RADIUS
Systems

Gravity Sewer Systems

Ultra-Rib and Ultra Fortis Technical Information

Published by Radius Systems Ltd., Berristowe Lane, Blackwell, Derbyshire, DE55 5JD, as an electronic publication available from their website www.radius-systems.co.uk

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Contents

ULTRA-RIB AND ULTRA FORTIS HANDLING AND STORAGE

1.1. Handling of Ultra-Rib and Ultra Fortis

Any diameter, 3 m stick, of either Ultra-Rib or Ultra Fortis can easily be handled by one person, however mechanical aid will be required for framed bundles. As a guide, the approximate weight of a 1 m length of Ultra-Rib and Ultra Fortis pipe, a 3 m stick and pack weights are specified within **Table (1)**. Radius Systems' sewer pipes are lightweight, robust and site tolerant. this site tolerances is specifically demonstrated by their impact toughness.

Table 1. Approximate Weight of pipes

Nominal Diameter	**150mm**			**225mm**			**300mm**		
Per Unit	metre	Stick	Pack	metre	Stick	Pack	metre	Stick	Pack
	kg/m	kg/3m	kg/90m	kg/m	kg/3m	kg/36m	kg/m	kg/3m	kg/27m
Ultra Fortis	2.0	6.0	180	4.0	12.0	144	7.0	21.0	189
Ultra-Rib	1.9	5.7	171	5.0	15.0	180	7.8	23.4	210

Table 1

Table 2. Pack Quantities

Nominal Diameter	**Units**	**150 mm**	**225 mm**	**300 mm**
Pipes per pack	No	30	12	9
Pack Length	m	3.25	3.25	3.5
Pack Height	m	0.92	0.82	1.06
Pack Width	m	1.13	1.12	1.14

Table 2

As Ultra-Rib and Ultra Fortis are so easily handled, care should be taken, especially when unloading, stacking and distributing on site. When pipes are lifted mechanically, slings should be used; the pack dimensions are included in **table (2)** for transportation and site storage. During transportation, pipes should not overhang by more than one metre and care should be taken to ensure that there are no sharp projections, that could damage the pipes.

1.2. Storage of Ultra-Rib and Ultra Fortis

Ultra-Rib and Ultra Fortis should be stacked on flat firm ground, which has been cleared of debris. Pipes should be laid flat or on transverse bearers at least 75 mm wide at 1 m centres. Side supports with a minimum bearing width of 75 mm should be placed at intervals of 1.5 m or less.

For extended storage, waterproof sheeting should cover pipes and fittings, but good ventilation should be allowed, clear plastic sheeting must be avoided as it can produce a greenhouse effect.

Different types and sizes of pipes are best stacked separately; if this is unpractical, stack the larger pipes at the base. Pipes should not be nested for long periods and stacks should not exceed seven layers or 2 m in height. Framed packs must be stored timber on timber and maybe stacked up to three packs high.

When socketed pipes are stacked, the bottom layer of sockets should not be in contact with the ground, either by excavating under the socket, or preferably, by the use of transverse supports. Alternate layers should have the sockets protruding and at opposing ends.

Fittings should be stored in the boxes or bags supplied until ready for use. Sealing rings must be stored in their original packaging and not subjected to strong sunlight or weathering. They should never be stored on the ends of the pipes.

Section End

2. INSTALLATION AND STRUCTURAL DESIGN OF BURIED NON-PRESSURE ULTRA-RIB AND ULTRA FORTIS PIPELINES

Calculations for the structural design of buried Ultra-Rib or Ultra Fortis pipelines should be undertaken in accordance with the BS EN 1295-1:1998 procedure, (Structural design of buried pipelines under various conditions of loading). The 'flexible' design procedure should be used.

When either an Ultra-Rib or Ultra Fortis pipe is subjected to external pressure from soil, traffic or a combination of both, a passive resistance will be set-up between the pipe, pipe embedment and native soil. When designed correctly, this passive resistance will offer support to the pipe, thus controlling and limiting the degree of deformation that the pipe is subjected to.

The degree of deformation that a flexible pipe will undergo when buried and subjected to applied external soil and traffic pressures, is dependant on a number of factors, the most important of which are:

Pipe stiffness
Pipe embedment stiffness
Native soil stiffness
Applied external pressure

The Spangler 'Iowa' design theory is used to calculate the vertical deflection of a flexible pipe, which in its most basic form states:

$$\text{Pipe deformation} = \frac{\text{Vertical pressure on pipe}}{\text{Pipe stiffness + Soil stiffness}}$$

The design theory contained herein is for a single pipe in trench. Where there is more than one pipe in the trench then it is important to establish that each pipe is outside of the influence zone of the other pipe, that each pipe is fully supported and is not reliant on, nor is it applying additional pressure to the other pipe or pipes within the trench.

Where pipelines are installed in highways with a depth of cover to crown of less than 1.2 m, then there is a general requirement for additional protection to the pipeline. There are a number of installation details outlined within this guide for providing protection. Whichever detail is employed, assurance must be sought from the adopting or overseeing authority regarding the acceptance of the protection method employed.

2.1. Structural Design of Buried Ultra Rib or Ultra Fortis Pipelines

The following structural design procedure is detailed within BS EN 1295-1 and is re-stated here for convenience. Where additional guidance is required relating to this subject, then reference should be made to BS EN 1295-1.

The following information is required prior to commencing a structural design calculation for a flexible pipeline:

B_c	=	Outside diameter of pipe	(Table 3)
B_d	=	Effective width of trench	
E'_2	=	Embedment soil modulus	(Table 4)
E'_3	=	Native soil modulus	(Table 5)
P_e	=	Vertical soil pressure	(Table 6)
Ps	=	Surcharge pressure	(Table 6)
S_S	=	Short-term pipe stiffness	(Table 3)
S_L	=	Long-term pipe stiffness	(Table 3)
D_L	=	Deflection lag factor	(Table 4)
K_x	=	Deflection coefficient	(Table 4)
H	=	Depth of cover to pipe crown	
H_w	=	Height of water above pipe crown	

The following values are calculated using equations (1 to 8)

C_L	=	Soil modulus adjustment factor.	Eqn (1)
E'	=	Overall modulus of soil reaction.	Eqn (2)
$Fs_{(withsoil)}$	=	Factor of safety (with soil).	Eqn (4)
$Fs_{(withoutsoil)}$	=	Factor of safety (without soil).	Eqn (6)
$P_{crl(withsoil)}$	=	Long-term critical buckling pressure (with soil).	Eqn (3b)
$P_{crs(withsoil)}$	=	Short-term critical buckling pressure (with soil).	Eqn (3a)
$P_{crs(withoutsoil)}$	=	Critical buckling pressure (without soil).	Eqn (5)
$\Delta/D_{(Short-Term)}$	=	Short-term deflection.	Eqn (7)
$\Delta/D_{(Long-Term)}$	=	Long-term deflection.	Eqn (8)

2.1.1. Structural Design Reference Tables

Table 3a. Dimensional properties of Ultra-Rib pipes

DN	Nominal ID	Nominal OD	Pipe stiffness Short-term (S_S)	Pipe stiffness Long-term, 2 years (S_L)
mm	mm	mm	kPa	kPa
150	153.0	170	8.00	4.00
225	226.5	250	8.00	4.00
300	300.5	335	8.00	4.00

Table 3a.

Table 3b. Dimensional properties of Ultra Fortis pipes

DN	Nominal ID	Nominal OD	Pipe stiffness Short-term (S_S)	Pipe stiffness Long-term, 2 years (S_L)
mm	mm	mm	kPa	kPa
150	150.5	170	8.00	2.00
225	221.0	250	8.00	2.00
300	296.0	335	8.00	2.00

Table 3b.

Table 4. Flexible pipe embedment properties

Embedment class		**Class S1**					**Class S2**					**Class S3**			**Class S4**		
Deflection coefficient	Kx	K_x = 0.083					K_x = 0.083					K_x = 0.100			K_x = 0.100		
Compaction	Mp %	Un-compacted	80	85	90	95	Un-compacted	80	85	90	95	85	90	95	85	90	95
Modulus of soil reaction	E'_2 MPa	5	7	7	10	14	3	5	7	10	20	5	7	14	3	5	10
Deflection lag factor	D_L	1.5	1.25	1	1	1	1.5	1.3	1	1	1	2	1.3	1	2	1.3	1

Note 1. For construction details of embedment classes see **Table (5)**
Note 2. Quoted values of E'_2 assume pipeline will be installed below groundwater.
Note 3. Mp indicates modified Proctor density; The heavy compaction test in BS 1377

Table 4.

Table 5. Guide values of Spangler modulus for native soils

Soil type	Spangler modulus for soils in various conditions (MPa)						
Clay	Very hard	Hard	Very stiff	Stiff	Firm	Soft	Very soft
Others	Very dense	Dense	Medium dense	Loose	Very loose	NA	NA
Clay	11 to 14	10 to 11	6 to 10	4 to 6	3 to 4	1.5 to 3	0 to 1.5
Gravel	Over 40	15 to 40	9 to 15	5 to 9	3 to 5	NA	NA
Sand	15 to 20	9 to 15	4 to 9	2 to 4	1 to 2	NA	NA
Clayey, silty sand	10 to 15	6 to 10	2.5 to 6	1.5 to 2.5	0.5 to 1.5	NA	NA

Table 5.

Table 6. Transmitted Soil Pressures to Buried Pipelines

Depth m	Pe Soil kPa	Ps Field kPa	Ps Main kPa
1.20	23.54	27.80	62.80
1.30	25.50	24.70	58.60
1.40	27.46	22.00	55.00
1.50	29.42	19.80	51.80
1.60	31.38	17.80	49.00
1.70	33.34	16.10	46.50
1.80	35.30	14.70	44.30
1.90	37.27	13.40	42.20
2.00	39.23	12.30	40.30
2.20	43.15	10.40	36.90
2.40	47.07	8.89	33.90
2.60	50.99	7.69	31.20
2.80	54.92	6.72	28.80
3.00	58.84	5.91	26.70
3.20	62.76	5.24	24.70
3.40	66.69	4.67	22.90
3.60	70.61	4.19	21.30
3.80	74.53	3.78	19.80
4.00	78.45	3.43	18.50
4.50	88.26	2.73	15.60
5.00	98.07	2.23	13.30
5.50	107.90	1.85	11.40
6.00	117.70	1.56	9.92
6.50	127.50	1.30	8.67
7.00	137.30	1.15	7.63
8.00	156.90	0.88	6.02
9.00	176.50	0.69	4.86
10.00	196.10	0.57	4.00

Note 1. Soil pressure calculated using a soil density of 2000 kg/m^3.

Table 6.

Table 7. Flexible Pipe Embedments

Embedment class	Embedment configuration	Bed and sidefill materials	Notes
S1 and S2		Class S1: Gravel (single size) Class S2: Gravel (graded)	Normally processed granular materials
S3 and S4		Class S3: Sand and coarse grained soil with >12% fines. Class S4: Coarse grained soil with >12% fines **OR** Fine grained soil, liquid limit with <50%, medium to no plasticity and >25% coarse grained material.	These represent 'as dug' soils and, require particularly close control when used with low stiffness pipes.

Table 7.

