Product & Material Specifications

(Part B – Sewer Network)
# PART B – SEWER NETWORK

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1.0 MANHOLES

1.1 General

At each change of gradient or direction, at each intersection with other sewers and at such other points, a manhole shall be constructed. Manholes are to be constructed in circular precast reinforced concrete sections or brick construction.

The bases of all manholes shall be formed of concrete with minimum thickness of 300 mm. Channel inverts shall be accurately laid to meet pipe invert elevations at the same time as the sewer pipes are laid, the bends being as “slow” as possible by siting the manholes “off-center” at changes in direction. Short lengths of pipe with flexible joints shall be provided at entry and exit to manholes.

Provision shall be made for future sewer connections to manholes by providing a box-out sealed with bricks. Heavy duty ductile iron covers, Grade 10, to BS 497 shall be laid with their frames bedded on the pre-cast concrete rings. Manholes covers generally shall be set to the road profile and be flush with the road surface. Manhole covers located in unimproved areas shall be constructed at an elevation to prevent the entry of surface water.

Where drop manholes are necessitated they shall be formed where the upstream length of sewer enters a manhole at a higher level than the manhole invert level. All pipes and fittings in drop connection shall be the same material and of the same size as the connecting pipeline. All manholes shall be watertight on completion and where leakage is discovered the Contractor shall perform such work and provide all materials as are necessary to render such faulty work watertight. The Contractor should take the necessary measures to ensure that the manholes are not used as rubbish and waste dumps. The Contractor shall keep pipelines and manholes clear of such rubbish and debris.

1.2 Pre-cast Manholes

1.2.1 General Description

Pre-cast concrete manhole sections shall conform in all respects to BS 556. All joints in pre-cast manhole sections shall be made with cement mortar. Manhole floors shall be constructed with concrete formed to the required shapes with concrete channel inverts including half round concrete channels, bends, tapers, junctions and double junctions. The top of the in-situ benching shall be sloped back at 1 in 12. Pre-cast manholes shall be encased with concrete with minimum of 150 mm thickness. Rough shuttering shall be used for the concrete surround to manholes. All concrete are to be 20 MPa (MegaPascal) Portland cement concrete with 20 mm minimum internal lining of high alumina cement mortar.

1.3 Ductile Iron Manhole Covers and Frames

1.3.1 General

Manhole covers and frames shall comply, with the specifications in European Standard, EN 124:1994.
1.3.2 Load Class

For public sewers, manhole covers/frames shall be capable of bearing wheel loads of up to 400 kN and as such shall meet the test load requirements for class D 400 manhole tops in EN 124.

For other sewers, manhole covers/frames shall:

i. be class D 400 where placed in road carriageways, hard shoulders, parking areas and anywhere where vehicle access is possible

ii. class C 250 for all other locations where vehicle access is not possible

1.3.3 Material

The material for manhole covers and frames shall be spheroidal or nodular graphite iron (otherwise known as ductile iron) complying with the requirements specified in BS 2789 for grade 500/7.

1.3.4 Dimensions, Marking and Surface Finish

The dimensions, marking and surface finish of manhole covers and frames shall accord with the requirements given in the drawing.

Tolerance on dimensions shown in the drawings shall be ± 1 mm. The casting of markings shall be clearly legible.

1.3.5 Seating

When a random cover is placed in a random frame the adjacent top surfaces of the cover and frame shall have flushness of level to within ± 1 mm.

1.3.6 Casting

All cast units shall be clearly cast and shall be free from air holes, sand holes, cold shuts and chill. They shall be neatly dressed and carefully fettled. All castings shall be free from voids, whether due to shrinkage, gas inclusions or other causes.

1.3.7 Protective Coating

All surfaces of manhole covers and frames shall be supplied coated with either:

i. hot applied bituminous material complying with BS 4147 Type 1 grade C

ii. cold applied bituminous material complying with BS 3416 Type II

Immediately prior to coating, surfaces shall be clean, dry and free of rust. The coating shall be free of bare patches or lack of adhesion. The mean thickness shall be not less than 70 µm and the local thickness not less than 50 µm.
1.3.8 Water-tightness

Where a watertight cover is specified, it shall satisfy the test requirements in Appendix E of AS 3996.

1.3.9 Lifting Lugs

Covers shall be provided with lifting lugs. Lifting lugs shall not permit water to pass through the cover.

1.3.10 Locking

A locking arrangement shall be fitted to lock ductile iron covers to the frames and to prevent rocking due to traffic. Bolts and nuts for locking devises shall be hexagon headed, complying with BS 3692 and shall be of stainless steel in accordance with ISO 3506 or BS 6105.

1.3.11 Product Certification

Manhole covers and frames shall be certified as complying with the requirements of this specifications. Certification shall be undertaken by SIRIM or other third party certification body accredited in accordance with MS EN 45011.

Certified manhole covers and frames shall have met the requirements given in clause 10 of EN 124. However, the final inspection and tests and the frequency of tests/inspection shall not be as shown in Table A3 of EN 124. Instead, the specifications as shown in Table below must be followed. All final inspection and test documents shall be retained for at least 5 years.

Table 1.1.12: Final Inspection and Testing

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<th>Final Test/Inspection</th>
<th>Frequency of Test/Inspection</th>
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<tr>
<td>(b)</td>
<td>Load Class Test</td>
<td>1 per 100</td>
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<tr>
<td>(d)</td>
<td>Measurements of all dimensions</td>
<td>1 per 100</td>
</tr>
<tr>
<td>(d)</td>
<td>Markings legibility inspection</td>
<td>every unit</td>
</tr>
<tr>
<td>(e)</td>
<td>Seating flushness of cover in frame</td>
<td>1 per 20</td>
</tr>
<tr>
<td>(f)</td>
<td>Casting defects inspection</td>
<td>every unit</td>
</tr>
<tr>
<td>(g)</td>
<td>Protective coating inspection</td>
<td>every unit</td>
</tr>
<tr>
<td>(g)</td>
<td>Protective coating thickness measurement</td>
<td>1 per 200</td>
</tr>
<tr>
<td>(h)</td>
<td>Watertightness Test (only applicable for covers required to be watertight)</td>
<td>1 per 100</td>
</tr>
<tr>
<td>(j)</td>
<td>Locking devise inspection</td>
<td>every unit</td>
</tr>
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1.3.12 Channel, Etc. In Manholes

Main channels, branch channels, bends, etc. are to be glazedware or precast high alum granolithic cement concrete, and shall be obtained from approved manufacturer. All channels are to be properly bedded and jointed in sulphate resistance cement mortar.

