

D - STEEL PIPES AND SPECIALS

1.0 GENERAL REQUIREMENTS

1.1 Scope

This section of the Specifications covers the requirements for the manufacture and testing of welded steel pipes together with fittings complete with internal and external protection systems.

1.2 Definition

The following terms shall have the meanings hereby assigned to them except where the context clearly renders these meanings inapplicable.

“Pipes” means straight pipes, whether whole or in cut lengths.

“Fittings or pipe specials” means tees, bends, tapers, collars, flange adapters, blank flanges, expansion joints, mechanical joints, ring girders and similar accessories.

1.3 Standards and Codes of Practice

The following Standards and Codes of Practice are referred to in this section of the Specification. The Standard or Codes shall be the latest edition current at the time of its preparation unless otherwise specified for particular application.

| | | |
|----------------|------|---|
| API | 5L | Line pipe |
| API | 5LS | Spiral-weld line pipe |
| API | 1104 | Standard for welding pipelines and related facilities |
| BS Handbook 21 | | Methods for sampling and analysis of iron, steel and other ferrous metals |
| BS 12 | | Specification for Ordinary and Rapid Hardening Portland cement |
| BS 534 | | Steel pipes, fittings and specials for water, gas and sewage |
| BS 903 | | Methods of testing vulcanised rubber |
| BS 1154 | | Specification for natural rubber compounds (high quality) |
| BS 2494 | | Materials for elastomeric joint rings for pipework and pipeline |

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|---------------------|---|
| BS 2569 | Sprayed metal coatings |
| BS 4147 | Hot applied bitumen based coatings for ferrous products |
| BS 4232 | Surface finish of blast-cleaned steel for painting |
| BS 4360/Part 2/2169 | Weldable structural steels |
| BS 4504 | Flanges and bolting for pipes, valves and Fittings Part I : Ferrous |
| BS 5292 | Jointing materials and compounds |
| BS 5500 | Unfired fusion welded pressure vessels |
| AWWA MII | Steel pipe design and installation |
| BSEN 10025:93 | Hot rolled products of non-alloy structure steel – Technical delivery condition |
| BSEN 1092-1:2002 | Flanges and their joints – circular flanges for pipes, valves, fittings and accessories PN designated. Part 1: Steel Flanges. |

1.4 Submissions

The Contractor shall provide drawings, calculations and data in respect of the following:-

For pipes and fittings:

- drawings with descriptions to show the method of forming pipes and fittings in standard lengths from steel sheets or strip

For joints:

- drawings for spigot and socket joints showing allowable tolerances and arrangements to permit air testing of completed joins on Site.

For welding procedure :

- details of plant, methods, materials , make and size of electrodes, number of runs and current strength for each type of weld.

For internal lining :

- full details of method of lining and curing including details and sieve analysis of materials to be used and type of cement.

For internal coating :

- full details of coating process to be used, including details of the bitumen and the inner and outer wrappings.

2.0 GENERAL REQUIREMENTS OF PIPES AND FITTINGS

2.1 Pipes and Fittings

All pipes and fittings shall be provided by the Contractor and delivered to the Site. Unless otherwise shown or specified, the Contractor shall at his own cost, supply all pipes and fittings required for the works and should be new and of makes approved by SYABAS. Each items supplied shall be suitably marked to permit identification with items in the Bill of Quantities.

2.2 Steel Pipes

Steel pipes shall be manufactured, except where stated otherwise hereunder, in accordance with API Specification 5L or API Specification 5LS. Material for pipes shall be made from carbon steel plate to Grade 43A of BS 4360 Part 2 1969 or better with a minimum lower yield stress of 245N/mm² supplied in plate or strip form as of appropriate for the method of pipe manufacture. The pipes shall be formed by the automatic submerged arc process, with either a longitudinal seam or a spiral seam at the option of the Contractor. With the method of manufacture decided upon, the relevant standard will then apply i.e. API Specification 5L for longitudinal seam pipe or API Specification 5LS for spiral seam pipe. The API standards shall be referred to hereunder as Std 5L/S and shall be deemed to apply to all pipe sizes, including those whose outside diameter (OD) falls outside the upper limit covered by the standards.

