offer adjoining flange to bolts.
6. Tighten four location bolts in order given in diagram to roughly secure adjoining flange.
7. Insert remaining bolts and tighten diametrically opposite bolts. Check all bolt holes are filled.

Bolt tightening sequence for typical flanged joint



CUTTING OF PIPES

Standard methods of cutting pipes:

1. Power-driven abrasive wheel cutters are efficient, clean and fast when cutting in the field.
2. Manual or power operated wheel cutters may be used. Ensure the type of wheel used is suitable for ductile iron. Cut ends require dressing with a file or grinder to form a chamfer for Push-in Flexible Joint pipe.
3. Pipes cut beyond the limit of outside diameter tolerance may require grinding or dressing to remove the peening pattern on the pipe's outside surface to facilitate jointing.

Note. Hydraulic snap cutters used for grey cast iron pipes are not suitable for cutting ductile iron pipes.

Reed power assisted rotary cutter

Abrasive disc cutter

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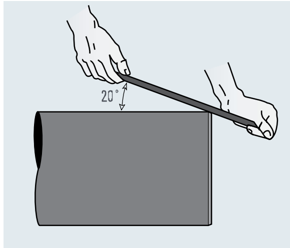
PREPARATION OF SPIGOTS ON SITE

Where spigots require preparation on site, the outside of the spigot should be filed or ground to produce a chamfer angle of approximately 20˚. This removes sharp or rough edges which might damage the gasket, and in addition facilitates the entry of the spigot past the gasket.

All spigots must be chamfered

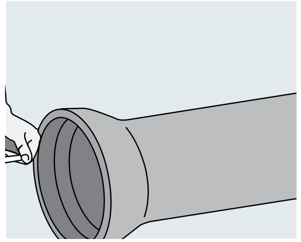


JOINTING CUT PIPE

To assist in the assembly of a field cut joint, mark the prepared cut end in accordance with the dimensions indicated in the table below. Complete the assembly as for full length pipe.

Marking prepared cut pipe

Pipe Dn	Maximum Spigot Insertion Depth	Minimun Spigot Insertion Depth
80	80 mm	70 mm
100	80 mm	70 mm
150	90 mm	80 mm
200	100 mm	90 mm
250	100 mm	90 mm
300	110 mm	100 mm
350	110 mm	100 mm
400	110 mm	100 mm
450	120 mm	110 mm
500	120 mm	110 mm
600	120 mm	110 mm
700	150 mm	140 mm
800	155 mm	145 mm
900	170 mm	160 mm
1000	180 mm	170 mm



OVALITY

Pipes are checked for ovality before leaving the manufacturer's plant and under normal delivery conditions, no ovality correction would be required. If pipes are incorrectly stacked or damaged on site, ovality may occur. This could happen in a spigot or cut end of pipe generally larger than DN 450.

Ovality can be detected by inability to make the joint. If this situation arises, the pipe should be measured to locate the major and minor axes of the cross section.

Ovality correction is carried out by applying external force to the major axis or internal force to the minor axis before jointing. Care should be taken not to damage the internal cement lining.

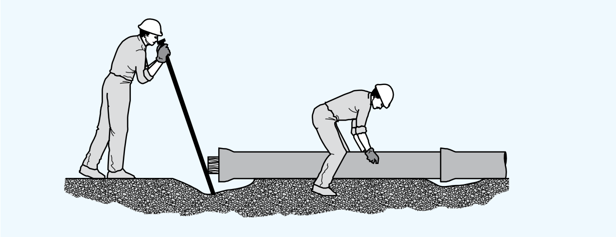
Lubrication of pipe spigot prior to jointing

METHODS OF ASSEMBLY FOR PUSH - IN FLEXIBLE JOINT - PIPES AND FITTINGS

Assembly of the joint is quick and simple, and may, according to size and local conditions, be carried out by any of the following methods.