1.3.13 Drop Pipes To Manholes

Where the total drop exceed 2 feet (0.6m) all drop pipes, their bends and tee pieces, shall be ductile iron unless otherwise specified. The concrete surround to all drop pipes shall not be less than 6 inches (150 mm) thick.

1.4 Concrete and Reinforcement

a. Structural concrete shall be designed in accordance with MS 1195
b. Concrete shall generally comply with the relevant requirements in MS 523
c. Concrete for manholes and pumping stations shall have a strength grade not less than grade C35.
d. Concrete for purposes other than manholes and pumping stations shall have a strength grade not less than grade C20 where unreinforced, and not less than grade C30 where reinforced.
e. Concrete exposed to a sewage atmosphere shall be lined with high alumina cement mortar to BS 915 Part 2 of 20 mm minimum thickness or epoxy coating of 2 mm minimum thickness.
f. Concrete and cement mortar shall be made using cement suitably resistant to sulphate attack, as specified in this clause.
g. Cement to be used to resist sulphate attack shall be sulphate-resisting portland cement complying with MS 1037. Where not available, one of the following cements shall be used to resist sulphate attack:
   • Portland pulverised fuel ash cement complying with MS 1227
   • Ground granulated blast furnace slag complying with MS 1387
   • High silica content portland cement
   • Supersulphated cement complying with BS 4248
h. Aggregates shall comply with MS 29 and shall be coarse aggregate of 20 mm nominal maximum size
i. Approval for admixtures shall be obtained prior to inclusion in the concrete mix. All admixtures shall comply with MS 822
j. Steel reinforcement shall comply with:
   • MS 144 for cold reduced mild steel wire
   • MS 145 for steel fabric
   • MS 146 for hot rolled steel bars
k. Scheduling, dimensioning, bending and cutting of steel reinforcement shall be in accordance with BS 4466.
l. Welding of steel reinforcement shall be in accordance with BS 7123.
m. Formwork shall be in accordance with BS 5975.
Section 2
Sewerage Networks System
## 2.0 Sewerage Networks System

### 2.1 Sewer Pipe

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2.0 SEWERAGE NETWORKS SYSTEM

2.1 Sewer Pipe

2.1.1 General

Within the past few decades there has been a growing choice of sewerage system such as gravity, force main, vacuum and pipe jacking. There is an extensive range of materials available for these sewerage applications that has been approved by the Director General as listed below.

a. Gravity Sewerage System:
   i. Vitrified Clay Pipe
   ii. Reinforced Concrete Pipe
   iii. Ductile Iron Pipe
   iv. GRP Pipe
   v. Profile Wall Polyethylene Pipe

b. Force Main:
   i. Ductile Iron Pipe
   ii. GRP Pipe
   iii. Steel Pipe
   iv. Acrylonitrile Butadiene Styrene (ABS) Pipe
   v. Solid Wall Polyethylene Pipe

c. Vacuum Sewerage System:
   i. Acrylonitrile Butadiene Styrene (ABS) Pipe – for internal use only
   ii. Solid Wall Polyethylene pipe – for external use only

d. Pipe Jacking:
   i. Vitrified Clay Pipe
   ii. Reinforced Concrete Pipe
   iii. GRP Pipe

The above approved pipe materials shall comply with specific requirements such as pipe class, joint type, linings etc. so as to suite for the above applications as dictated in subsequent section of this volume. Furthermore, only pipes and fittings from manufacturers and suppliers approved by the DGSS shall be permitted for the designated applications.

2.1.2 Requirements

The pipe material for sewer networks shall comply to these requirements:

1. Resistance to acid sulphate corrosion which is prevalent in sewer networks in tropical climates
2. Resistance to neutral sulphate attack from aggressive soils and groundwater
3. Resistance to corrosion in contaminated soils
4. Resistance to severe abrasion from sewage and usual cleaning methods
5. Resistance of the joint to groundwater entry (infiltration) and sewage escape (ex-filtration)
6. Resistance of the joint material to corrosion and micro-biological degradation
7. Structural and other damage that may occur in handling
8. Handling, laying and jointing care and difficulties
9. Methods of pipe embedment to ensure structural performance
10. Maintenance of structural strength and performance in service
11. Methods of maintenance and repair
12. Cost of supply, transportation and installation
13. Range and suitability of fittings where considered for smaller diameter sewers
14. Previous local experience
15. Local availability

2.1.3 Vitrified Clay Pipes

2.1.3.1 General

Material compositions of VC pipes as in accordance with MS 1061:1999 shall comprise blends of suitable clays source from different locations and/or strata in a form of grog and fired to vitrification. The clays may contain shale, sand, prefired material of such a quality and homogeneity. Calcine clays shall be included to minimize pipe wall permeability. Recycle materials shall not be added in producing the VC pipes.

All VC pipes and fittings shall be tested at the factory after manufacture and shall satisfy all the performance requirements in achieving the crushing strength for the pipes and fittings.

2.1.3.2 Standards Compliance

The manufacture, design and installation of VC pipes shall comply to the requirements stipulated in the following Standards:

1. Manufacture
   a. MS 1061:1999 - Vitrified clay pipes and fittings and pipe joints for drains and sewers
   b. BS EN 295-1:1991 - Vitrified clay pipes and fittings and pipe joints for drains and sewers. Requirements
   c. BS EN 295-2:1996 - Vitrified clay pipes and fittings and pipe joints for drains and sewers. Testing
   d. BS EN 295-7:1995 - Vitrified clay pipes and fittings and pipe joints for drains and sewers. Requirements for vitrified clay pipes and joints for pipe jacking
   e. BS 65:1991 - Specification for vitrified clay pipes, fittings and ducts, also flexible mechanical joints for use solely with surface water pipes and fittings

2. Design and Installation
   a. BS EN 752:1997 - Drain and sewer systems outside buildings.
   b. ASTM C12-91
2.1.3.3 Sizes

**Nominal size (DN)** is a numerical designation of the minimum internal diameter of VC pipes. It is a convenient round number approximately equal or equal to a manufacturing dimension and the bore of the pipe shall not deviate from the nominal size beyond the set limits in *MS 1061: 1999*.

**Nominal length** of VC pipes for DN 200 and greater either shall be whole multiples of 250mm or preferred length of 1.5m, 1.75m, 2.0m, 2.5m and 3.0m. There are no preferred nominal lengths for DN 100 and DN 150 pipes. The pipes length other than the offered standard length can be obtained by cutting the pipes with pipe cutting chain.