2.1.2. Structural Design Equations

The soil modulus adjustment factor C_L, is calculated using **Equation (1)**, the soil modulus adjustment factor is applied to the embedment soil modulus to determine **the overall modulus of soil reaction E',**

$$C_L = \frac{0.985 + (0.544 B_d/B_c)}{(1.985 - 0.456(B_d/B_c))(E'_2/E'_3) - (1 - (B_d/B_c))} \quad \textbf{Eqn (1)}$$

The overall modulus of soil reaction E', is determined by use of **Equation (2)**. This soil support is attributed to a given diameter of pipe for a particular trench width, embedment and native soil combination.

$$E' = E'_2 C_L \quad \textbf{Eqn (2)}$$

NOTE: If the trench width is more than 4.3 times the external pipe diameter, the value of E' can be taken as equal to the value of E'_2.

Factor of safety against buckling, ($Fs_{(withsoil)}$): With soil support (this should be calculated for all cases, using **Equation (4) and the values for $P_{crs(withsoil)}$ and $P_{crl(withsoil)}$ from Equations (3a) and (3b)**. This factor of safety is determined to ensure that for a given external pressure, there is an adequate factor of safety against pipe buckling

$$P_{crs(withsoil)} = 0.6(S_S)^{0.33}(E')^{0.67} \quad \textbf{Eqn (3a)}$$

$$P_{crl(withsoil)} = 0.6(S_L)^{0.33}(E')^{0.67} \quad \textbf{Eqn (3b)}$$

$$Fs_{(withsoil)} = 1/((P_e/P_{crl}) + (P_s/P_{crs})) \quad \textbf{Eqn (4)}$$

For **Equation (3a and 3b),** the short-term (S_S) and the long-term (S_L) value of the pipe stiffness **(Table 3a or 3b)** are used to calculate P_{crs} and P_{crl} respectively.

Factor of safety against buckling, ($Fs_{(withoutsoil)}$): Without soil support (This case need only be considered when H<1.5m to cover the possible situation of adjacent excavations).

$$P_{crs(without\ soil)} = 24(S_S) \quad \textbf{Eqn (5)}$$

$$Fs_{(without\ soil)} = P_{crs(without\ soil)}/Pe \quad \textbf{Eqn (6)}$$

For **Equation (5)**, the short-term value of the pipe stiffness (S_s) is used to calculate P_{crs}.

Ovalisation Δ/D

$$\Delta/D_{(ShortTerm)} = \frac{K_x((D_L P_e) + P_s)}{8(S_S) + 0.061E'} \quad \textbf{Eqn (7)}$$

$$\Delta/D_{(LongTerm)} = \frac{K_x((D_L P_e) + P_s)}{8(S_L) + 0.061E'} \quad \textbf{Eqn (8)}$$

The vertical ovalisation of the pipe when subjected to applied soil and surcharge pressure is calculated using **Equation (7)** and **Equation (8)** for the short and long-term ovalisation respectively.

NOTE: The short-term ovalisation **Equation (7)** is obtained with the value of D_L set at 1.0, and the long-term deflection with a value of D_L from **Table (4)**

To obtain the pipe's percentage ovalisation, multiply both $\Delta/D_{(Short\text{-}Term)}$ and $\Delta/D_{(Long\text{-}Term)}$ by 100.

2.1.3. Buried Ultra Fortis installation, Example calculation

Installation criteria

Pipe type		Ultra Fortis
Pipe diameter		150mm
Cover depth		2 metre
Loading type		Main road
Trench width		0.525 metre
Native soil		Stiff clay
Embedment		
	Class	S2 (Graded gravel)
	Particle size	10-14mm
	Compaction	85% MPd

Design values

B_c	=	Outside diameter of pipe	0.17 m
B_d	=	Effective width of trench	0.525 m
D_L	=	Deflection lag factor (Short-term)	1.0
D_L	=	Deflection lag factor (Long-term)	1.0
E'_2	=	Embedment soil modulus	7 MPa
E'_3	=	Native soil modulus	4 MPa
Kx	=	Deflection coefficient	0.083
P_e	=	Vertical soil pressure	39.23 kPa
P_s	=	Surcharge pressure	40.30 kPa
S_S	=	Short-term pipe stiffness	8.00 kPa
S_L	=	Long-term pipe stiffness	2.00 kPa

Calculated values

CL	=	Soil modulus adjustment factor	0.86
E'	=	Overall modulus of soil reaction	6.022 MPa
Pcrl	=	Long-term critical pressure	257.00 kPa
Pcrs	=	Short-term critical pressure	406.08 kPa
Fs(with soil)	=	Factor of safety (with soil support)	3.97
Pcrs(without soil)	=	Short-term critical pressure (without soil)	192 kPa
Fs(without soil)	=	Factor of safety (without soil support)	4.89
Δ/D(Short-Term)	=	Ovalisation (Short-term)	1.53 %
Δ/D(Long-Term)	=	Ovalisation (Long-term)	1.72 %

The long term ovalisation has been based on a 2 year pipe stiffness value.

2.1.4. Buried Ultra Fortis Installation, Example Design Curve

The following graph details the percentage long term deflection and buckling safety factors, both with and without soil support, against depth of cover for compaction factors of 80,85,90, and 95% Modified Proctor Density.

This data set covers many typical Ultra Fortis installations as depicted in diagram 1 and outlined below.

- It is applicable for all sizes of Ultra Fortis with a trench width of three times the outside diameter of the chosen pipe.
- The loading condition is taken to be that of a main road and the bedding and side fill material is Class S2 Gravel (graded).
- Finally, a native soil modulus of 6 MPa has been chosen, and can be applicable for: loose gravel, medium dense sand, Medium dense to dense clayey, silty sand, and stiff to very stiff clay.

Minimum design Criteria in accordance with BS EN 1295-1

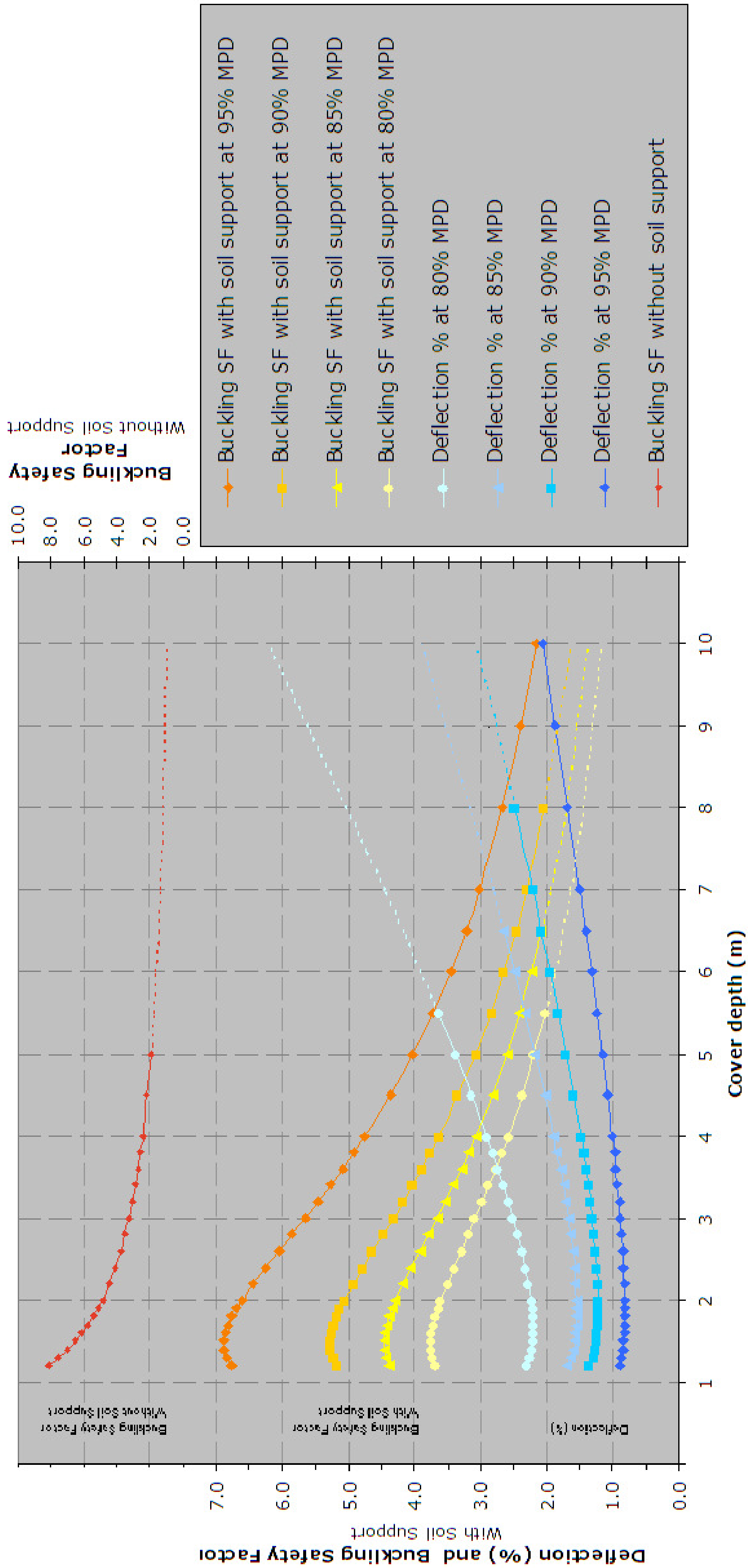
- Deformation must not exceed 6%
- Buckling Safety Factor should be greater than 2

Graph 1 is an illustration of a typical structural design; it can be used only if the conditions used to calculate the data match those of the installation.

All structural designs should be checked against the requirements of the adopting authority.

Ultra Fortis Structural Design BS EN 1295-1 Example curves

Main Road Loading, Native soil Mod 6 MPa, Trench 3 x pipe OD, Bedding and side fill material S2



NB. The dotted lines indicate the continuation of the curves below the minimum design criteria

2.2. Selection of pipe embedment and sidefill materials

As a general guide, the materials used for pipe embedment and sidefill should have the following properties. To enable a complete understanding of this subject however, this document should be read in conjunction with the water industry publications detailed on Page 22

1) In order to minimise the effects of point loading, the maximum particle size should not exceed those values specified within **Table (8)** of this guide.
2) They should be free flowing and easily worked to form a uniform level bedding to support the pipe, they should be easily distributed into the haunching zones of the pipe.
3) They should not break up when wet or when compacted.
4) The material grading distribution should be such that it will not allow material fines that are supporting the pipe to be washed away see **Table (8)**.
5) Materials contaminated with domestic, building or industrial waste must not be used.
6) Materials should be free from organic matter and should be non-combustible.
7) Pipe embedment materials should not be used in a frozen state.
8) Ideally, materials will require minimal compactive effort to enable their design density to be reached.
9) They should offer adequate support to the pipe without applying point loading or stress concentrations into the wall of the pipe.

NOTE:
Acceptance and the suitability of the materials used for pipe embedment must be sought from the adopting or overseeing authority prior to the pipe's installation.