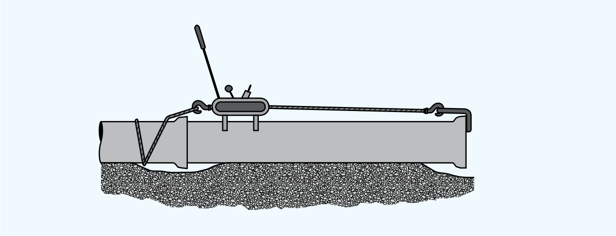
CROWBAR METHOD

Complete entry of the spigot into the socket may be obtained by pushing with a crowbar or suitable lever against the face of the socket of the entering pipe.



TIRFOR OR COME-ALONG METHOD

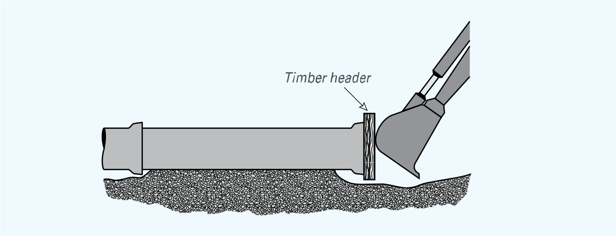
For joints above DN 150 a wire rope or chain puller can be used as shown the in diagram. These pullers are readily available.



TRENCH EXCAVATOR METHOD

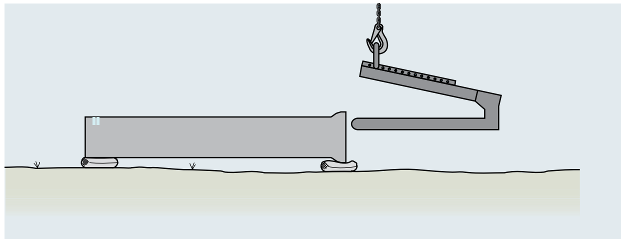
Where the trench is being prepared by using a backhoe or excavator, either machine may be used to push the spigot home.

This system is mainly used on large diameter pipe and a timber header should be placed between the pipe and the bucket to prevent damage to the pipe.



HAIRPIN LIFTING METHOD

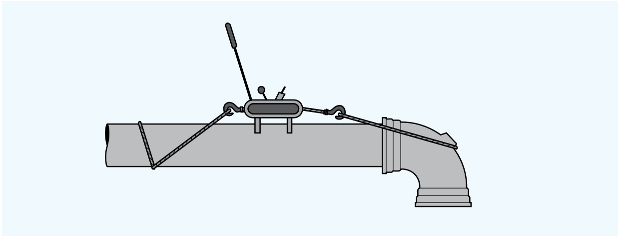
A hairpin lifting mandrel may be utilised for both lifting the pipe and making the joint. The mandrel is inserted into the bore of the pipe as shown, making sure care is taken not to damage the internal cement lining. The pipe can then be lifted and placed into the trench and jointed. The hairpin may also be used for sleeving pipes prior to laying and jointing.



FITTINGS

Small diameter socketed fittings can be pushed onto the pipe by using a crowbar.

Larger fittings are generally provided with a jointing lug suitably located in order that a wire rope or chain puller can be used to pull the fitting onto the spigot of the pipe.