2.1.3.4 Classes

**Classes** of VC pipes for gravity sewerage system is defined by the ring crushing strength (FN), which can be directly used in structural design calculations. For this application, the crushing strengths (kN/m) of the VC pipe shall not be less than 22 kN/m for DN ≤150mm and shall be in accordance with *MS 1061: 1999* for DN 200 and above.

**Classes** of VC pipes for pipe jacking is defined by the various types of strength specified herein, which used in structural design calculations.

- **Crushing strengths (FN)** of VC pipes or pipe sections shall not be less than 28 kN/m for pipes of nominal size DN 100 and DN 150 and shall be in accordance with *MS 1061: 1999* for DN 200 and above.
- **Compressive strength** of VC pipes for pipe jacking shall not be less than 75 N/mm².
- **Jacking strength** shall be determined in accordance with *BS EN 295-7:1995* by applying the load without shock and increase it at a convenient rate not exceeding 35.0 N/mm².min up to half the maximum anticipated load. The test shall be done of at least 10 specimens cut from the same pipe.
- **Design jacking load** shall be declared by the manufacturer. This will depend on jacking strength and on the specific design of the joint and packing ring.
- **Maximum working jacking load** shall be determined by using factors of safety of either 1.6 for automatically steered jacking machines or 2.0 for manually steered systems.

2.1.3.5 Protective Coatings

No protective coatings are required for VC pipe. External and internal glazing is a mean of improving impermeability of VC pipes. Glazing is not compulsory so long the products perform to requirements. When glazed they need not be glazed on the jointing surfaces of the spigot and socket.

2.1.3.6 Joints

Joint methods of VC pipes for gravity sewerage system are basically of the flexible joints type. The types of jointing available from the approved manufacturers are generally of the following types:

1. Spigot-socket with rubber ‘O’ ring type is available from all approved manufacturers and is the recommended type to be used in most applications.
2. Skid type sealing joint - This is another type of push-in flexible joint which is already prefabricated into the spigot/socket. The purpose of this type of joint is to minimise the installation time.
Joint methods of VC pipes for pipe jacking in accordance with *BS EN 295-7:1995* shall be as following:

1. Double spigot joint with collar and rolling or confined rubber ring
2. Double spigot joint with collar and polyurethane sealing

### 2.1.3.7 Sealing Material

Sealing materials of VC pipes shall be of the following types in accordance with *BS EN 295*:

1. Rubber sealing elements – The rubber ring seals shall be made of EPDM or styrene butadiene rubber (SBR). When placed at the correct position over the end of the spigot, it will roll 360° (one full turn) into place when the joint is pushed in. It is critical that the ring is not twisted and the joint shall be cleaned before jointing to avoid loose joint.
2. Polyurethane sealing elements - These sealing elements are usually applied in skid type sealing joint. No joint in the spigot is required. Light lubrication of the seal is needed before the spigot skids in.
3. Stainless steel sleeves (for pipe jacking)
   
   The corrosion resistance of stainless steel shall be equal or greater than the resistance of austenitic stainless steel with minimum chrome content of 17% and minimum nickel content of 8%. The sleeves shall be edge dressed and free from sharp edges. The internal surface of the sleeve shall be finished to provide a sealing surface.

4. Polypropylene sleeve couplings (for pipe jacking)

5. Materials of other components

Components of other materials shall comply with the relevant European Standards or the manufacturer’ declared specifications, which shall also include requirements for long term behaviour.

### 2.1.3.8 Fittings

Fittings for VC pipes are prone to unusual loading, which can cause differential loads and settlement. Therefore it is necessary to encase the fittings in concrete to prevent bending and shear failures which VC fittings are vulnerable to.

### 2.1.4 RC Pipe

#### 2.1.4.1 General

Material compositions for RC pipes shall comprise blends of cement, aggregates and water and reinforced with hard drawn wire. Ordinary Portland cement compliance to *MS 522* shall be used, unless other types of cement are specified by the suppliers/manufacturers.

The fully compacted concrete shall contain not less than 360kg cement/m³ and shall have a maximum water/cement ratio of 0.45. The coarse aggregates shall have the flakiness index of not more than 35 and 10% fines value of not less than 100kN. The maximum nominal size of aggregate shall not exceed 20mm.
The manufacturing processes that have been adopted by local manufacturers to produce RC pipes are centrifugal spinning process, vertical cast process that sub-categorised to dry vertical cast process and wet vertical cast process and roller suspension process.

For the RC pipes that are manufactured with elliptically reinforcement, the load line shall be clearly marked to identify the laying orientation of the pipes.

2.1.4.2 Standards Compliance

The manufacture, design and installation of RC pipes shall comply to the requirements stipulated in the following Standards:

1. Manufacture
   a. MS 881: 1991 - Specification for pre-cast concrete pipes and fittings for drainage and sewerage
   b. BS 5911-1:2002 - Concrete pipes and ancillary concrete products. Specification for unreinforced and reinforced concrete pipes (including jacking pipes) and fittings with flexible joints (complementary to BSEN 1916:2002)

2. Design and Installation
   a. AS 3725-1989 - Loads on buried concrete pipe

2.1.4.3 Sizes

Nominal size (DN) is commonly used as a numerical designation of the size of RC pipes. It is a convenient round number approximately equal to a manufacturing dimension and the bore of the pipe shall not deviate from the nominal size beyond the set limits in MS 881: 1991. The use of RC pipe for 300 mm and less is handicapped by the lack of fittings for junction requirements, further the use of RC pipe smaller than DN 375mm is not recommended by DGSS.

Effective length of pipes shall be between 0.45m and 5m inclusive with a maximum of 3 m for pipes DN 600 or less. Pipe cannot be cut on site.

2.1.4.4 Classes

Classes of RC pipe are defined in terms of the crushing strength in kN/m of the pipe cross section as tested according to MS 881: 1991. RC pipes are categorised into three main crushing strength classes, which are Low (L), Medium (M) and High (H). The crushing strength of RC pipe is varied by the strength of the concrete, the thickness of the wall and the amount and placing of reinforcement.

2.1.4.5 Protective Coatings

External coating is not required for RC pipe. However, where corrosion is likely to occur from external aggressive soil, the pipes shall be manufactured using sulphate-resisting Portland cement complying with MS 1037. The other types of cements that can be used with the approval from the DGSS are:

- a. Portland pulverised fuel ash cement complying with MS 1227; or
- b. Portland blast furnace cement complying with MS 1389; or
- c. Supersulphated cement complying with BS 4248.