Table 8. Processed granular bedding and sidefill materials for flexible pipes

Pipe nominal bore	**Nominal maximum particle size**	**Maximum CF value for acceptability (1)**	**Materials specified in British Standards (2)**
mm	mm	Non Pressure Pipe	
100	10	0.15	10mm nominal single size
Over 100 to 150	15	0.15	10 or 14mm nominal single size or 14mm to 5mm graded
Over 150 to 300	20	0.15	10, 14 or 20mm nominal single size or 14mm to 5mm graded or 20mm to 5mm graded
Over 300 to 550	20	0.15	14 or 20mm nominal single size or 14mm to 5mm graded or 20mm to 5mm graded
Over 550	40	0.15	14, 20 or 40mm single size Or 14mm to 5mm graded Or 20mm to 5mm graded Or 40mm to 5mm graded

Note 1. Processed granular materials to include aggregates to BS882, air-cooled blast furnace slag to BS1047 and lightweight aggregates to BS3797.
Note 2. Compaction Fraction value (CF)

Table 8.

2.3. Compaction fraction test to determine the CF value

As-dug non-cohesive bedding and sidefill materials on which the structural performance of the pipeline does depend should be evaluated using the compaction fraction test. Materials are suitable if the values obtained do not exceed those given in **Table (8)**.

Equipment required

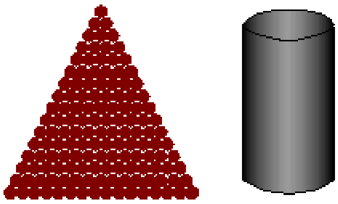
- Open ended cylinder, approximately 250 mm in length and having an internal diameter of 150 mm (+10 mm –5 mm).
- Metal rammer weighing between 0.8 and 1.3kg and having a striking face of approximately 40 mm diameter.
- Rule, 300 mm in length.

Method

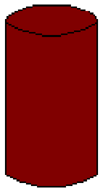
1. Obtain a representative sample* of material that is more than sufficient to fill the cylinder when it is placed on a flat clean surface. Ensure that the moisture content of the sample material does not differ from that used for bedding and sidefill purposes at the time of its use in the trench.
2. Ensure that the maximum particle size limitations of **Table (8)** are adhered to.
3. Stand the cylinder vertically upright on a firm flat surface and gently pour the sample material into it, without any compactive effort such as tamping or vibrating.
4. Strike off the sample material, flush with the surface of the cylinder and remove all surplus material.
5. Lift the cylinder clear of its contents and place on a firm flat surface.
6. Pour approximately 25% of the sample material into the cylinder and tamp with the metal rammer until no further compaction can be obtained.
7. Repeat with the second, third and forth quarter of material and ensure that the finished tamped surface is level. Care should be taken to ensure the sample material being compacted does not break during compaction.
8. Using a rule, measure from the finished tamped surface to the top of the cylinder. This measured distance divided by the cylinder length will give the compaction fraction of the sample material being tested.
9. The maximum acceptable compaction fraction value to be used with non pressure flexible pipelines is 0.15, (therefore for a cylinder 250mm in length, the depth of sample material in the cylinder after compaction should not be less than 212.5mm).

* To ensure that a representative sample of material is obtained, select approximately 50 kg of material. Using a shovel, turn this material 3 times and heap into a cone shape. Split this material into quarters by slicing vertically down the centre of the cone. Two of the opposite quarters should be discarded leaving one half of the original 50kg of material (approximately 25kg). This halving of material should be repeated until the required volume of sample material remains for the compaction fraction test.

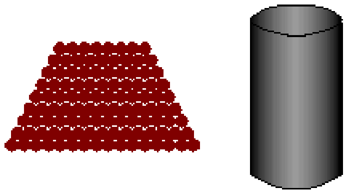
2.3.1. Compaction fraction test, graphical representation of procedure



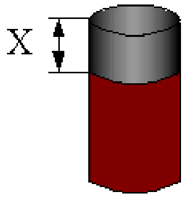
Step 1 Representative soil sample and open ended-cylinder, approximately 250mm in length and having an internal diameter of 150mm (+10mm –5mm).



Step 2 Cylinder filled with representative sample of soil and struck off flush with the cylinder surface.



Step 3 Empty contents of cylinder



Step 4 Pour approximately 25% of the sample material into the cylinder, tamp with a metal rammer until no further compaction can be obtained. Repeat with the second, third and forth quarter of material and ensure that the finished tamped surface is level. Care should be taken to ensure the sample material being compacted does not break during compaction. Using a rule, measure from the finished tamped surface of the tamped material to the top of the cylinder (X). This measured distance (X) divided by the cylinder length will give the compaction fraction of the sample material being tested

Step 5 Divide the value of 'X' by the cylinder length to obtain the compaction fraction, CF value; the value of CF should not exceed the values quoted in **Table (8).**

2.3.2. Recording of compaction fraction tests.

To ensure that accurate records of the materials used for the pipe embedment are maintained, it is recommended that the following information is recorded as a minimum for each compaction fraction test.

- Date of test

- Linear position along pipeline length
- Visual description of soil type
- Depth at which soil sample is taken
- Calculated value of the compaction fraction

Definitions

As-dug materials, Those materials generally derived from the soil excavated from the trench that is deemed suitable for use as pipe embedment without processing.

Pipe embedment, The zone around the pipe comprising the lower bedding, sidefill and initial backfill as shown in **diagram 1**

Compaction fraction, The value calculated by dividing the length of the depth of compacted soil in the test cylinder by the overall test cylinder length.

Note: Acceptance and the suitability of the materials used for pipe embedment must be sought from the adopting or overseeing authority prior to the pipe's installation.

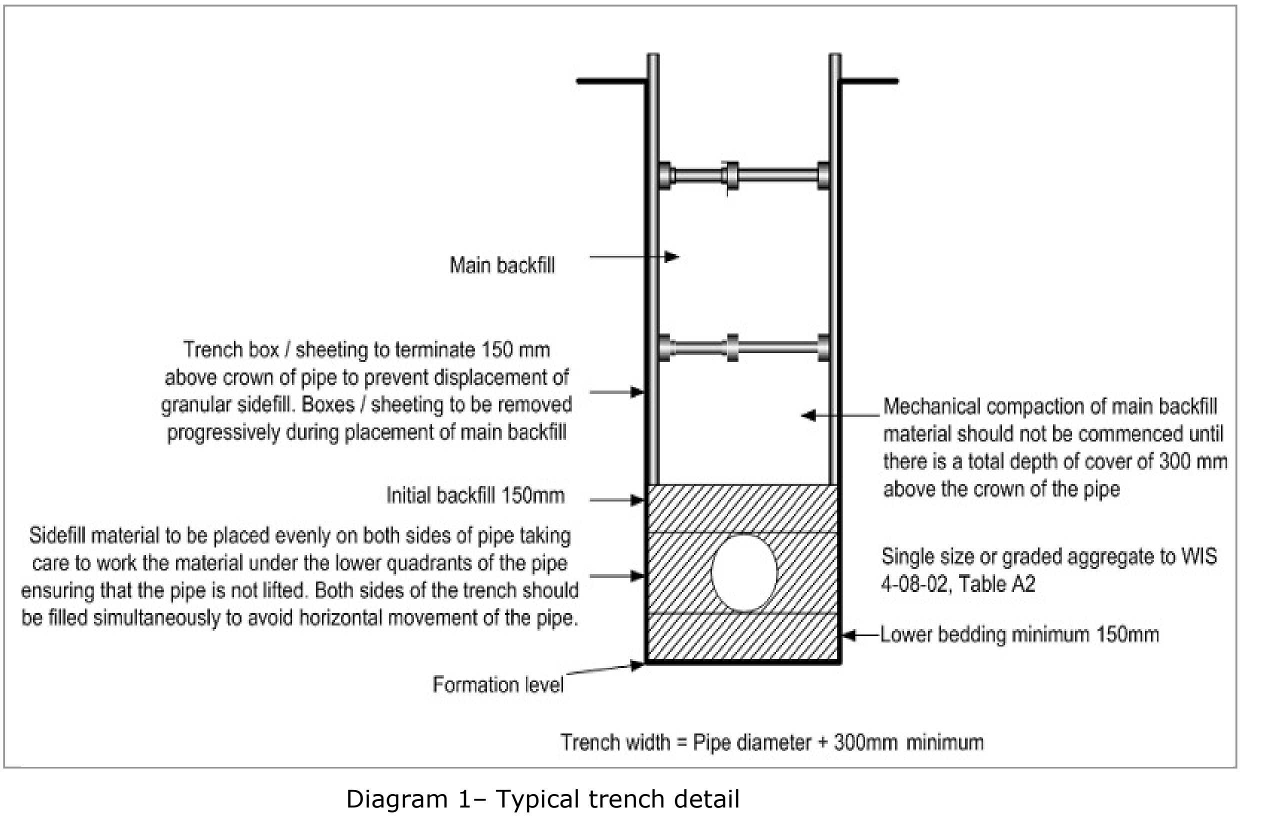


Diagram 1– Typical trench detail

2.4. Protection of pipelines installed at shallow depths.

Where Ultra-Rib or Ultra Fortis pipes are buried at shallow cover depths, generally taken as less than 1.2 m* cover to the pipe crown, there is a requirement to provide adequate protection to the pipe.

The purpose of this protection is:

1) To signify the presence of a buried service and offer adequate protection against third party damage.
2) To minimise the effects of applied concentrated wheel loadings.

Table 2.4 of Sewers for Adoption 6th Edition, gives guidance on each individual water company's preferred method of protection. Additional guidance may be referenced in Clause 5.5.3 of Sewers for Adoption 6th Edition

Diagrams 2 and 3of this guide show general details of protection methods, however the protection method and its precise detail and construction should be discussed in advance of installation with the adopting or overseeing authority to ensure compliance with their acceptance criteria.

In addition to the requirements detailed within Sewers for Adoption 6th Edition, there are requirements for ground stabilisation where pipelines are laid in close proximity to a building. For these installations, guidance may be obtained from the Building Regulations, Approved Document H. A typical installation detail is shown in diagram 2, again this detail and its construction method should be discussed in advance of installation with the adopting or overseeing authority to ensure compliance with their requirements.

* The required depth of cover for pipeline protection is dependant on the installation and the individual requirements of the adopting or overseeing authority.