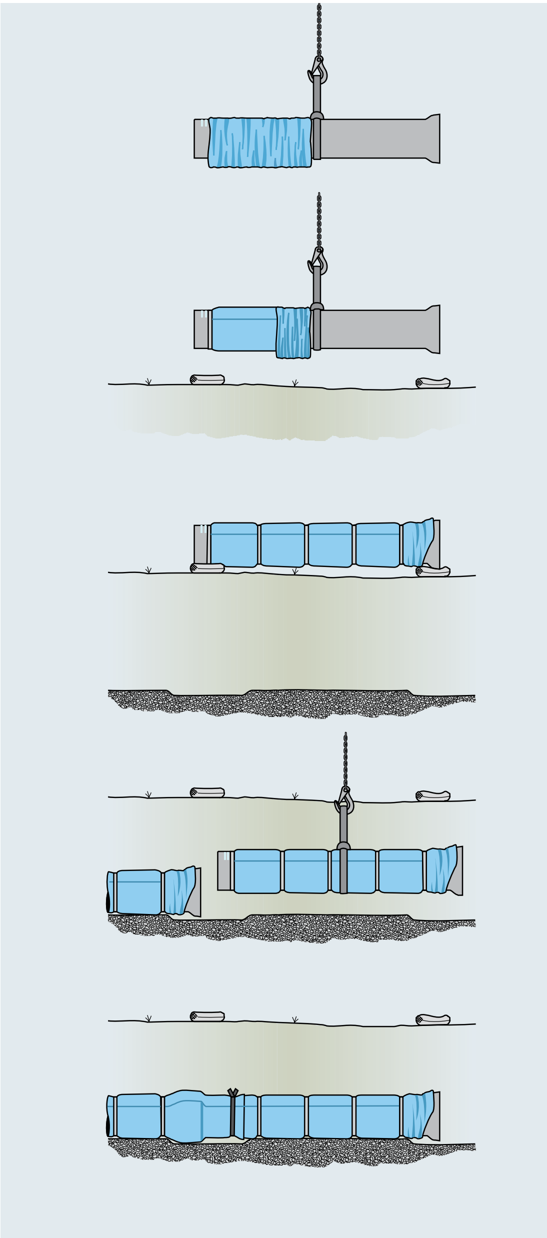


APPLICATION OF LOOSE POLYETHYLENE

Protection against corrosion is ensured by following these important points.

- Sleeving type - only SuperTYT polyethylene sleeving is recommended.
- -A clean pipe - there should be no dirt or soil trapped inside the sleeving.
- Spigot end seal - the sleeving must be sealed to the pipe at the spigot end to stop free flow of water under the sleeving.
- Fold on top - the pipe should be laid with the fold in the sleeving on top so that the triple thickness gives extra protection.
- Close, snug fit - the sleeving should fit the pipe snugly, to reduce any water inside to a minimum.
- Overlap seal - the sleeving overlap from each pipe should be sealed to the sleeving of the next using strap and buckle.
- Inspection - the sleeving should be inspected for damage just before laying and again before backfilling.
- Restoration - all holes or tears must be repaired and all free edges sealed to ensure a continuous barrier, especially if there are any changes to the pipeline.
- Safe surround - the pipe must be surrounded with a granular material with no sharp edges which could damage the sleeving.

Sleeving pipe with SuperTYT polyethyene sleeving at Kuala Lumpur International Airport



PIPELINE SLEEVING PROCEDURE

The following procedures are in line with ISO 8180 – 'Guidelines for the Application of Polyethylene Sleeving to Ductile Iron Pipelines and Fittings'.

1. Lift the pipe to the sleeving area. Check the pipe surface is free from any adherent soil.

   Remove a sleeve from the roll and draw it over the spigot end of the pipe. Draw the entire sleeve onto the raised end of the pipe, bunching the sleeving in concertina fashion toward the sling.

2. Locate the sleeve end on the line of diamonds near the spigot end. Pull the sleeving tightly around the pipe barrel, over a length of approximately 1.5m from the spigot end, and fold the surplus over to form a triple layer thickness of sleeving on top of the pipe.

   Secure the sleeve end to the pipe by sealing the free edge to the pipe with three overlapping turns of tape.

   Work loose sleeving toward the sling and secure the fold with tape. Lower onto sand bags and remove sling.

3. Spread the bunched sleeve toward the socket, tightly wrapping and securing the fold with tape at 1m intervals.

4. Lower the pipe into the trench after ensuring that a suitable depression has been made in the bedding at the joint to allow the overlap to be made.

5. Locate the spigot of the pipe in the preceding socket when bedding the pipe. Remove the sling and complete assembly of the joint.

   Draw the bunched sleeving from behind the socket of the preceding pipe over the joint onto the barrel of the next pipe. Care should be taken to avoid scooping backfill into the sleeving as it is pulled across the bedding depression.