The types of internal protective linings that shall be applied to RC pipes for sewerage application are as following:
1. **High Alumina Cement Mortar Lining (HAL)**
   
   This type of lining is recommended to be used with the RC pipes with nominal size less than DN 1000 mm. The layer of HAL shall have a minimum thickness of 12 mm (to comply with MS 881: Part 1) and shall comprise one part of high alumina cement and 3 parts of fine sand as a secondary process.

   The HAL shall be lined on the pipe while the concrete is still wet to ensure firm adhesion of the lining to the pipe. RC pipes lined with HAL shall not be steam cured to prevent the deterioration of high alumina cement concrete that is directly influenced by increased in heat and humidity.

2. **PVC/HDPE Lining**
   
   This type of lining shall be used with the RC pipes with the nominal size more than or equal to DN 1000 mm. The layer of the lining shall have a minimum thickness of 5 mm. It is suitable for sewers experiencing serious corrosion problem.

   The lining shall be projected by keying a PVC/HDPE sheet from one face around the inner of pipe before the concrete is cured.

   The stud of the lining shall be of spirally arrangement to prevent water sipping into the area between the pipes and the lining. The lapping of PVC/HDPE at jointing shall be provided with stainless steel or other non-coated corrosion resistant metal ring.

3. **Sacrificial Concrete Lining**
   
   This type of lining is an alternative protection lining to the RC pipe that shall have a minimum thickness of 38 mm.

   If pulverised fuel ash cement is used to produce the RC pipes, no protective lining is required.

**2.1.4.6 Joints**

Joint methods for RC pipes in accordance with BS 5911 shall be of the following types:

1. Flexible joint of spigot-socket with rubber ‘O’ ring type
2. Rigid joint of spigot socket with cement mortar filling is commonly used where flexibility is not an issue. It can be applied both for normal gravity and jacking pipe installation.
3. Flexible rebated/ogee joint with rubber ‘O’ ring is used to joint the rebated pipes.
4. Rigid rebated/ogee joint with cement mortar filling is more commonly used for rigid pipeline installation, like jacking pipe where flexibility is not required.
5. Double spigot joint with collar/ butt joint with collar is usually used for pipe jacking application.

**2.1.4.7 Sealing Material**

Sealing material used for the joints varies depending on the type of joints used and shall be of the following:

1. Rolling rubber O-ring shall be used in spigot-socket joint and rebated joint for flexibility.
2. Cement mortar shall be used to fill the gap in a rebated joint. However, this will induced rigidity at the joint and thus only suitable for application where flexibility is not required.
3. Stainless Steel Type 316 sleeve (or other non-coated corrosion resistant metal or reinforced/unreinforced plastics with sufficient strength) is used to butt joint two rebated spigot ended pipes with rubber ring seals in pipe jacking.
2.1.4.8 Fittings

Fittings are not a stock item with RC pipe manufacturers and any junctions or bends are made up as specials. Specifications of fittings like bends and junctions shall be in accordance with MS 881: 1991.

2.1.5 Ductile Iron Pipe

2.1.5.1 General

Material used is basically ductile iron. Some may include certain percentages of recycled material produced during the casting process. Ductile iron is also known as spheroidal or nodular graphite (SG) cast iron. The casting material, i.e iron and carbon based, and the latter element is being present principally as graphite in spherical nodular form to improve the tensile, bending strength and fracture toughness of the material. It is also incorporated some of the miscellaneous components such as silicon, manganese, magnesium, phosphorus, sulphur.

The common manufacturing process to manufacture DI pipes is centrifugal cast, while the DI fittings are cast using traditional gravity casting.

2.1.5.2 Standards Compliance

The manufacture, design and installation of DI pipes shall comply to the requirements stipulated in the following Standards:

1. Manufacture
   a. BS EN 598:1995 - Ductile iron pipes, fittings, accessories and their joints for sewerage applications. Requirements and test methods
   b. BS EN 545:2002 - Ductile iron pipes, fittings, accessories and their joints for water pipelines. Requirements and test methods
   d. ISO 2531: 1998 - Ductile iron pipes, fittings, accessories and their joints for water or gas applications

2. Design and Installation
   a. AS/NZS 2566.1: 1998 - Buried flexible pipelines-Structural design
   b. AS/NZS 2566.2: 2002 - Buried flexible pipelines-Installation

2.1.5.3 Sizes

Nominal size (DN) for ductile iron pipes have dimensions based on imperial sizing. As a result, the metric nominal sizing relates only roughly to the internal diameter of the pipe after cement lining. The bore of the pipe is governed by the classes and pressure load to the pipe, which will then affect the iron wall thickness. The minimum iron wall thickness of the pipe shall not be less than the minimum values given in BS EN 598:1995.

Pipe Lengths are standardised according to BS EN 598:1995 and are within ±150 mm of the standardised lengths as follows:

- DN 100 to 600 - standards length shall be 5.0, 5.5 or 6.0 m;
- DN 700 to 800 - standards length shall be 5.5, 6.0 or 7.0 m;
- DN 900 to 1400 - standards length shall be 6.0, 7.0 or 8.15 m; and
- DN 1500 to 2000 - standards length shall be 8.15 m
2.1.5.4 Classes

*Classes* of DI pipe have not been defined in the European Standard *BS EN 598:1995* for sewerage applications. However, the standard has set specific requirements on pipe performance to ensure the pipes are capable to operate with pressures up to 6 bar (0.6 MPa).

Commonly, the DI pipe for sewerage application are classified according to *BS EN 545:2002*. In this standard, the DI pipe is classified based on wall thickness and not pressure rating. The class for DI pipes shall be a minimum of Class K9 for this application.

2.1.5.5 Protective Coatings

The *external protective coatings* for DI pipes shall be as follows:

1. **Metallic zinc coatings and prime layer with bitumen paint as finished layer.**
2. **Epoxy coating** shall be used for all fittings and accessories as required by DGSS.
3. **Bitumen paint** can also be used as the protective coating for the pipes and fittings. However, this is not commonly used and prior approval from DGSS is required.
4. **Polyethylene sleevings** can be used as a final layer to provide extra protection when installed in corrosive ground. DGSS requires this sleevings to be used for all buried application. Polyethylene sleeve can be applied in the factory during pipe production or installed on site.
5. **Cathodic protection** is an alternative to the other protection system but is not normally preferred. Bonding across the joints is necessary to guarantee electrical continuity when this system is to be installed.

The DI pipe shall be protected internally with:

1. **High alumina cement mortar lining** is commonly used in sewage application and recommended by DGSS. Epoxy-based coating on the end surfaces is required if this lining is used. The HAC lining thickness shall be in accordance with *BS EN 598: 1994*.
2. **Other cement lining** using Portland cement or sulphate resistant cements are also available. However the usage of this cement lining is limited by the characteristic of the medium to be conveyed.