The Contractor shall provide a ladle analysis of the steel used for the pipes in accordance with Clause 6.1 of BS 4360 Part 2 1969. Check analysis of the finished pipe shall be taken in accordance with Clause 6.2 of BS 4360 Part 2 1969 and Clause 3.4 of Std. 5L/S. In case of dispute, the methods of chemical analysis shall be in accordance with BS Handbook No.21.

At the discretion of the S.O. test certificates may be required from approved independent inspection agencies for all materials used in the manufacture of the pipes and specials and the cost of this shall be deemed to be included in the Contract Rates.

With every consignment of pipes, valves and fittings delivered under this Contract, the Contractor shall furnish a certificate worded as follows :-

This is to certify that the quality of the pipes, valves and fittings delivered in this consignment is not inferior to the sample for which the Contract was awarded or to the quality laid down in the Specification whichever is applicable.

The thickness of steel plates shall be in accordance with Table 1 subject to the rolling margins for plates as shown in Table 4 of BS 4360 Part 2 :1969 unless otherwise stated in the Bill of Quantities.

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The thickness of pipes used for branch pipe-work off the main pipelines or for use in forming fittings shall be the greatest of the following :-

- The thickness necessary to provide the same outside diameter to wall thickness ratio specified for straight pipes;
- The minimum thickness shown in Table 6.2 of Std 5L or Table 6.1 of Std 5LS for pipes of the appropriate diameter (or the nearest equivalent therein);
- The thickness determined to be necessary in the design of fittings as shown on the Drawings.

Standard length straight pipes shall be manufactured with not more than three circumferential joints and with an effective length as shown in the table below:

| Finished Internal Diameter (mm) | Standard Length (m) |
|---------------------------------|---------------------|
| 450 to 1200 | 9 -10 |
| Below 450 | 6 |

Thickness of Steel Pipes

| Nominal Diameter (mm) | Finished internal Diameter (mm) | Minimum Steel Plate Thickness (mm) | Concrete Lining Thickness (mm) | External Diameter (mm) | Factory Hydraulic Test Pressure (bars) |
|-----------------------|---------------------------------|------------------------------------|--------------------------------|------------------------|--|
| 100 | 93.7 | 4.1 | 10 | 121.9 | 70 |
| 150 | 149.1 | 4.1 | 10 | 177.3 | 70 |
| 200 | 204.0 | 4.1 | 10 | 232.2 | 70 |
| 250 | 257.8 | 4.1 | 10 | 285.0 | 70 |
| 300 | 313.8 | 5.8 | 10 | 245.4 | 70 |
| 350 | 361.7 | 5.8 | 13 | 399.3 | 63 |
| 400 | 415.5 | 5.8 | 13 | 453.1 | 56 |
| 450 | 469.4 | 5.8 | 13 | 507.0 | 50 |
| 500 | 522.7 | 5.8 | 13 | 560.3 | 45 |
| 600 | 628.0 | 6.5 | 13 | 667.0 | 42 |
| 650 | 651.2 | 7.4 | 13 | 692.0 | 39 |
| 700 | 701.2 | 7.4 | 19 | 754.0 | 39 |
| 800 | 801.2 | 7.4 | 19 | 854.0 | 39 |
| 900 | 901.2 | 7.4 | 19 | 954.0 | 34 |
| 1000 | 1000.0 | 8.0 | 19 | 1054.0 | 30 |
| 1100 | 1100.0 | 9.5 | 19 | 1157.0 | 30 |
| 1200 | 1210.0 | 10.0 | 25 | 1270.0 | 30 |
| 1300 | 1300.0 | 11.0 | 25 | 1372.0 | 29 |
| 1400 | 1400.0 | 11.0 | 25 | 1472.0 | 29 |
| 1500 | 1500.0 | 13.0 | 25 | 1576.0 | 26 |
| 1600 | 1600.0 | 13.0 | 25 | 1676.0 | 26 |
| 1700 | 1700.0 | 13.0 | 25 | 1776.0 | 26 |
| 1800 | 1800.0 | 13.0 | 25 | 1876.0 | 26 |
| 1900 | 1900.0 | 13.0 | 25 | 1976.0 | 26 |
| 2000 | 2000.0 | 14.0 | 30 | 2088.0 | 25 |
| 2100 | 2100.0 | 14.5 | 30 | 2189.0 | 24 |
| 2200 | 2200.0 | 15.0 | 30 | 2290.0 | 23 |

The allowable tolerance on standard length pipes shall be ± 150 mm. Standard length pipes and truly circular standard straight pipes shall be supplied. All standard pipes shall have ends formed as specified below for joints capable of angular rotation. Truly circular standard straight pipes required for cutting purposes shall be truly circular throughout the length.