Detail 'A'

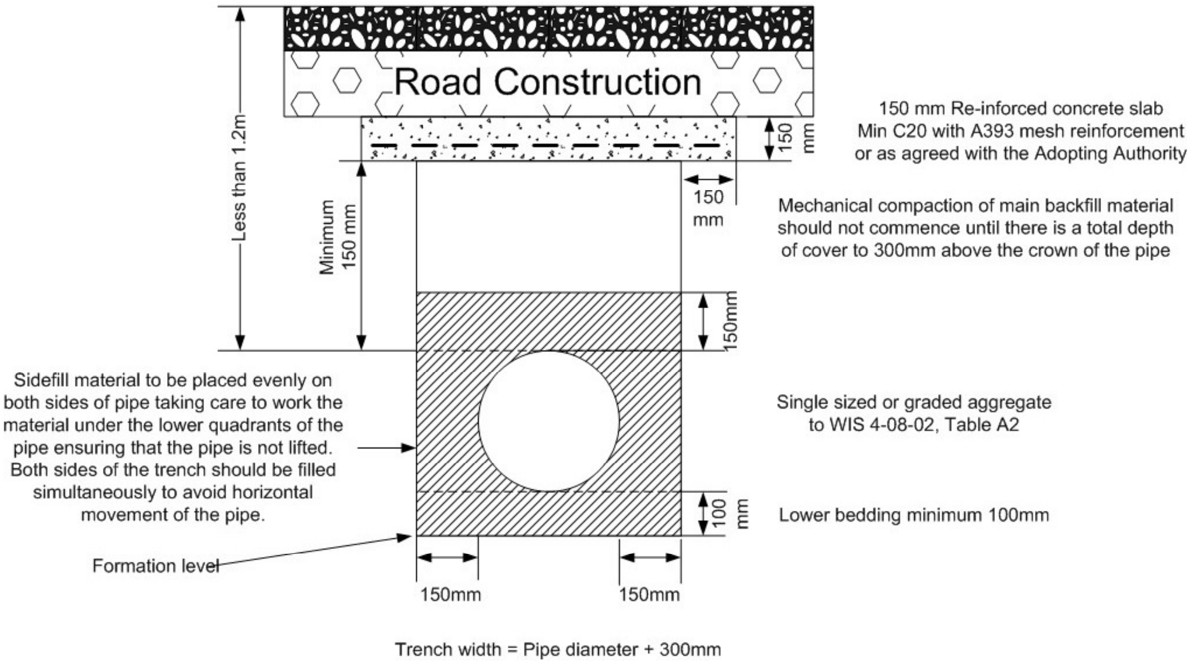
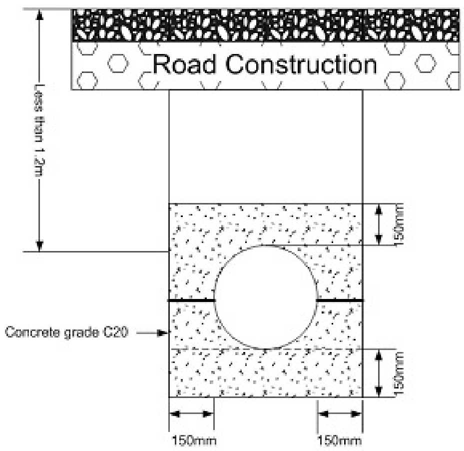
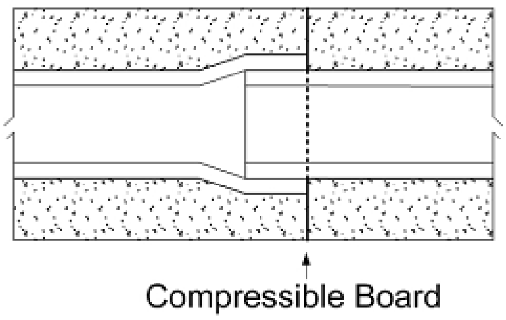


Diagram 2– Typical detail for guidance purposes, acceptance and the suitability of the method used for pipe protection must be sought from the adopting or overseeing authority prior to the pipe's installation**.**





Note: The concrete surround dimensions are for guidance purposes only.

Diagram 3 Concrete protection to shallow pipelines. (The maximum recommended maximum pipe length for use in this construction detail is 3m, a flexible break should be provided at each pipe joint)

2.5. Additional guidance on installation and structural design

Additional guidance on the subject of structural design, pipe embedment and shallow protection, may be found in the following publications:

BS EN 1295-1: 1998, *Structural design of buried pipelines under various conditions of loading, Part 1*.

BS EN 1610: 1998, *Construction and testing of drains and sewers*.

Information & Guidance Note 4-08-01, *Bedding and sidefill materials for buried pipelines.*

Water Industry Specification 4-08-02, *Specification for bedding and sidefill materials for buried pipelines.*

ENV 1046: 2001, *Plastics piping and ducting systems – Systems outside building structures for the conveyance of water or sewage – Practices for installation above and below ground*.

Water UK, *Sewers for adoption 6th Edition.*

Civil Engineering Specification for the Water Industry 6th Edition

The Building Regulations 2000, *Approved Document H*

Section End

3. HYDRAULIC FLOW IN ULTRA-RIB AND ULTRA FORTIS PIPES

The smooth bore of Ultra-Rib and Ultra Fortis pipes provides excellent hydraulic characteristics, resulting in low frictional resistance to liquid flow. For hydraulic design purposes, the metric form of the Colebrook-White equation is used

$$V = -2\sqrt{2gDi} \cdot \log\left\{\frac{Ks}{3.7D} + \frac{2.51\nu}{D\sqrt{2gDi}}\right\}$$

Where

V	=	Mean velocity in metres/second
g	=	Gravitational acceleration (a value of 9.807 m/sec^2 has been used)
i	=	Hydraulic gradient (Head loss in pipe / pipe length)
ν	=	Kinematic viscosity (a value of $1.141*10^{-6}$ m^2/sec has been used for water at 15°C)
Ks	=	Linear measure of pipe roughness in metres
D	=	Mean internal diameter of pipe in metres

The recommended 'frictional resistance coefficients (Ks)' to be used for the hydraulic design of Ultra-Rib and Ultra Fortis pipelines are

- Foul water sewers Ks = 0.0015 m (1.5 mm)
- Surface water sewers Ks = 0.0006 m (0.6 mm)

3.1. Full bore flow and velocity in Ultra-Rib pipelines

The values in **Table (9)** shown the full-bore velocity (V) and discharge (Q) and have been calculated using the following Ultra-Rib internal diameter values.

- 150mm nominal diameter = 0.1530 m (153.0 mm)
- 225mm nominal diameter = 0.2265 m (226.5 mm)
- 300mm nominal diameter = 0.3005 m (300.5 mm)

3.2. Full bore flow and velocity in Ultra Fortis pipelines

The values in **Table (10)** shown the full-bore velocity (V) and discharge (Q) and have been calculated using the following Ultra Fortis internal diameter values.

- 150mm nominal diameter = 0.1505 m (150.5 mm)
- 225mm nominal diameter = 0.2210 m (221.0 mm)
- 300mm nominal diameter = 0.2960 m (296.0 mm)

Table 9. The full-bore velocity (V) and discharge (Q) For Ultra Rib

Nominal Diameter		150 mm		225 mm		300 mm	
Velocity (V) & Discharge (Q) for Gradient (1 in X)		Ks = 0.6 mm	Ks = 1.5 mm	Ks = 0.6 mm	Ks = 1.5 mm	Ks = 0.6 mm	Ks = 1.5 mm
1	**(V) m/s**	10.29	8.92	13.24	11.57	15.85	13.93
	(Q) l/s	189.21	164.03	533.59	466.37	1124.25	987.87
5	**(V) m/s**	4.59	3.99	5.91	5.17	7.08	6.23
	(Q) l/s	84.46	73.29	238.29	208.43	502.19	441.55
10	**(V) m/s**	3.24	2.82	4.18	3.66	5.00	4.40
	(Q) l/s	59.64	51.79	168.32	147.31	354.79	312.10
20	**(V) m/s**	2.29	1.99	2.95	2.58	3.53	3.11
	(Q) l/s	42.09	36.59	118.85	104.09	250.56	220.56
30	**(V) m/s**	1.87	1.62	2.41	2.11	2.88	2.54
	(Q) l/s	34.32	29.86	96.93	84.95	204.39	180.01
40	**(V) m/s**	1.61	1.41	2.08	1.82	2.49	2.20
	(Q) l/s	29.69	25.84	83.86	73.53	176.87	155.83
50	**(V) m/s**	1.44	1.26	1.86	1.63	2.23	1.96
	(Q) l/s	26.53	23.10	74.95	65.75	158.09	139.34
60	**(V) m/s**	1.32	1.15	1.70	1.49	2.03	1.79
	(Q) l/s	24.19	21.08	68.37	60.00	144.22	127.16
70	**(V) m/s**	1.22	1.06	1.57	1.38	1.88	1.66
	(Q) l/s	22.38	19.51	63.25	55.53	133.45	117.69
80	**(V) m/s**	1.14	0.99	1.47	1.29	1.76	1.55
	(Q) l/s	20.92	18.24	59.13	51.93	124.76	110.07
90	**(V) m/s**	1.07	0.94	1.38	1.21	1.66	1.46
	(Q) l/s	19.70	17.19	55.72	48.94	117.57	103.75
100	**(V) m/s**	1.02	0.89	1.31	1.15	1.57	1.39
	(Q) l/s	18.68	16.30	52.83	46.42	111.48	98.40
110	**(V) m/s**	0.97	0.85	1.25	1.10	1.50	1.32
	(Q) l/s	17.80	15.54	50.34	44.25	106.25	93.80
120	**(V) m/s**	0.93	0.81	1.20	1.05	1.43	1.27
	(Q) l/s	17.03	14.87	48.17	42.35	101.68	89.79
130	**(V) m/s**	0.89	0.78	1.15	1.01	1.38	1.22
	(Q) l/s	16.35	14.29	46.26	40.68	97.65	86.25
140	**(V) m/s**	0.86	0.75	1.11	0.97	1.33	1.17
	(Q) l/s	15.75	13.76	44.56	39.19	94.06	83.10
150	**(V) m/s**	0.83	0.72	1.07	0.94	1.28	1.13
	(Q) l/s	15.21	13.29	43.03	37.86	90.84	80.27
160	**(V) m/s**	0.80	0.70	1.03	0.91	1.24	1.10
	(Q) l/s	14.72	12.87	41.65	36.65	87.92	77.70
170	**(V) m/s**	0.78	0.68	1.00	0.88	1.20	1.06
	(Q) l/s	14.27	12.48	40.39	35.55	85.27	75.37
180	**(V) m/s**	0.75	0.66	0.97	0.86	1.17	1.03
	(Q) l/s	13.86	12.12	39.23	34.54	82.84	73.24
190	**(V) m/s**	0.73	0.64	0.95	0.83	1.14	1.00
	(Q) l/s	13.48	11.80	38.17	33.61	80.60	71.27
200	**(V) m/s**	0.71	0.63	0.92	0.81	1.11	0.98
	(Q) l/s	13.14	11.50	37.19	32.75	78.54	69.46