2.1.5.6 Joints

The joints for DI pipe are generally of a type using elastomeric gaskets as a sealing medium. Joint methods used in DI pipe installation in accordance with *BS 8010* are as follows:

1. **Push-in joints** are made on pipes having a chamfered plain spigot at one end and especially formed socket at the other. The sockets shall be grooved to capture elastomeric seals.
2. **Self-anchoring push-in joints** have a special gasket in respect of dimensions and shape but stainless steel toothed inserts are moulded into the gasket.
3. **Flange joints** are made on pipes by welding, screwing or integrally casting flanges onto the end of the standard pipe with a seal of 3 mm flat elastomeric full face gasket compressed between the flanges by means of bolts.
4. **Bolted mechanical joints** are made on pipes having a plain spigot at one end and a specially formed socket at the other.
5. **Flange adapters** are designed to connect flange pipe or any flanged fitting to plain-ended pipe. They shall consist of a flange and sleeve piece, a wedge-shaped rubber gasket and a loose gland fastened to the main body by bolts.
6. **Self-anchoring flange adapters** shall consist of a loose flange, bolts and one or more rubber seals carrying anchoring segments.

7. **Self-anchoring bolted mechanical joints** is incorporating a ductile iron circlip which is located in a chamber or groove cast in the socket and which registers with a groove specially machined in the spigot.

8. **Slip-on couplings** are designed for use with plain end pipes. The coupling consists of a sleeve, at the ends of, which are wedge-shaped rubber gaskets and flanges held together by bolts.

9. **Self-anchoring tie-bar joints** have a special loose anchor ring placed behind the socket and a special anchor ring welded onto the outer surface of the spigot.

### 2.1.5.7 Sealing Material

Sealing materials shall be of elastomeric compounds comprising suitable polymers such as:

1. Ethylene propylene diene monomer (EPDM) with 40% minimum volume of compound for IRHD of \(\geq 55 < 85\); or
2. Styrene butadiene rubber (SBR) with 50% minimum volume of compound for IRHD of \(\geq 55 < 85\).

The design of the seal’s profile and the compounding of the elastomer needs to ensure long term sealing of the joint. The elastomer seals shall be protected from unnecessary exposure to the effects of ultra-violet light and ozone.

Jointing lubricant of water based emulsion shall be used in the application of elastomeric seals.

### 2.1.5.8 Fittings

For gravity sewer applications, the exact fittings required for junctions and manhole drops are not available. The configurations of fittings also vary from those normally used in VC fittings. The fittings come with either flange joint or other joints.

### 2.1.6 GRP Pipe

#### 2.1.6.1 General

**Material compositions** of the GRP pipes in accordance with BS 5480:1990 consist mainly of thermosetting resin, normally isophthalic polyester, or vinyl ester resin for special chemical resistance requirements. It is incorporated with a fibrous reinforcement derived from continuously drawn filaments of E-glass and shall be used in the following forms alone or in any combination subject to compatibility with the resin used:

a. Roving;  
b. Chopped strand mat;  
c. Woven fabric.

A surface tissue shall be incorporated into the superficial layers of the internal surfaces of a GRP pipe or fittings to enhance chemical resistance. They shall be made of:

a. Glass material of C-glass; or  
b. Woven textiles based on polyester or acrylic fibres; or  
c. Non-woven textiles based on polyester or acrylic fibres.
An aggregates and fillers can also be incorporated into the GRP pipe as a part of the composite structure to enhance the stiffness of the pipe. The aggregates shall be of inert granular material with the size range between 0.05 mm and 5mm and the inert fillers shall be of a fine material with a particle size below 0.05 mm.

The resin may incorporate the additives for modifying the properties of the resin, and pigments or dyes as a colourant.

There are two types of manufacturing process for GRP pipes, which are:

1. Filament winding
2. Centrifugally casting

**2.1.6.2 Standards Compliance**

The manufacture, design and installation of DI pipes shall comply to the requirements stipulated in the following Standards:

1. Manufacture
   a. BS 5480:1990 - Specification for glass reinforced plastics (GRP) pipes, joints and fittings for use for water supply or sewerage
   b. ASTM D 3262 - Specification for “Fiberglass” Glass-Fiber-Reinforced Thermosetting-Resin Sewer Pipe

2. Design and Installation
   a. AS/NZS 2566.1: 1998 - Buried flexible pipelines-Structural design
   b. AS/NZS 2566.2: 2002 - Buried flexible pipelines-Installation

**2.1.6.3 Sizes**

**Nominal size (DN)** of GRP pipe is a numerical designation of size designated by outside diameters or by thread size. It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions.

**Pipe Lengths** should show the effective length of the pipes. The pipes shall comprise a straight length of either 3 m or 6m with the permissible deviations of ±25 mm. The GRP pipes can be cut and chamfered to the desirable length by water-fed petrol driven abrasive disc cutter. Sealing of cut pipe ends is not required.

**2.1.6.4 Classes**

**Classes** of GRP pipes for sewerage system are defined by the pressure class and stiffness class of the pipe in accordance with BS 5480:1990, as described below:

1. Pressure – GRP pipes is classified for use under gravity, indicated by G, imply that the component is capable of withstanding internal hydrostatic pressure up to 0.5 bar.

   GRP pipe that classified for use under pressure is capable of withstanding internal hydrostatic pressure more than 0.5 bar. The pressure classes are referred as PN 12.5, PN 16 and PN 20 that corresponding to 12.5, 16 and 20 bar of working pressure. The pressure rating of the GRP pipe is not dependent on the wall thickness but the GRP composite through wall is the component that increases the pressure rating of the GRP pipe.
2. Stiffness – GRP pipes is classified according to their minimum initial specific stiffness. This shall be referred to the preferred numbers (SN values) for nominal minimum initial stiffness in N/m² of SN 1250, 2500, 5000, 10000, 15000 and 20000. The ring bending stiffness is increased as the wall thickness of the GRP pipe is increased. Figure 4.19 defines the stiffness of the GFRP pipe.

2.1.6.5 Protective Coatings

**External protection** of GRP pipe is by a layer of thermosetting resin. The layer provides scratch resistance and also acts as a barrier against ultraviolet.

**Internal protection** of GRP pipe is by a smooth resin rich lining free of glass filament that has good corrosion resistance across a wide pH range. It also enhances a smooth flow in the pipe. The surface tissue shall be incorporated to the pipe to enhance chemical resistance.