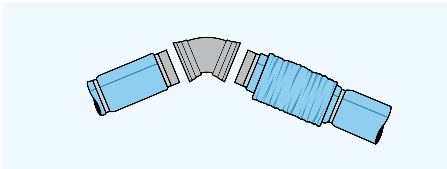
   Ensure the overlapping sleeving follows the contour of the joint, avoiding bridging of irregular profiles.

6. Secure the overlap to the sleeved barrel of the last pipe using strap and buckle.

SLEEVING FITTINGS

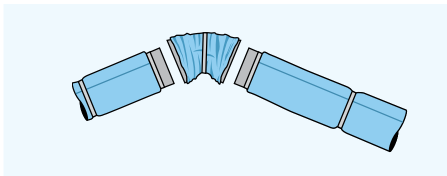
BENDS – METHOD A

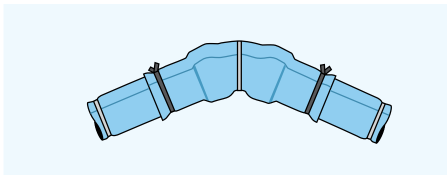
1. Where the body of the bend is too short to be sleeved separately, cut a piece of sleeving of sufficient length to extend from the barrels of the pipes on either side of the bend.
2. Make the joint at one side of the bend. Slide the short length of sleeving loosely onto the spigot end of the pipe to be jointed and make the joint
3. After jointing draw the joint sleeve over the joint, fold neatly with the overlap at the crown and secure with strap and buckle. The strap must overlap the ends of the joint sleeve onto the sleeving on the pipe barrel to effect a seal. It is essential that the joint sleeve should follow the contour of the joint to prevent damage by backfilling material.



BENDS – METHOD B

1. Where the body of the bend is long enough to permit sleeving, cut a piece of sleeving long enough to cover the bend and overlap the ends by about 300mm.
2. Put the sleeving onto the bend with overlap on each side, make a fold at the top and secure with turns of tape around the centre of the bend.
3. Ease the bunched sleeving over each joint onto the barrel of the pipe.
4. Fold the ends of the sleeve and seal them to the sleeved pipes with strap and buckle.





TEES

Step One

1. Two pieces of sleeving are needed, one for the branch and one for the body.
2. Piece 1 should be cut to point A along the top edge so it can be fitted along the whole body.
3. Piece 2 should be cut to point B on both edges so it can be fitted over the branch.

Step Two

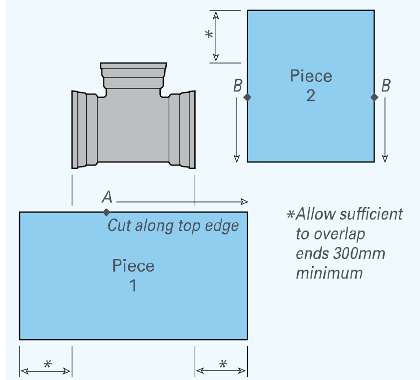
1. Lift fitting using a webbing sling around the socket of the branch.
2. Pull sleeving onto the body. Overlap and seal the edges. Tape around the body of the tee behind each socket.

Step Three

1. Lower the tee onto sandbags.
2. Pull the second piece of sleeving over the branch. Pull the sleeving down to make a snug fit and tape around the socket. Tape the flaps to the body of the tee.

Step Four

Install tee into pipeline and seal overlaps to sleeved pipes with strap and buck.



BACKFILLING

Prior to testing, the trench should be backfilled and compacted around the pipe barrel to prevent the pipeline from moving during testing. Joints may be left accessible for subsequent examination. In badly drained ground or where heavy rain is expected, finished sections should not be left unfilled as there is a risk that the pipeline could be moved by flotation. Backfilling of a trench depends on the resulting use to which the ground will be put. Backfilling can be broken up into zones as shown in the diagram below.

ZONE A

This material provides support to the pipeline enabling it to with-stand external loads. The higher the external loading (depth of trench or vehicle loading) the higher the grade of material to be used or the greater the degree of compaction to be carried out. If the excavated material is not suitable to provide the support required, imported fill must be used.