Table 9

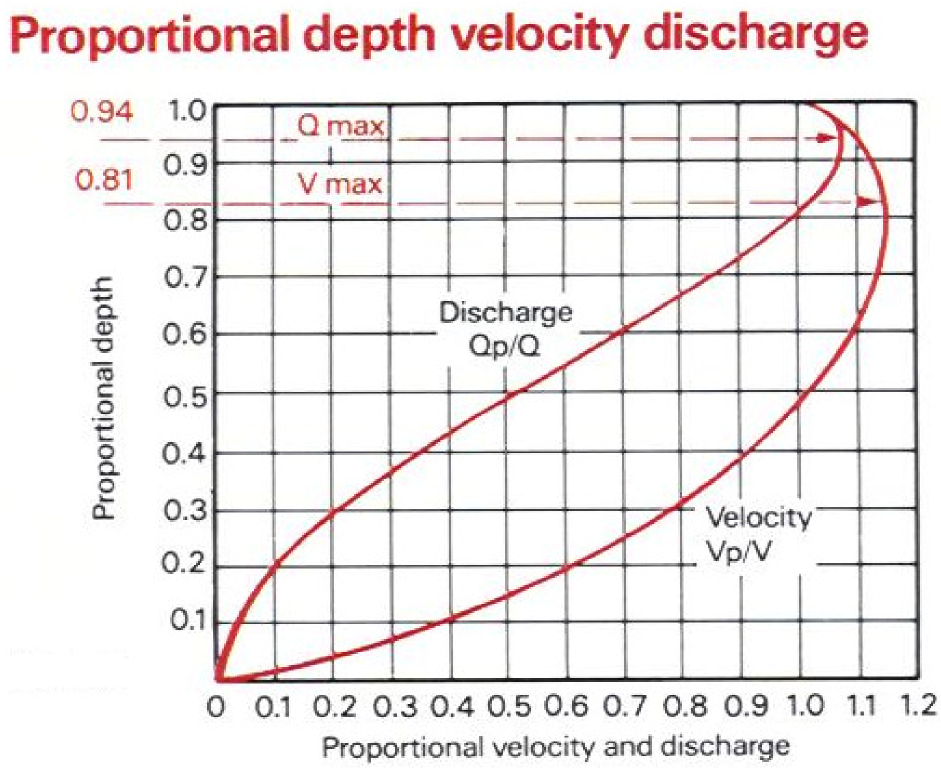
Table 10. The full-bore velocity (V) and discharge (Q) For Ultra Fortis

Nominal Diameter		150 mm		225 mm		300 mm	
Velocity (V) & Discharge (Q) for Gradient (1 in X)		Ks = 0.6 mm	Ks = 1.5 mm	Ks = 0.6 mm	Ks = 1.5 mm	Ks = 0.6 mm	Ks = 1.5 mm
1	**(V) m/s**	10.18	8.82	13.04	11.39	15.63	13.73
	(Q) l/s	181.13	156.97	500.08	436.86	1061.33	932.21
5	**(V) m/s**	4.55	3.94	5.82	5.09	6.98	6.14
	(Q) l/s	80.86	70.14	223.32	195.24	474.07	416.67
10	**(V) m/s**	3.21	2.79	4.11	3.60	4.93	4.34
	(Q) l/s	57.10	49.56	157.74	137.99	334.92	294.51
20	**(V) m/s**	2.27	1.97	2.90	2.54	3.48	3.07
	(Q) l/s	40.30	35.02	111.37	97.50	236.53	208.13
30	**(V) m/s**	1.85	1.61	2.37	2.07	2.84	2.50
	(Q) l/s	32.85	28.57	90.83	79.57	192.94	169.86
40	**(V) m/s**	1.60	1.39	2.05	1.80	2.46	2.17
	(Q) l/s	28.42	24.73	78.59	68.88	166.96	147.05
50	**(V) m/s**	1.43	1.24	1.83	1.61	2.20	1.94
	(Q) l/s	25.39	22.11	70.23	61.58	149.23	131.48
60	**(V) m/s**	1.30	1.13	1.67	1.47	2.01	1.77
	(Q) l/s	23.16	20.17	64.07	56.20	136.14	119.99
70	**(V) m/s**	1.20	1.05	1.55	1.36	1.86	1.64
	(Q) l/s	21.42	18.67	59.27	52.01	125.97	111.06
80	**(V) m/s**	1.13	0.98	1.44	1.27	1.73	1.53
	(Q) l/s	20.02	17.45	55.41	48.64	117.77	103.86
90	**(V) m/s**	1.06	0.92	1.36	1.20	1.63	1.44
	(Q) l/s	18.86	16.45	52.21	45.84	110.98	97.90
100	**(V) m/s**	1.01	0.88	1.29	1.13	1.55	1.37
	(Q) l/s	17.88	15.60	49.50	43.48	105.23	92.85
110	**(V) m/s**	0.96	0.84	1.23	1.08	1.48	1.30
	(Q) l/s	17.04	14.87	47.17	41.44	100.29	88.51
120	**(V) m/s**	0.92	0.80	1.18	1.03	1.41	1.25
	(Q) l/s	16.30	14.23	45.14	39.67	95.98	84.73
130	**(V) m/s**	0.88	0.77	1.13	0.99	1.36	1.20
	(Q) l/s	15.65	13.67	43.35	38.11	92.18	81.39
140	**(V) m/s**	0.85	0.74	1.09	0.96	1.31	1.16
	(Q) l/s	15.07	13.17	41.75	36.71	88.79	78.41
150	**(V) m/s**	0.82	0.71	1.05	0.92	1.26	1.12
	(Q) l/s	14.55	12.72	40.32	35.46	85.74	75.74
160	**(V) m/s**	0.79	0.69	1.02	0.89	1.22	1.08
	(Q) l/s	14.08	12.31	39.02	34.33	82.99	73.32
170	**(V) m/s**	0.77	0.67	0.99	0.87	1.19	1.05
	(Q) l/s	13.66	11.94	37.84	33.29	80.49	71.12
180	**(V) m/s**	0.75	0.65	0.96	0.84	1.15	1.02
	(Q) l/s	13.27	11.60	36.76	32.35	78.19	69.11
190	**(V) m/s**	0.73	0.63	0.93	0.82	1.12	0.99
	(Q) l/s	12.91	11.29	35.77	31.48	76.08	67.25
200	**(V) m/s**	0.71	0.62	0.91	0.80	1.09	0.97
	(Q) l/s	12.57	11.00	34.85	30.68	74.13	65.54

Table 10.

3.3. Proportional velocity and discharge.

The above values for full bore velocity and discharge should be used in conjunction with the proportional velocity and discharge curve below, to enable the full bore values to be adjusted to partial bore values for pipelines operating at less than full bore.



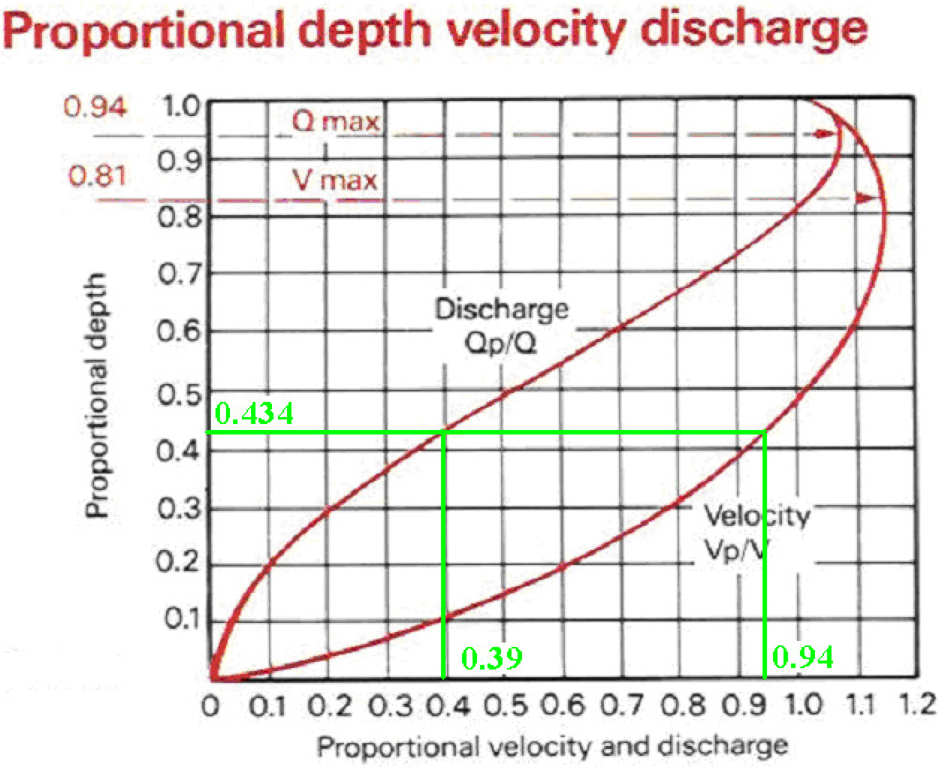
Example

An Ultra Fortis pipe is to be installed to take the surface water of 18 litres / second discharge from a property, the gradient that the pipeline is to be installed at is 1 in 110. What diameter of pipe is required and what is the full bore velocity and discharge and the partial velocity and depth of flow.

The discharge of 18 litres / second exceeds the full bore discharge of a 150mm diameter pipe when laid at a gradient of 1 in 110, therefore a 225mm diameter pipe (219 ID) has been selected.

Hydraulic roughness factor = 0.6mm (Surface water)
From the above tables:

- Full bore velocity = 1.22 m/sec
- Full bore discharge = 46.05 l/sec



The proportional depth and velocity of the pipeline is determined as follows:

Qp / Q = 18 / 46.05 = 0.391, read vertically upward from the x axis 0.391, until an intersection with the discharge Qp/Q is reached.

Read across from this intersection point to the Y axis to determine the proportional depth of flow 0.434 (43.4%) or 219 * 0.434 = 95.05mm (depth of flow).

Read across (right) from this intersection point to the intersection with the velocity Vp/v is reached and read of this value from the x axis 0.94, therefore the partial velocity for a flow rate of 18 litres / second is 0.94 * Full bore velocity = 0.94 * 1.22 = 1.147 metres / second.

3.4. Additional guidance on hydraulic flow

Additional guidance on the subject of Hydraulic flow may be found in the following publications:

BS EN 752-04, Drain and sewer systems outside buildings: hydraulic design and environmental considerations

Water UK, *Sewers for adoption 6th Edition.*

Section End

4. ULTRA-RIB AND ULTRA FORTIS PIPE AND FITTING JOINTING PROCEDURE

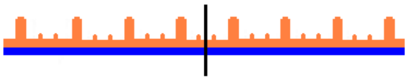
Both the Ultra-rib and Ultra Fortis systems use a simple spigot end and socket (push fit) joint system with a high performance non-handed rubber seal to provide a leak tight joint. Once the ring seal is positioned, between the 2^{nd} and 3^{rd} ribs it is captive and displacement during jointing should not occur.

Ultra-Rib or other sealing rings must not be used to joint Ultra Fortis pipes to Ultra Fortis pipes or Ultra Fortis pipes to Ultra Fortis fittings and conversely Ultra Fortis Ring seals must not be used to join Ultra-Rib pipes and fittings.

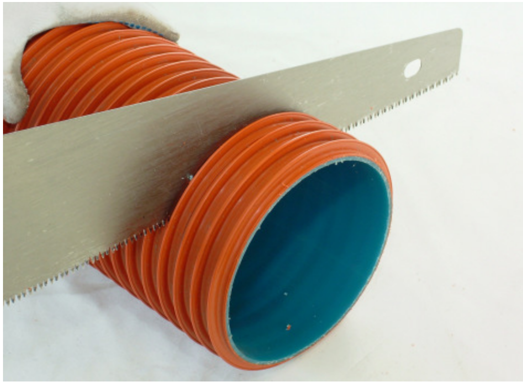
4.1. Installing an Ultra-rib or Ultra Fortis joint

The recommended jointing procedure is as follows:

1) Prior to jointing, ensure that the pipe is cut mid way between the larger ribs. The cut should be square to the pipe axis and the spigot end should be clean and free from cutting swarf.