2.1.6.6 Joints

Joints for GRP pipe are generally of a type of flexible joints using elastomeric sealing rings as a medium to allow a deflection for the pipe. The types of joint for GRP pipe in accordance with BS 8010-2.5:1989 for sewerage system are as following:

1. **Integral socket and spigot joint** is a push-in joint incorporating a specially formed socket and spigot with the seal is effected by means of an elastomeric gasket. Spigots shall have witness marks to identify the insertion depth.
2. **Loose collar joint** is a simple push-in joint consisting of a full-width elastomeric profile, usually of an EPDM rubber, overwrapped with GRP.
3. **Slip-on coupling** is designed for use with plain-ended pipes. It consists of a sleeve, at the ends of, which are wedge-shaped elastomeric gaskets and flanges held together by bolts.
4. **Stepped slip-on coupling** is a special slip on couplings used to connect pipes of different diameters or materials
5. **Band coupling** is designed for used with plain-ended pipes. It consists of a metallic band encasing a shaped elastomeric profile
6. **Flange adapters** is designed to connect flanged pipe or any flanged fitting to plain-ended pipe. It consists of a flange and sleeve piece, a wedge-shaped elastomeric gasket and a loose gland fastened to the main body by bolts.
7. **Flange joints** are made by integral forming or attaching a preformed GRP flange or forming a stub flange with metallic backing flange.

2.1.6.7 Sealing Material

**Sealing materials** shall be of elastomeric compounds comprising suitable polymers such as:

1. Ethylene propylene diene monomer (EPDM) with 40% minimum volume of compound for IRHD of >=55<85; or
2. Styrene butadiene rubber (SBR) with 50% minimum volume of compound for IRHD of >=55<85.

The design of the seal’s profile and the compounding of the elastomer needs to ensure long term sealing of the joint.

**Jointing lubricant** of water based emulsion shall be used in the application of elastomeric seals.
2.1.6.8 Fittings

Fittings of the GRP pipe are made of continuous glass rovings with either chopped strand mat or chopped rovings (E-glass) with coupling agent to bond to resin. The chopped rovings coupling shall be coated with pigmented resin or acrylic paint for above ground use.

2.1.7 Profile Wall HDPE Pipe

2.1.7.1 General

**Material composition** of the profile wall HDPE pipes shall be a high density polyethylene (HDPE) plastic in the form of powders, granules or pellets with no more than 10% of recycled materials. The materials shall be as uniform in composition and size and as free of contamination. Some carbon black or titanium dioxide, about 2-3% may be added as ultraviolet stabiliser. Other additives added are lubricants, antioxidants and pigments.

**Manufacturing processes** of profile wall HDPE pipes can be by injection moulding or rotational moulding. The steps of manufacturing process of profile wall HDPE pipe is varied, depending on the patterns of the profile wall pipe, which is helical or annular.

2.1.7.2 Standards Compliance

The manufacture, design and installation of profile wall HDPE pipes shall comply to the requirements stipulated in the following Standards:

1. Manufacture
   a. DIN 16961-1 (2000-03) - Thermoplastic pipes and fittings with profiled outer and smooth inner surfaces-Dimensions
   d. CAN/CSA-B182.6-M92 - Profile Polyethylene Sewer Pipe and Fittings
   e. ISO TC 138 SC1 - Plastics pipes and fittings for soil, waste and drainage (including land drainage)
   f. CEN/TC 155/WG 13 - Systems with structured-wall pipes for non-pressure drainage and sewerage - PE, PP, PVC-U
   g. ASTM D 3350 - Standard Specification for Polyethylene Plastics Pipe and Fitting Materials

2. Design and Installation
   a. AS/NZS 2566.1: 1998 - Buried flexible pipelines-Structural design
   b. AS/NZS 2566.2: 2002 - Buried flexible pipelines-Installation

2.1.7.3 Sizes

**Nominal size (DN)** is commonly used as a numerical designation of the internal diameter of HDPE profile wall pipes. It is a convenient round number approximately equal to a manufacturing dimension. In some cases, two internal diameters may be assigned to one nominal size.

**Pipe Lengths** should show the effective length of the pipe. HDPE profile wall pipes can be cut on site using most types of saws. However, it is not desirable to cut helically wound profile pipe, as it is difficult to cut square and need to seal open end of profile.
2.1.7.4 Classes

The classes of HDPE profile wall in accordance with AS/NZS 2566.1:1998 shall be classified in terms of nominal stiffness of pipe, which is governed by the HDPE grade, wall thickness and cross-section geometry. The minimum pipe ring stiffness shall not be less than SN 1250 and SN 2500 corresponding to a value between 1250 N/m² and 2500 N/m². The minimum value between these limits depends on the installation conditions.

The material type and the level of required strength for sewerage application in reference to MS 1058:1994 shall be a minimum of Type 80 and 8.0 MPa respectively. The design stress of the pipe is obtained by applying a design coefficient of 1.25 to the minimum required strength value of the pipe.

The wall thickness of profile wall HDPE pipe shall not be less than 2.3mm.

2.1.7.5 Protective Coatings

External and internal protection for profile wall HDPE pipe is not required.

2.1.7.6 Joints

The jointing methods for the profile wall HDPE pipes are of the following:

a. Spigot-socket with rubber ring seals type
b. Thermofusion welding is formerly known as fusion welding. The thermofusion welding can be carried out to the following:
   - Welded spigot-socket
   - Welded plain ends using a fillet or butt weld
   - Welded spigot socket using a butt weld
   - Flange end joint

2.1.7.7 Sealing Material

Sealing material of rubber ring seal type shall be used for profile wall HDPE pipes. The rubber seal shall be positioned and bonded in the socket prior to jointing or placed between the outer corrugations at the spigot end. All joints are of the skid type where application of lubricant is required at the jointing surfaces.

2.1.7.8 Fittings

The fittings for profile wall HDPE shall be moulded or fabricated. The fabricated fittings are less compact than the moulded fittings and are thus less convenient for handling and installation. They will also require a greater support area. For junctions, only the Y fitting need be of HDPE materials. An appropriately dimensioned spigot or socket end on the Y or the adaptor to the Y is permitted to be in another material.

2.1.8 Steel Pipe

2.1.8.1 General

Material compositions for mild steel pipes is carbon steel that shall consist of structural or analysis grade steel comply with BS EN 10025: 1993 and BS 3601: 1987. The stainless steel pipes is consist of stainless steel mother coils, which their grades and compositions shall comply with BS 3600:1976.
The most common manufacturing process that can be applied to produce all sizes of mild steel pipes is by using helical winding method. The mild steel pipes can also be manufactured using other methods of manufacturing processes that is dependent on the sizes of the pipe, such as:

1. **Steel pipes with diameter less than DN 500**
   - Hot rolling billets, bars, or ingots into a seamless tube; and
   - Involves cold rolling steel strip through rollers into the pipe shape and then welding.