ZONE B

This material provides a cushion of stone-free material to prevent stones or other sharp objects imparting high point loads to the pipeline and is normally compacted to the same degree as Zone A. Where special material is used for Zone A the same material would be used for Zone B.

ZONE C

This remaining fill material builds the trench up to the original ground level and the degree of compaction required is dependent on the resulting allowable surface settlement. Under roads and in other certain locations the load carrying capacity of the ground surface is important and the backfill must be carefully compacted in thin layers to avoid residual settlement. Where backfilling is carried out in trenches across open land the compaction requirements are not normally as stringent and the surface can be slightly built up to allow for a degree of future settlement. The material used would normally be the excavated trench material, however, where very high levels of compaction are required in bad natural ground, imported fill might be required.

ZONE D

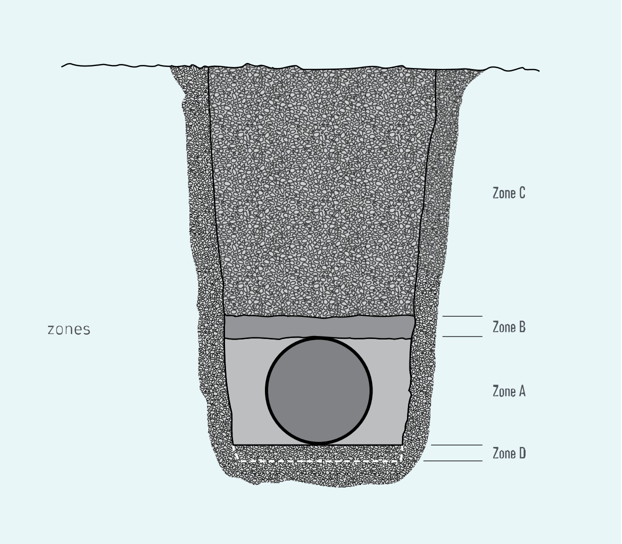
Where rock is encountered, a bedding layer, usually of imported granular material, should be used to prevent point loads on the pipe invert.

TRENCH TYPES

ISO requirements allow for five standard trench types which specify

TRENCH TYPE	DEGREE OF COMPACTION	STANDARD PROCTOR DENSITY
1	Dumped	<70%
2	Tamped	>70%
3	Light	>80%
4	Medium	>85%
5	High	>95%

Typical trench backfill



Pipeline construction in Riyadh, Saudi Arabia

PIPELINE PRESSURE TESTING

Pipelines are subjected to site test pressures for the purpose of checking:

1. The mechanical soundness and leak tightness of pipes and fittings.
2. The leak tightness of joints.
3. The soundness of any construction work such as anchorages.
4. The quality of workmanship of the pipelayers and jointers. All pipelines should be tested before being brought into service. Generally, mains to carry liquids are hydrostatically tested and mains to carry gases are pneumatically tested.

HYDROSTATIC TESTING

The length of each section to be tested depends on:

1. Availability of suitable volumes of water.
2. Number of joints to be inspected.
3. Difference in elevations between one part of the pipeline and another in the same test section.

Prior to testing, the trench should be backfilled and compacted on the pipe barrels only to prevent the pipeline from moving during testing. Joints may be left accessible for subsequent examination. Concrete in all thrust blocks should be cured before any hydrostatic test is carried out. End caps or blank flanges can be used to seal the line.

The sealed end should be temporarily anchored securely. Filling of the test section should be at a slow rate to ensure displacement of all air through vents at high points. An allowance should be made for the slow absorption of water by the concrete lining. This can be offset by allowing a 24 hour soaking period before testing.