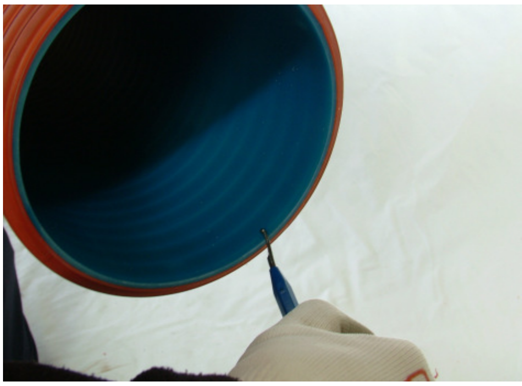
2) Where it is necessary to cut the pipe to length, ensure that it is cut mid way between the larger ribs and using a general purpose 10 tpi hand saw cut the pipe square to its longitudinal axis (as shown).



Radius Systems recommend that safety glasses and gloves be used for the cutting and jointing procedure
The sealing rings for Ultra Rib and Ultra Fortis are different, and care must be taken to ensure the correct ring seals are used.

3) Using a de-burring tool, remove the inner burr and cutting swarf from the pipe spigot.

Chamfering of the pipe spigot is not required.



4) Make sure that the spigot end of the pipe is clean and free from debris. Place the ring seal between the 2^{nd} and 3^{rd} ribs from the spigot end (as shown)

Ultra-Rib or other sealing rings must not be used to joint Ultra Fortis pipes to Ultra Fortis pipes or Ultra Fortis pipes to Ultra Fortis fittings and conversely Ultra Fortis Ring seals must not be used to join Ultra-Rib pipes and fittings.

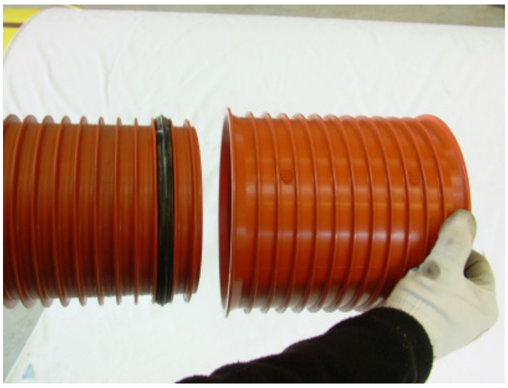
5) Make sure that the ring seal is correctly seated and is not twisted.

6) Using a brush, apply the recommended lubricant to the ring seal and socket.

The recommended lubricant is Vinoleo 77/14 and is supplied by Radius Systems .

Radius Systems recommend that safety glasses and gloves be used for the cutting and jointing procedure
The sealing rings for Ultra Rib and Ultra Fortis are different, and care must be taken to ensure the correct ring seals are used.

7) Offer the socket of the pipe or coupler up to the pipe spigot, ensure that they are correctly aligned to one another.



8) Push the pipe spigot into the socket until it is fully engaged. Where additional effort is required to complete the joint, the block and bar lever technique is recommended.

Under no circumstances should mechanical excavator buckets be used to complete the joint.

9) Where a coupler is used to join two pipe spigots, then the spigot of the adjoining pipe should be prepared and connected to the coupler using the above procedure.

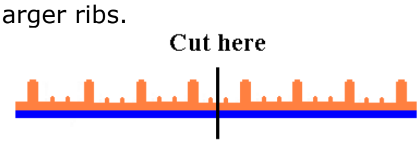
10) Where it is necessary to connect pipe spigots with the use of a slip coupler (without central register), the insertion depth of the coupler should be clearly marked on the spigot end of both pipes. For a correctly formed joint the insertion depth is equal to half the coupler length.
When the joint is complete, the insertion mark should be clearly visible and adjacent to the shoulder of both ends of the coupler.

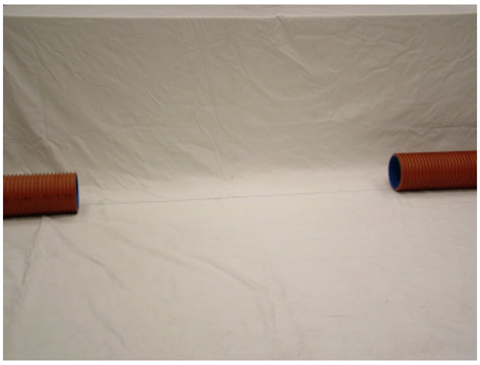
Radius Systems recommend that safety glasses and gloves be used for the cutting and jointing procedure
The sealing rings for Ultra Rib and Ultra Fortis are different, and care must be taken to ensure the correct ring seals are used.

4.2. Insertion of a branch into an Ultra-Rib or Ultra Fortis pipeline

Where there is a need to insert a branch connection into an existing Ultra Rib or Ultra Fortis pipeline, it is recommended that a branch and two slip couplers be used. The recommended procedure is as follows:

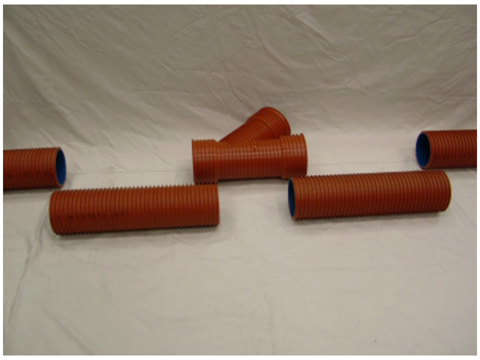
1) A section of pipe must be cut from the existing pipeline, ensure that the pipe is cut squarely to its axis and mid way between the larger ribs.



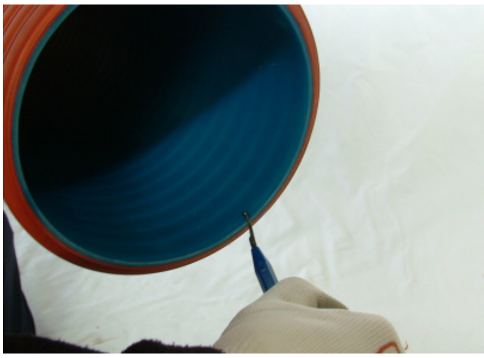


2) Two short spigot end make up pieces of pipe must be cut to connect the branch to the existing pipeline.

The lengths of the make up pieces are equal to the length of the section cut from the exiting pipeline minus the central body length of the branch (not including sockets). This pipe length should be cut in half to provide the two make up pieces.



3) Using a de-burring tool, remove the inner burr from all of the pipe spigots.



Radius Systems recommend that safety glasses and gloves be used for the cutting and jointing procedure
The sealing rings for Ultra Rib and Ultra Fortis are different, care must be taken to ensure the correct ring seals are used.

4) Make sure that the spigot end of the pipe is clean and free from debris. Place the ring seal between the 2nd and 3rd ribs from the spigot end.

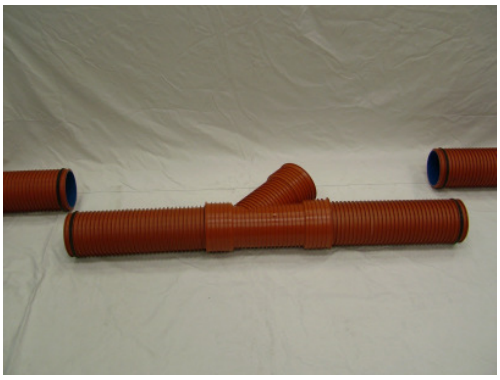
Note: The sealing rings for Ultra Rib and Ultra Fortis are different, and care must be taken to ensure the correct ring seals are used.

5) Make sure that the ring seal is correctly seated and not twisted.

6) Using a brush, apply the recommended lubricant to the ring seal and socket.

7) In turn, push the spigot of each make up piece into the branch socket until fully engaged. Where additional effort is required to complete the joint, the block and bar lever technique is recommended.

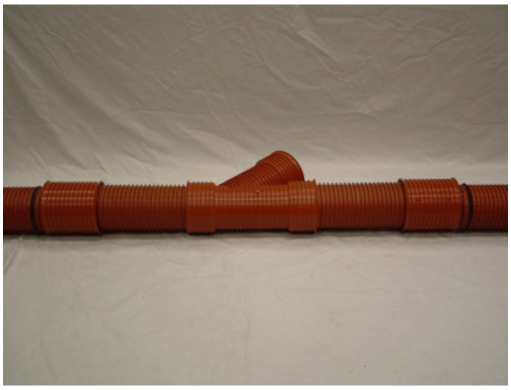
Under no circumstances should mechanical excavator buckets be used to complete the joint.



8) The insertion depth of the coupler should be clearly marked on the spigot end of both the existing pipe and the make up piece. For a correctly formed joint the insertion depth is equal to half the coupler length.

9) The slip couplings should be placed either on the existing pipeline (10a) or alternatively onto the make up pieces of the branch (10b).

10a) The branch connection, including make up pieces and couplers should be aligned with the existing pipeline.

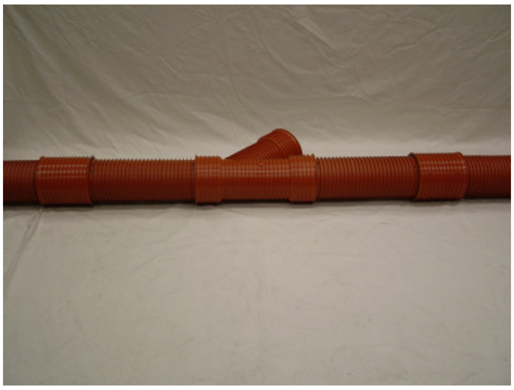


Radius Systems recommend that safety glasses and gloves be used for the cutting and jointing procedure
The sealing rings for Ultra Rib and Ultra Fortis are different, and care must be taken to ensure the correct ring seals are used.

10b) The branch connection, should be aligned with the existing pipeline and couplers.

11) In turn, the couplings should be pushed onto the pipe spigot end to form a connection between the two spigot ends.

For a correctly formed joint the insertion depth is equal to half the coupler length. When the joint is complete, the insertion mark should be clearly visible and adjacent to the shoulder of both ends of the coupler.



The Ultra Fortis sealing ring is a non-handed sealing ring it is manufactured from SBR and is identified by a white marking on its side.

Ultra-Rib or other sealing rings must not be used to joint Ultra Fortis pipes to Ultra Fortis pipes or Ultra Fortis pipes to Ultra Fortis fittings and conversely Ultra Fortis Ring seals must not be used to join Ultra-Rib pipes and fittings.

Note: Where a repair is necessary a modified version of the above procedure can be used to insert a length of Ultra-Rib or Ultra Fortis pipe into an existing pipeline.

Section End

5. LEAK-TIGHTNESS TESTING OF ULTRA-RIB OR ULTRA FORTIS SEWER SYSTEMS

As part of the installation procedure for Ultra-Rib or Ultra Fortis sewer systems, there is a requirement to prove the leak-tightness of the system.

This leak tightness requirement for Ultra-Rib or Ultra Fortis pipelines will generally be achieved by either:

- **Air test,** as defined within Sewers for Adoption 6th Edition & BS EN1610 Construction and testing of drains and sewers, or
- **Water test,** as defined within Sewers for Adoption 6th Edition & BS EN1610 Construction and testing of drains and sewers

The preferred test method and the acceptance criteria should be discussed in advance with the adopting or overseeing authority.