2. **Steel pipes with diameter DN 500 and up to DN 1050**
   The manufacturing process for these sizes of pipes involves a formation of steel plates into a circular shape using a ‘U’ press followed by an ‘O’ press. Then the joint is welded along the pipe barrel by submerged arc welding.

3. **For sizes up to DN 3000**
   The production for these sizes of pipes involves a cold rolling of steel plates into a circular or half-circular shape. One circular shaped steel plate is then welded along the barrel. For larger diameter pipes two half-circular shapes will be welded together along the barrel.

### 2.1.8.2 Standards Compliance

The manufacture, design and installation of steel pipes shall comply to the requirements stipulated in the following Standards:

1. **Manufacture**
   - BS 534:1990
   - BS 3600:1976
   - BS 3601:1987
   - BS EN 10025:1993

2. **Design and Installation**
   - AS/NZS 2566.1: 1998 - *Buried flexible pipelines-Structural design*
   - AS/NZS 2566.2: 2002 - *Buried flexible pipelines-Installation*

### 2.1.8.3 Sizes

**Nominal size (DN)** is commonly used as a numerical designation of the outer diameter of steel pipes. It is a convenient round number approximately equal to a manufacturing dimension. The bore of the pipe, which is affected by the wall thickness will govern the pressure load to the pipe. Pipe sizes are not restricted to these nominal sizes and can be made to any outside diameter upon request from the purchaser.

**Effective length** of steel pipe is referred to the actual length that a pipe contributes when correctly assembled in a run of piping. This dimension excludes the additional length contributed by a slip-on type coupling when this is used.

The pipes shall be supplied in either random lengths or cut lengths. Where cut length is specified, the maximum variation in length shall be +6, -0mm for lengths up to and including 6m. For every 3 m increase in length above 6 m, the plus tolerance shall increase by 1.5 mm to maximum of 12.5 mm. The pipe can also be cut on site by oxy-cutter.

### 2.1.8.4 Classes

**Classes** of the steel pipe have not been defined in BS EN 534:1990. The classification of grades and qualities of steel pipe shall be in accordance with BS EN 10025:1990.
2.1.8.5 Protective Coatings

**External coating** for mild steel pipes that commonly applied for the pipe’s protection is bitumen whereas a coal tar enamel, asphalt enamel and glass fibre still can also be used in accordance with *BS 534:1990*.

**Internal lining** shall be applied at the end of the manufacturing process. High alumina cement mortar, sulphate resistant cement mortar, coal tar enamel, coal tar epoxy or bitumen shall be used as the internal lining protection to the pipes. In accordance with *BS 534:1990*, the minimum cement content shall be 330kg/m³ and the maximum water:cement ratio shall not exceed 0.46:1. The steel pipe is subjected for priming before the internal coal tar or bitumen protection is applied.

Thermosetting (epoxy paint or powder or epoxy tar resin) and thermoplastic (polyethylene, polyurethane) shall be applied to the internal and external surfaces of the pipe.

**Protective coatings and linings** are not applicable for stainless steel pipe.

2.1.8.6 Joints

Jointing of steel pipes can be achieved with the following methods in accordance with *BS 534:1990*:

a. Butt-welded joints. This is commonly used but is not suitable for lined pipes in sizes 610mm OD and smaller.

b. Sleeve joints for welding. Three types of sleeve joints for welding are described in *BS 534:1990*. The pipes are supplied with the spigot end and the sleeve end. This joint is the preferred type but it is exceptional for pump station pipework and valve connections where flange joints shall be used.

c. Slip-on type coupling. This type of coupling is for use with plain end pipe.

d. Flange joint. It is compulsory to use for pump station pipework and valve connections

e. Threaded and coupled joint.

Mechanical joints are only permitted for cut pipe lengths, where internal cement mortar lining at joint is not possible and where movement of the pipeline is to be allowed for.

2.1.8.7 Fittings

Fittings are fabricated by welding together sections of steel pipe and are tailor-made which have been hydraulically tested before coating. Hence, they are considered as steel pipe specials. The end fittings produced are prepared to match those of the pipes to which they are to be joined. Steel fittings are much more costly because fabrication is labour intensive with the need to manually weld and apply cement mortar lining.

2.1.9 Solid Wall PE Pipe

2.1.9.1 General

**Material compositions** of the solid wall HDPE pipes pipe is polyethylene (PE) resins with density range of 950-965 kg/m³ containing no more than 10% of recycled materials. The PE plastic can be in the form of powders, granules or pellets. Some carbon black or titanium dioxide, about 2-3% shall be added as ultraviolet stabiliser. Other additives added are lubricants, antioxidants and pigments.
2.1.9.2 Standards Compliance

The manufacture, design and installation of solid wall HDPE pipes shall comply to the requirements stipulated in the following Standards:

1. Manufacture
   a. MS 1058: Part 1: 2002 - Specification for polyethylene (PE) Piping systems for water supply:
      : Part 1 : General (Third revision)
   b. MS 1058: Part 2: 2002 - Specification for polyethylene (PE) Piping systems for water supply:
      Part 2: Pipes (Third revision)
   c. ISO TC 138 SC1 - Plastics pipes and fittings for soil, waste and drainage (including land
      drainage)
   d. ASTM D 3350 - Standard Specification for Polyethylene Plastics Pipe and Fitting Materials

2. Design and Installation
   a. AS/NZS 2566.1: 1998 - Buried flexible pipelines-Structural design
   b. AS/NZS 2566.2: 2002 - Buried flexible pipelines-Installation

2.1.9.3 Sizes

Nominal Outside Diameter, $d_n$ of solid wall HDPE pipes is a numerical designation of size to HDPE piping system other than flanges and components designated by thread size. It is a convenient round number for reference purposes. This diameter is fixed while the internal diameter varies depend on the classes. The increment is not constant and the sizing follows the adopted international standards for thermoplastic pipe for pressure applications.

**Standard length** of pipe indicated the overall effective length of the pipe. HDPE solid wall pipes can be cut on site using most types of saws.