Water should be pumped in until the test pressure is reached. As a guide, water loses one thousandth (i.e. 1/1000) of its volume for each 2 MPa of pressure applied, for example a section of main holding 1000 litres completely filled with water would require an additional 2.25 litres to be pumped in to raise the pressure to 4.5 MPa, assuming the volume of the main does not increase due to stretch (bulk modulus of elasticity of water is approximately 2 x 109 N/m2). The test pressure should be measured at the lowest point of the section under test or a static head allowance between the lowest point and the point of measurement should be made to ensure that the required test pressure is not exceeded. If the pressure has dropped at the end of the test period, the quantity of water required to increase the pressure to the original test pressure should be established. For normal installations it is considered satisfactory if the quantity of water added does not exceed 0.1 litres per millimetre of pipe diameter per kilometre of pipeline for 24 hours for each 30 metres head of pressure.

The site test pressure will normally be specified in the relevant contract documents. Maximum recommended site test pressures for ductile iron pipelines are shown in the Pipeline Component Data section (see pages 9 and 11).

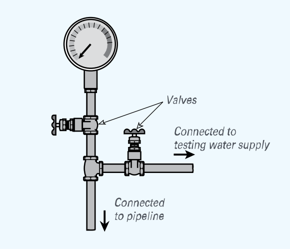
AIR TESTING OF WATER MAINS

On occasions when water is not available for testing, air is recommended. This test is to prove the tightness of the joints rather than the full strength of the pipeline. Normally, a pneumatic test with air pressure not exceeding 0.21 N/mm2 (30 lbf/in2) may be used. Owing to the compressibility of air, large volumes have to be introduced into the pipeline to slightly raise the pressure and consequently large volumes must escape to significantly reduce the pressure. Safety considerations should be strictly observed during all air tests. It is difficult to easily detect leaks in air pressurised mains unless in water-logged ground. Soap solution can be used to examine individual joints. It is normal to allow the pipeline to remain at the test pressure for at least 24 hours. Extended testing periods may be required for larger diameter pipelines. An allowance should be made for temperature and atmospheric pressure variations when measuring any reduction in applied pressure.

COMMISSIONING WATER PIPELINES

Where a hydrostatic test has been applied the test water should be drained from the line. A pipeline which will carry potable water should be swabbed and sterilised with chlorinated water. After standing for the prescribed period, the water should be tested for residual chlorine to ensure sterilisation has been achieved. Potable water may then be used to displace the chlorinated water. The pipeline should not be put into service until bacteriological tests of water delivered at the end of the pipeline show that a satisfactory potable standard has been achieved.

Typical standpipe used for testing



METRIC UNITS

Prefixes used to form the names and symbols of SI units used in these conversion tables are given below.

PREFIX	SI	FACTOR BY WHICH BASE UNIT IS MULTIPLIED	
tera	T	10^{12}	= 1 000 000 000 000
giga	G	10^{9}	= 1 000 000 000
mega	M	10^{6}	= 1 000 000
kilo	k	10^{3}	= 1 000
hecto*	h	10^{2}	= 100
deka*	da	10	= 10
deci*	d	10^{-1}	= 0.1
centi*	c	10^{-2}	= 0.01
milli	m	10^{-3}	= 0.001
micro	m	10^{-6}	= 0.000 001
nano	n	10^{-9}	= 0.000 000 001
pico	p	10^{-12}	= 0.000 000 000 001
femto	f	10^{-15}	= 0.000 000 000 000 001
atto	a	10^{-18}	= 0.000 000 000 000 000 001

*These multiples with corresponding names and symbols are not preferred and their use should be limited.

COMMON APPROXIMATE CONVERSIONS

Pressure N/mm²	=	1 MPa
1 psi	=	6.9 kPa
1 atmosphere	=	101.325 kPa
	=	10.33 m head of water
	=	1 bar
	=	760 cm Hg
1 kg	=	2.2 lb
1″	=	25.4 mm
1 UKgallon	=	4.55 l
1 kg	=	9.81 N
1 UK gallon	=	1.2 USgallon
1 m³	=	1000 l = 1 kl
1 Joule	=	1 Nm
1 kN/m	=	1 N/mm