In general sewers should be tested for leak-tightness both after:

- They are jointed and before any backfilling or concrete protection is applied to the pipeline, and
- After backfilling is complete

It may be beneficial to apply a shallow cover of pipe embedment material to the pipeline to minimise movement and prevent any thermal temperature change of the pipeline during the test.

5.1. Typical air test for gravity sewers

- The ends of the pipeline shall be adequately sealed with the use of end closures, a U-tube gauge capable of recording a pressure of 100mm water gauge shall be connected to the system.
- Air shall be introduced into the pipeline until the internal pressure of 100mm water gauge is registered on the U-tube gauge.
- After a period of stabilisation, air shall be re-introduced into the pipeline to restore the 100mm water gauge pressure.
- For the air-test to be deemed acceptable the air pressure within the pipeline must remain above 75mm water gauge pressure after a 5-minute test period (without introducing more air into the system).

Note: Water gauge pressures must not be in excess of 100mm for testing purposes.

Where BS EN 1610 is used, test method LA, should be applied.

5.2. Typical water test for gravity sewers

- The ends of the pipeline shall be adequately sealed with the use of end closures and a suitable means of introducing water into the pipeline should be provided.
- The pipeline shall be filled with water until a head of water of not less than 1.2m above the pipe soffit or ground water level (which ever is the higher) at the highest point and not greater than 6m head of water at the lowest point is achieved.

Adequate restraint may be required to ensure movement of the pipeline and end closures does not occur.

- The pipeline shall be allowed to stand for a minimum period of 2 hours to enable absorption and thermal equilibrium to be reached between the pipe and the test water.
- Water shall be added to the pipeline over a 30-minute period, from a measuring vessel at intervals of 5 minutes, the quantity of water required to maintain the original water level should be recorded.
- For the water test to be deemed acceptable the volume of water added to the pipeline over the 30-minute period should not exceed 0.5 litres per linear metre of pipe per metre of nominal diameter.

5.3. Testing with smoke

The use of 'smoke' for testing Ultra-Rib or Ultra Fortis sewer pipes is not recommended. Smoke adheres to the internal surfaces of the pipe and causes a carbon deposit; this in turn reduces the clarity of CCTV surveys.

5.4. Considerations when testing Ultra-Rib or Ultra Fortis sewer pipes

Ultra-Rib and Ultra Fortis sewer pipes are relatively lightweight, when undertaking an air test on an exposed or unrestrained pipe, the following points should be considered.

- Check that the equipment used for testing purposes is defect free.
- All bends branches and pipe ends should be anchored, generally by the use of pipe bedding or where necessary the use of sand bags or similar.
- The force on a pipe stopper or end cap from an 100mm air test is equal to:

Nominal Internal diameter	Head of water	Force at pipe end
mm	mm	kg force
150	100	1.75
225	100	3.97
300	100	7.01

- This force should be restrained by pipe embedment material or other suitable means.
- Ultra-Rib and Ultra Fortis sewer pipes are manufactured from thermoplastic materials, therefore, pipelines that are exposed to temperature variations may result in the fixed mass of air contained within the pipeline expanding or contracting depending on whether the temperature increases or decreases. This may cause a variation in test pressure.
- Ideally pipelines should be shielded from external temperature variations, this can be achieved by 'blinding' pipes prior to testing to minimise temperature variation.

5.5. Additional guidance on leak-tightness testing

- Sewers for Adoption 6th Edition
- EN 1610 Construction & testing of drains and sewers

Section End

6. CHEMICAL RESISTANCE OF THE ULTRA-RIB AND ULTRA FORTIS GRAVITY SEWER SYSTEM

The Ultra Fortis gravity sewer system, comprises of the following materials:

- Pipe – Polypropylene
- Fittings – Polypropylene and unPlasticised Polyvinyl Chloride
- Sealing Rings – Styrene Butadiene Rubber

The Ultra-Rib gravity sewer system, comprises of the following materials:

- Pipe – unPlasticised Polyvinyl Chloride
- Fittings – Polypropylene and unPlasticised Polyvinyl Chloride
- Sealing Rings – Styrene Butadiene Rubber

6.1. General guidance on the chemical resistance of Ultra-Rib or Ultra Fortis materials

General guidance on the chemical resistance of the above materials may be found within the following publications:

Polypropylene
International Standards Organisation / Technical Report 7471
Code of Practice – CP312: Part 1

UnPlasticised Polyvinyl Chloride
International Standards Organisation / Technical Report 7473
Code of Practice – CP312: Part 1

Styrene Butadiene Rubber
International Standards Organisation / Technical Report 7620

Section End

7. HIGH-PRESSURE WATER JETTING OF THE ULTRA FORTIS SEWER SYSTEMS

7.1. Introduction

Ultra Fortis pipe has been specifically designed to resist the damaging effects of high-pressure water jetting activities that are carried out during the maintenance of a drain or sewer system.

Ultra Fortis pipe surpasses the 2,600 psi performance requirement for thermoplastic structured wall sewer pipes as defined within Water Industry Specification 4/35/01: 2000*. The performance of Ultra Fortis pipe has been externally third party certified to resist a single static 4,000 psi concentrated jet of water for a period of two minutes, without damage, when tested in accordance with WIS 4/35/01:2000. Damage is defined as '*Penetration through the wall of the pipe for solid wall and multi layer pipe where all of the layers are of solid construction*'

7.2. Code of Practice for Sewer Jetting.

Although Ultra Fortis offers an increased resistance to high-pressure water jetting maintenance activities, the responsible jetting contractor will undertake jetting activities in accordance with the Water Research Centre's (Sewer Jetting, Code of Practice), which aims to clear blockages whilst minimising damage to the fabric of the sewer.

The Water Research Centre's code of practice identifies procedures and recommended jetting pressures to be used for the maintenance of all materials including those used for the manufacture of structured wall sewer pipes.

Prior to commencement of work, the jetting contractor should determine the following information relating to the pipeline to be maintained; this will form the basis for the nozzle selection and jetting pressure to be used, thus ensuring that the sewer is not damaged during the maintenance operation.

- Determine who is the owner of the drain or sewer.
- Determine the diameter, material and structural condition grade of the sewer.
- Determine the nature, location and extent of the blockage within the drain or sewer.

7.2.1. Jetting if sewer details not available (Use of standard efficiency nozzle).

For drain and sewer maintenance, when using high-pressure water jetting techniques, the maximum stationary period for the nozzle should not exceed 60 seconds.

Where the contractor is unable to determine the material used for the construction of the drain or sewer or is unable to determine the structural condition grade. Then it should be assumed that the drain or sewer is structural condition grade 3 and a jetting pressure of 1,900 psi (gauge pressure) should not be exceeded. Except where brick, masonry or pitch fibre drains or sewers may be present where a jetting pressure of 1500 psi (gauge pressure) must not be exceeded.

Where the jetting contractor is unable to remove the blockage using the condition grade 3 pressure limitations (above) then the contractor should refer to the pipeline owner.

7.2.2. Jetting of structured wall sewer pipes used for sewers and highway drains in good condition (structural condition grades 1 and 2, using a standard efficiency nozzle).

For drain and sewer maintenance activities using high-pressure water jetting techniques, the nozzle should not remain stationary for a period of more than 60 seconds.

Where the structural condition grade of the sewer or highway drain is known to be either 1 or 2 and where the sewer construction material is known to conform to the requirements of WIS 4/35/01, the maximum recommended jetting pressure is 2,600 psi (gauge pressure)

Where the blockage cannot be removed, using the above pressure limitation then the contractor should refer to the pipeline owner.

7.2.3. Use of jetting pressures in excess of 2,600 psi for structured wall sewer pipes (Use of standard efficiency nozzle).

Only where the pipeline owner or contractor is able to confirm that the drain or sewer is constructed using Ultra Fortis, and after seeking the owners, consent may the contractor increase the jetting pressure.

The maximum recommended jetting pressure for Ultra Fortis pipe is 4,000 psi (gauge pressure), when using a standard efficiency field jetting nozzle (pencil jet type), the maximum period recommended for a stationary nozzle is 60 seconds. A recommended minimum orifice diameter of 1.2mm is generally used for sewer maintenance activities.

As part of the nozzle selection process, the contractor should:

- Select the appropriate nozzle, ensuring that it is matched to the output pressure and discharge volume of the pump unit.
- Where possible, select a nozzle that will result in an increased flow rate rather than an increased pressure.
    - The use of high water volumes at low pressures is generally more efficient at removing and transporting debris through a pipeline.
    - Increasing the water volume discharged through the nozzle and correctly selecting the nozzle will result in a greater all round clearance of the inner surface of the sewer.
    - Reducing the jetting pressure, reduces the likelihood of damage occurring to the drain or sewer.
- Where possible select a nozzle with a recessed orifice outlet, this will increase the distance which the water jet will have to travel before impacting on the wall of the pipe. The closer a nozzle orifice is to the pipe wall, the greater the potential for damage.
- Ensure that high pressure water jetting nozzles which incorporate mechanical root cutters or chain flails are not used for maintaining structured wall sewer pipes.

In line with good operational practice the jetting nozzle should wherever possible be kept moving, if for whatever reason the nozzle is held stationary then the maximum period of operation of a stationary nozzle must not exceed 60 seconds.

It is generally accepted that normal operational blockages found in thermo-plastic sewer pipelines will be removed at relatively low pressures. Where normal operational blockages are more difficult to remove, then consideration should be given to increasing the water volume rather than increasing the water pressure. This has been shown to be far more effective and efficient in blockage removal and also aids transportation of debris to a suitable point within the sewer system for removal.

A low impact nozzle is one based on a spreading jet profile, rather than a straight jet profile. Low impact jetting nozzles recommended by Radius Systems and suitable for the maintenance of Ultra Fortis is available.

Extensive blockage and debris removal from structured wall sewer pipes has been undertaken, it has been found that blockages ranging from 1/3 full bore concrete to full bore nappy and lard type, have been removed at pressures less than 1500 psi, using both the standard efficiency and low impact jetting nozzles. Blockages caused by concrete or other building materials are not considered 'normal blockages' in operational sewers. Where possible, Radius Systems recommend the use of low pressure / high volume jetting equipment for the maintenance of Ultra Fortis.

Nozzle orifice diameters typically range from 1.2 mm to 2.5 mm. For a given flow rate, the smaller the orifice diameter the greater the pressure required to discharge a given flow, increasing the orifice diameter will result in the required flow rate being discharged at a lower pressure, thus reducing potential damage to the drain or sewer.

Nozzle orifice diameters of less than 1.2 mm are generally used as cutting tools and as such are considered ineffective in sewer maintenance procedures.

The most common design of jetting nozzle available to the high-pressure water jetting industry has been found to be one incorporating a straight orifice profile (this does not include either fan, high efficiency or spinning jets). Radius Systems have therefore based their product testing and recommendations around this design.