2.1.9.4 Classes

Classes of solid wall uPVC pipes is designated by the material types, PE 100 and PE 80, which correspond to the level of minimum design strength at 20°C for up to 50 years. PE 80 and PE 100 show the capabilities of the pipes to withstand 80 bar (8 MPa) and 100 bar (100 MPa) of strength respectively. The maximum design stress is obtained by applying a design coefficient of 1.25 to the strength.

PE is available in various compounds of different density and this alters the allowable stress that a pipe can withstand. The higher the allowable design stress, the thinner the wall for the same working pressure. Ring stiffness of 8 kN/m² (8000 MPa) is generally taken as the minimum stiffness for smaller diameter pipe. Hence PE 80 with typical resins density of 950 to 955 kg/m³ is recommended for use in pressure sewerage. Working pressure is increased by increasing the wall thickness (to ensure pipe bores align at joints requires that each pipe have the same pressure class).

2.1.9.5 Protective Coatings

External protection and internal protection is not required for solid wall HDPE pipes.

2.1.9.6 Joints

The jointing methods for solid wall HDPE pipe shall be as follows:

1. **Thermofusion welding** is formerly known as fusion welding. This method uses heated tools to weld the joint faces together and can be applied to specially made moulded socket fittings and also to those made for butt jointing
a. **Butt fusion welding** is suited for the jointing of HDPE for all sizes of pipe. The joint is produced by heating the faces of the components against a heated flat plate, which is usually coated with PTFE and then bringing them together under controlled pressure.

Butt welding also leaves a raised bead about the joint inside the pipe, which will interfere with the flow. Tools are available to remove this internal bead but because this is not easily inspected for, installers may avoid this operation.

b. **Spigot socket joints** – For this joint one end of the pipe is opened up to act as the socket of a moulded fitting and thereafter the butt fusion welding is carried out.

2. **Electrofusion** is simpler than butt fusion but only applicable for small diameter of pipe up to 315 mm only. The heating and timing operations are all automatically undertaken by a control unit of the following procedures:
   - Electrofusion coupling slipped over the ends of the pipe to join
   - Resistance wires in the coupler are heated by a controlled electrical current
   - The coupler and pipe are melted and then fused to each other.

The main deterrent to the use of electrofusion joints is their greater cost compare to the method of thermofusion welding.

3. **Flange joints** shall be used when require jointing to fittings or pipes of other material and most commonly used for larger diameter pipes. It consist either a full face or stub flanges welded to the pipe or alternately can be formed on the pipe. The rotational flexibility that this joint type provides is however compensated for by the longitudinal flexibility of polyethylene pipe.

4. **Mechanical metal couplings** do not provide the strength or long term performance as compare to a properly made fusion joint and are only considered for some repair operations. There are wide ranges of plastic (acetal and GRP used) fittings for small diameters that use mechanical (compressed rubber seal) joints and development continue on larger sizes.

2.1.9.7 Fittings

The fabricated fittings for solid wall HDPE pipes are available in sizes 225 and larger. It comprise of pipe sections that are fillet welded together to form the fitting configuration. Like the pipes, fittings are also jointed by butt fusion.

2.1.10 ABS Pipe

2.1.10.1 General

**Material compositions** of ABS pipes are consist of a copolymer of the monomers acrylonitrile, butadiene and styrene. Each monomer brings to the copolymer different properties, such as:

a. Acrylonitrile is to provide resistance to chemicals and ageing (ultraviolet light) and rigidity;

b. Butadiene provides impact strength, toughness and abrasion resistance; and

c. Styrene contributes to strength and ease of processing.

Varying the quantities of each monomer will modify the performance properties of ABS pipes. For pipe applications as a pressure sewerage system, appropriate quantities of each monomer are selected to optimise the performance properties of tensile strength, chemical resistance, ductility and weatherability. Material suitable for pressure pipe applications shall be Type 12142 in conformance with **MS ISO 2580-1**.
Manufacturing process of ABS pipes is much the same as used for other extruded thermoplastic pipe.

2.1.10.2 Standards Compliance

The manufacture, design and installation of solid wall HDPE pipes shall comply to the requirements stipulated in the following Standards:

1. Manufacture
   a. MS 1419: Part 1 to 3: 1997
   b. MS 1419: Part 4: 1998
   e. AS 3690: 1989
   f. AS 3691: 1989
   g. BS 5391: Part 1
   h. BS 5392: Part 1

2. Design and Installation
   a. AS/NZS 2566.1: 1998 - Buried flexible pipelines-Structural design
   b. AS/NZS 2566.2: 2002 - Buried flexible pipelines-Installation

2.1.10.3 Sizes

Nominal size (DN) is commonly used as a numerical designation of the outside diameter of ABS pipe. ABS pipe is extruded with a fixed outside diameter while the inside diameter is varied to achieve the range of pipe classes. The ABS pipe without couplings shall conform to the dimensions recommended in MS 1419: Part 1-1997.

Pipe lengths should show the standard overall length of the pipe, exclusive of coupling, of 6 ± 0.05, - 0m. All measurements shall be adjusted to an equivalent length at 20°C. The ABS pipe can be cut at site to the desirable length by handsaw or powersaw. However, care must be taken to ensure squareness of cut ends.

2.1.10.4 Classes

Classes of ABS for force main are defined according to maximum static working pressure at a pipe material temperature of 20°C, which the minimum class for sewerage application shall be of Class 4.5 denoted that the minimum maximum static pressure is 0.45 MPa. The working pressure decreases with increasing temperature.

2.1.10.5 Protective Coatings

The protective coating and lining is not required for ABS pipe since the material itself can resist the corrosion attack from the sewage.

2.1.10.6 Joints

The methods of jointing ABS pipes for force main are as following:

1. Spigot-socket with solvent cement welding joint
   The jointing process shall be properly performed to provide an ideal joint for the elimination of infiltration and root intrusion.
2. **Spigot-socket with elastomeric seal joint**
   Spigot and socket pipe for elastomeric seal jointing shall carry a witness mark such that when the spigot is inserted into a matching pipe socket to the witness mark, the joints are confined to the socket and jointing seal.

3. **Stub flange joint**
   The flange is required to be solvent cemented onto a spigot end. The stub flange requires the use of a backing plate and a rubber gasket between the flanges for specific joint application.

The jointing of ABS pipe requires special trainings because of the care required to make a solvent cement joint, particularly in large diameters.

### 2.1.10.7 Sealing Materials

**Solvent cement** shall consist of one or more solvents and a sufficient quantity of base ABS material dissolved in the solvents to give the cement the body and consistency required for proper application. Small amounts of inert fillers are added to control shrinkage during drying.

### 2.1.10.8 Fittings

ABS fittings for making of junction connections are available and it can be injection moulded or fabricated.