RULES OF THUMB

Headloss a	$1/D^2$

USEFUL METRIC UNITS WITH IMPERIAL CONVERSIONS

ACCELERATION		
1 ft/s²	0.3048	m/s²
AREA		
1 in²	6.4516	cm²
1 ft²	0.092903	m²
1 yd²	0.836127	m²
1 acre	4046.86	m² = 0.404686 ha
1 sq mile	2.58999	km² = 258.999 ha
CALORIFIC VALUE OR SPECIFIC ENTHALPY		
1 Btu/ft³	37.2589	kJ/m³
1 Btu/lb	2.326	kJ/kg
1 cal/g	4.1868	J/g
1 kcal/m³	4.1868	kJ/m³
DENSITY		
1 lb/ft³	16.0185	kg/m³
1 lb/UK gal	99.7763	kg/m³
1 lb/US gal	119.826	kg/m³ = 0.1198 kg/l
1 slug/ft³	515.379	kg/m³
1 ton/yd³	1328.94	kg/m³
1 lb/in³	27680	kg/m³

DYNAMIC VISCOSITY		
1 lb/ft s	1.48816	kg/m s
ELECTRIC STRESS		
1 kV/in	0.039370	kV/mm
ENERGY, HEAT OR WORK		
1 erg	10^{-7}	J
1 hp h (horsepower hour)	2.68452	MJ
1 thermie		
= 10 cal	4.1855	MJ
1 therm		
= 100 000 Btu	105.506	MJ
1 therm		
1 cal	4.1868	J
1 Btu	1.05506	kJ
1 kWh	3.6	MJ

FORCE OR WEIGHT		
1 dyne	10^{-3}	N
1 pdl (poundal)	0.138255	N
1 ozf (ounce)	0.278014	N
1 lbf	4.44822	N
1 kgf	9.80665	N
1 tonf	9.96402	kN
FORCE OR WEIGHT PER UNIT LENGTH		
1 lbf/ft	14.5939	N/m
1 lbf/in.	175.127	N/m
1 tonf/ft	32.6903	kN/m
FORCE (WEIGHT) PER UNIT AREA OR PRESSURE OR STRESS		
1 pdl/ft²	1.48816	N/m²
1 lbf/ft²	47.8803	N/m²
1 mm Hg	133.322	N/m²
1 in H_2O	249.089	N/m²
1 ft H_2O	2989.07	N/m²
1 in. Hg	3386.39	N/m²
1 lbf/in²	6.89476	kN/m²
1 bar	= 105	N/m²
1 std.		
atmosphere	101.325	kN/m² = 1.01325 bar
1 tonf/ft²	107.252	kN/m²
1 tonf/in²	15.4443	MN/m² = 1.54443 hectobar
1 mm H_2O	= 9.8067	N/m² (= g)
SPECIFIC WEIGHT		
1 lbf/ft³	157.088	N/m³
1 lbf/UKgal	978.471	N/m³
1 tonf/yd³	13.0324	kN/m³
1 lbf/in³	271.447	kN/m³
GAS CONSTANT		
1 ft lbf/lb R_0	0.00538032	kJ/kg K
HEAT		
HEAT FLOW RATE		
1 Btu/h	0.293071	W
1 kcal/h	1.163	W
1 cal/s	4.1868	W
SPECIFIC HEAT CAPACITY		
1 Btu/lb F°	4. 1868	kJ/kg K
1 cal/g C°	4.1868	kJ/kg K
INTENSITY OF HEAT FLOW RATE		
1 Btu/ft²h	3.15459	W/m²
KINEMATIC VISCOSITY		
1 ft²/s	929.03 stokes = 0.092903	m²/s