During extensive product testing, blockages that could reasonably be considered to be of the type found during the normal operation of a sewer system were created in structured wall sewer pipes. Jetting pressures lower than 2,000 psi were used to remove the following types of blockage:

Blockage types

- Nappy and lard (full bore)
- Cured in place concrete 1/3 full bore (high cement ratio concrete)

Pressures required

- Nappy and lard blockages were removed and pipeline cleaned at pressures of 1,500 psi
- Concrete blockages were removed at pressures of 1,100 psi

7.2.4. Methods of ensuring that the recommended gauge pressure is not exceeded.

Ensure that the nozzle is calibrated to suit the pressure and flow of the pump unit. Factors to take into account are pressure, flow rate, hose diameter and hose length. If the nozzle is not able to discharge the volume of water that is input into the system then over pressurisation will occur.

The nozzle flow area should be matched to the system pressure and discharge, where the orifice diameters are to small or the flow rate is to great then the pump may be pumping against a partially closed end, this will result in increased system pressure. Corrective action should be to reduce the power output of the pump unit or increase the nozzle flow area. Where the nozzle flow area is excessively increased then a point will be reached whereby the pump unit cannot physically achieve the maximum pressure of 2,000 psi.

A suitably rated overpressure protection device such as a burst disc may be fitted to the pump unit. The purpose of the burst disc is to limit the pressure by rupturing when the pressure within the system exceeds the rated value of the burst disc.

7.2.5. Definitions

- Standard efficiency – a jet nozzle with a straight orifice throughout
- Stand off distance – The distance from the outlet of the jet nozzle to the point of surface impact.
- Pump gauge pressure – The system pressure registered at the pump unit
- Orifice angle – The internal angle from the centre line of the orifice to the surface of the material being jetted.

7.3. Health and safety

- High pressure water jetting activities must only be undertaken by trained competent personnel. Consideration should be given at all times to the relevant Health and Safety Regulations and any other directives that are appropriate to the work in hand.

* WIS 4-35-01, Specification for thermoplastics structured wall pipes, joints and couplers with a smooth bore for gravity sewers for the size range 150-900 inclusive.

Section End

8. HEALTH AND SAFETY (PVC PIPES & FITTINGS)

PVC pipes and fittings as finished products are not regarded as hazardous to health. Nevertheless, in the event of excessive heat application i.e. a fire situation the following comments should be noted:

Ignition and burning characteristics

Most PVC compositions, under normal conditions of storage and use, do not support combustion, but in common with other organic materials, they can be consumed by fire. The ease with which PVC compositions will burn under these circumstances will depend on their formulation, but in general ease of burning will increase with increasing plasticiser content. When PVC products are stored, it must be recognised that packing and pallets themselves can be a fire risk and are generally a much more likely route for rapid fire spread.

Decomposition products

PVC burns to give dense, acrid fumes. The major gaseous products of combustion/decomposition of PVC compositions are carbon dioxide, carbon monoxide and hydrogen chloride. Additionally, many other minor decomposition products have been identified, although these will not normally present additional hazard, toxic or corrosive, to that associated with carbon monoxide and hydrogen chloride. Carbon monoxide and hydrogen chloride are toxic. Carbon monoxide acts as an asphyxiant while hydrogen chloride is highly irritant.

The Threshold Limit Values are 50 ppm (OES) for carbon monoxide and 10 ppm (10 mins) Stel (MEL) for hydrogen chloride.

8.1. Action in the event of fire involving PVC

8.1.1. Fire fighting

All commonly available fire extinguishants are effective in fighting fires involving PVC, although due note should be taken of the particular situation (e.g when live electrical equipment is nearby) which may restrict the use of some media. Advice should be sought from the local Fire Authority as to the most suitable types of extinguisher to be installed. In the event of a small-localised fire, immediate action maybe taken by personnel in the vicinity, using available extinguishers.

Care should be taken to avoid inhalation of decomposition fumes when the fire has been extinguished, ventilation should be increased to clear the fumes as quickly as possible. If a major outbreak of fire is discovered, the Fire Brigade should be called immediately and personnel should be evacuated from the area. It is important to advise the fire fighting personnel to wear acid-resistant protective clothing and full-face masks.

Suitable breathing equipment should be worn by the fire fighters exposed to the products of combustion. Qualified medical aid should be sought if anything more than temporary irritation to the skin, eyes, throat, etc is experienced by personnel who are exposed to PVC decomposition products.

8.1.2. Corrosive fumes

Hydrogen chloride, which is given off during the combustion of PVC, has a highly corrosive effect on many materials. Equipment surfaces directly affected should be cleaned down to remove corrosive depositions as soon as possible after the fire has been extinguished.

Section End

9. FREQUENTLY ASKED QUESTIONS

Q1. What specification is Ultra-Rib manufactured to?

A1.1. Water Industry Specification 4-35-01: July 2000 'Specification for thermoplastics structured wall pipes, joints and couplers with a smooth bore for gravity sewers for the size range 150-900 mm inclusive'.

A1.2. There is a detail sheet of approvals for Ultra-Rib contained within the 'Ultra-Rib Specification & Installation Manual – Page 2.

Q2. What specification is Ultra Fortis manufactured to?

A2.1. Water Industry Specification 4-35-01: July 2000 'Specification for thermoplastics structured wall pipes, joints and couplers with a smooth bore for gravity sewers for the size range 150-900 mm inclusive'.

A2.2 In addition, further evaluation testing of the pipe has been undertaken by BSI in accordance with clause 6.10 of the Water Industry Specification 04-35-01, BSI have witnessed the 4,000 psi* jetting resistance of Ultra Fortis when tested in accordance with the specification.

A2.3. There is a detail sheet of approvals for Ultra Fortis contained within the Ultra Fortis Brochure

Q3. Does the Water Industry Specification 4-35-01 cover fittings?

A3.1. No, fittings are approved by the British Board of Agrement, the certificate numbers are:
i. 97/3335 – Public and Private sewer approval (Detail sheets 1,2 & 3)
ii. 89/HO44 – Roads & Bridges approval

A3.2. Copies of these certificates are available to forward to the customer

Q4. In what diameters does the BSI approve Ultra-Rib to the Water Industry Specification 4-35-01?

A4.1. 150, 225 and 300 mm Kitemark License number KM56662

A4.2. 360 & 500 mm are not approved in accordance with WIS 4-35-01 and currently do not have any UK approvals.

Q4. In what diameters does the BSI approve Ultra Fortis to the Water Industry Specification 4-35-01?

A4.1. 150, 225 and 300 mm, Kitemark License number KM56662

Q5. What does the nominal size of Ultra-Rib and Ultra Fortis refer?

Q5.1. 150 mm nominal size is 150 internal diameter 170 external diameter
Q5.2. 225 mm nominal size is 225 internal diameter 250 external diameter
Q5.3. 300 mm nominal size is 300 internal diameter 335 external diameter

Q6. **What material is used in the manufacture of Ultra-Rib pipe and fittings?**

A6.1. The Ultra-Rib pipe is currently manufactured from uPVC (unPlasticised Polyvinyl Chloride)
A6.2. The Ultra-Rib fittings in 150mm diameter are predominantly uPVC, in diameters 225 and 300 are predominantly polypropylene
A6.3. The sealing rings are manufactured from SBR – (styrene butadiene rubber).

Q6. **What material is used in the manufacture of Ultra Fortis pipe and fittings?**

A6.1. The Ultra Fortis pipe is currently manufactured from Polypropylene.
A6.2. The Ultra Fortis fittings are predominantly Polypropylene.
A6.3. The sealing rings are manufactured from SBR – (styrene butadiene rubber).

Q7. **Should Ultra-Rib or Ultra Fortis be designed as an above ground gravity sewer system?**

Q7.1. One of the main benefit of the Ultra-Rib and Ultra Fortis systems is the increased circumferential ring stiffness, resulting in its ability to withstand external loads, as such it is a system for use below ground, there would be no benefit of using pipes for above ground use.

Q8. **What are the main benefits of the Ultra-Rib system?**

A8.1. Equivalent internal bore dimensions to that of traditional materials, i.e
150 mm = 6″
225 mm = 9″
300 mm = 12″.
A8.2. Robust and light in weight, reduced requirement for handling with mechanical plant
A8.3. Excellent impact resistance resulting in reduced breakage.
A8.4. Longer lengths (3 metres) therefore fewer joints required.
A8.5. Ease of jointing with high performance captive non-handed sealing ring. The ring seal is designed to fit between the ribs on the pipe exterior, hence it is extremely difficult to displace the ring seal when jointing pipe.
A8.6. Joint flexibility with up to 2.5º angular deflection at each ring seal joint.
A8.7. In comparison with clay and concrete pipe, Ultra-Rib is relatively flexible, hence it is able to accommodate a certain amount of ground movement unlike clay and concrete which would try to resist movement and would possible fracture.
A8.8. No requirement for chamfering pipe spigot prior to jointing
A8.9. Smooth internal bore for excellent self-cleansing characteristics
A8.10. Increased circumferential ring stiffness over conventional solid wall SDR 41 sewer pipe.
8.11. A comprehensive range of socketed fittings and adaptors to alternative materials are available for the Ultra Fortis system

Q9. What are the main benefits of the Ultra Fortis system?

In addition to those listed above the following are benfits of eth Ultra Fortis system

A9.1 4000 psi* high pressure water jetting resistance in accordance with WIS 4-35-01

A9.2 Blue inner pipe surface for enhanced light reflection during CCTV activities

Q9. What internal pressure rating does the Ultra-Rib or Ultra Fortis system's have?

A9.1. Ultra-Rib and Ultra Fortis are not a pressure rated systems, they are manufactured for and should be designed as gravity drainage systems (without internal pressure).

Q10. What are the design hydraulic roughness factors that should be used for Ultra-Rib or Ultra Fortis?

A10.1 In accordance with Sewers For Adoption 6th Edition – A design and construction guide for developers:

The roughness value (Ks) for foul gravity sewer design should be 1.5 mm

The roughness value (Ks) for surface water sewer design should be 0.6 mm

A10.2. There is guidance upon this subject contained within the 'Ultra-Rib Specification & Installation Manual – Pages 14 – 16 inclusive'.

Q11. What design method should I use for the structural design of Ultra-Rib or Ultra Fortis systems?

Q11.1. The 'flexible' design method in accordance with BS EN1295.

Q11.2. There is guidance upon this subject contained within the 'Ultra-Rib Specification & Installation Manual – Pages 10-13 inclusive'.

Q12. Do Radius Systems produce 'rocker pipes' for the Ultra-Rib and Ultra Fortis systems

A12.1. No, however due to its ease in which Ultra Pipes can be cut it is possible to produce 'rocker pipes' using short lengths of Ultra-Rib pipe and double socket couplers.

Q13 Are the Ultra Rib and Ultra Fortis Product ranges compatible?

A13.1 Yes, Radius Systems' Ultra systems are interchangeable however, the higher jetting performance is only obtainable by using the Ultra Fortis System exclusively.

Q14. **Do the Ultra-Rib fittings and sealing rings fit other pipe systems, such as Marley Quantum or Polypipe's twin wall pipes?**

A14.1. No, Ultra-Rib fittings and ring seals have not been designed to be compatible with any other pipe system, other than Wavin produced Ultra-Rib for which they are totally compatible and interchangeable, obviously it would always be beneficial for the end user to use Radius Systems produced products.

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