LENGTH		
1 in	25.4	mm
1 ft	0.3048	m
1 yd	0.9144	m
1 fathom	1.8288	m
chain	20.1168	m
1 mile	1.60934	km
1 International nautical mile	1.852	km
1 UKnautical mile	1.85318	km
MASS		
1 grain	64.7989	mg
1 dram (avoir.)	0.00177185	kg
1 drachm (apoth.)	0.00388793	kg
1 ounce (troy or apoth.)	0.0311035	kg
1 oz (avoir.)	28.3495	g
1 lb	0.45359237	kg
1 lb	0.45359237	kg
1 slug	14.5939	kg
1 sh cwt (US hundredweight)	45.3592	kg
1 cwt (UKhundredweight)	50.8023	kg
1 UK ton	1016.05	kg
1 short ton	907.185	kg
MASS PER UNIT LENGTH		
1 lb/yd	0.496055	kg/m
1 UK ton/mile	0.631342	kg/m
1 UK ton/1000 yd	1.11116	kg/m
1 oz/in	1.11612	kg/m
1 lb/ft	1.48816	kg/m
1 lb/in	17.8580	kg/m
MASS PER UNIT AREA		
1 lb/acre	1.12085×10^{-4}	kg/m²
1 UK cwt/acre	0.0125535	kg/m²
1 oz/yd²	0.0339057	kg/m²
1 UK ton/acre	0.251071	kg/m²
1 oz/ft²	0.305152	kg/m²
1 lb/ft²	4.88243	kg/m²
1 lb/in²	703.070	kg/m²
1 UK ton/mile²	3.92298×10^{-4}	kg/m²
MASS FLOW RATE		
1 lb/h	1.25998×10^{-4}	kg/s
1 UKton/h	0.282235	kg/s

MOMENT, TORQUE OR COUPLE		
1 ozf in (ounce-force inch)	0.00706155	Nm
1 pdl ft	0.0421401	Nm
1 lbf in	0.112985	Nm
1 lbf ft	1.35582	Nm
1 tonf ft	3037.03	Nm = 3.03703 kNm
2ND MOMENT OF AREA		
1 in^4	41.6231	cm^4
1 ft^4	0.00863097	m = 86.3097dm^4
Moment of Inertia		
1 lb ft^2	0.0421401	kg m^2
1 slug ft^2	1.35582	kg m^2
Plane Angle		
1 rad (radian)	57.2958°	
1 degree	0.0174533 rad = 1.1111 grade	
1 minute	2.90888x10^{-4} rad = 0.0185 grade	
1 second	4.84814x10^{-6} rad = 0.0003 grade	
POWER		
1 hp = 550 ft lbf/s	0.745700	kW
1 metric horsepower (ch, PS)	735.499	W
SPECIFIC ENTROPY		
1 Btu/lb R_0	4.1868	kJ/kg K
THERMAL CONDUCTIVITY		
1 cal cm/cm^2s C°	41.868	W/m K
1 Btu ft/ft^2h F°	1.73073	W/m K
VELOCITY		
1 in./min	0.042333	cm/s
1 ft/min	0.00508	m/s
1 ft/s	0.3048	m/s
1 mile/h	1.60934	km/h
1 UKknot	1.85318	km/h
1 International knot	1.852	km/h
VELOCITY OF ROTATION		
1 rev/min	0.104720 rad/s	

VOLUME		
1 UK minim	0.0591938	cm^3
1 UKfluid drachm	3.55163	cm^3
1 UKfluid ounce	28.4131	cm^3
1 US fluid ounce	29.5735	cm^3
1 USliquid pint	473.176	cm^3 = 0.4732 dm^3 (= litre)
1 US dry pint	550.610	cm^3 = 0.5506 dm^3
1 Imperial pint	568.261	cm^3 = 0.5683 dm^3
1 UK gallon	4.54609	dm^3
1 US gallon	3.78541	dm^3
1 in^3	16.3871	cm^3
1 ft^3	0.0283168	m^3
1 yd^3	0.764555	m^3
SPECIFIC VOLUME		
1 in^3/lb	36.1273	cm^3/kg
1 ft^3/lb	0.0624280	m^3/kg

SuperTYT

QUALITY ACCREDITATION

Products supplied with the SuperTYT Brand come with the following Third Party Product and Quality System certifications.

BSI KITEMARK APPROVAL

BS EN 545
BS EN 598
BS ISO 2531

WRAS MATERIAL APPROVAL

BS 6920

NGV QUALITY ASSURANCE CERTIFICATION

ISO 9001