All pipes whether manufacture with a longitudinal or spiral seam shall be subjected to non-destructive testing of seam welds and skelp and welds in accordance with Section 7 of Std 5L or Section 7 of Std 5LS as appropriate.

2.3 Workmanship and Welding Standards

As a control on weld quality the Contractor shall be required to take and submit 100% ultrasonic test and 3% radiographs for all welds for the S.O.'s clearance. The clearance and acceptance of these radiographs shall be in accordance with API Standard 1104 unless otherwise directed by the S.O. Where the above tests are not possible, the contractor may propose magnetic particle or dye penetration test. The cost of this shall be deemed to be included in the Contract rates.

Weld defects shall include cracks, leaks, laminations, lack of complete penetration, lack of complete fusion, dents exceeding one eighth of the specified wall thickness and undercutting or reduction in pipe wall thickness adjacent to a weld exceeding 0.5mm in depth.

Slag inclusions and gas pockets or voids considered to be minor imperfections may be accepted if the maximum size and distributions does not exceed the limits shown in Section 9 of Std 5L or Section 7 of Std 5L/S.

Where radiographic examination reveals defects in the welds the S.O. will either reject the length of pipe containing such defects or will permit the Contractor to carry out repairs and to submit radiographs of such repairs for clearance. Lengths of pipe containing defects in welds after repair will be liable to be rejected.

If defects in welds are found in a length of pipe or fitting, the welds of the pipes and fittings immediately before and after the defective pipe or fitting in the production line shall be radiographed until the S.O. is satisfied that all the welds are considered satisfactory. The cost of such radiographs and radiographs of repaired welds shall be included in the Contract rates and shall not form part of the 3% of all welds specified in the first paragraph of this Clause.

2.4 Jointing of Pipes

2.4.1 Pipe Ends

Ends of pipe to be jointed shall generally be as follows :-

- Spigots and sockets for jointing in trench or above ground for pipes and fittings with diameter 700mm and above
- Plain ends for use with welded collars, mechanical couplings or flange adaptors for pipes and fittings with diameter 700mm and above
- Flanged for pipes and fittings below 600mm in diameters

The spigot and socket joints for the spherical type shall be designed to take angular deflection of up to 5 degrees from the axial to accommodate changes of pipe gradient and/or direction at individual joints. For hemispherical type, the angular deflection shall be up to 2 degrees.

Spigot and socket joints shall be of the spherical or hemispherical sleeve type with a minimum penetration of the formed ends. The joint design shall provide for the contact surface of the spigot end and the sleeve end to be formed to the same spherical radius which shall be more than 50% of the outside diameter of the barrel of the pipe for the spherical type and shall not be less than 50% of the outside of the barrel of the pipe for the hemispherical type. The minimum penetration of the spigot into the socket shall not be less than four times the pipe thickness and this overlap shall be obtained at the maximum deflection of 2 to 5 degrees. At zero deflection the minimum overlap shall be the minimum penetration as above increased by such allowance as is necessary to ensure contact between the spigot and socket over the specified maximum amount of joint movement. The joint engagement tolerance in any position shall not exceed an average of 1.60 mm with maximum isolated gaps of 2.00 mm adjacent to the weld seams.

Pipe ends of the spherical or hemispherical type shall be formed by hydraulic pressing using a full circle die or expanding former capable of forming ends consistently to a constant spherical contact surface through the pipe production run.

The internal surface of the socket and the external surface of the spigot shall be ground smooth along the pipe axis.

The external surface of the plain ended pipes shall be similarly prepared.

All sockets shall have two tapped holes spaced at 90 degrees apart on the circumference. They shall be of not less than 6mm diameter and shall be provided with matching plugs to facilitate the air pressure testing of field welds. These tapped holes shall be located within the end 30mm of the sockets and shall be cleared of welding runs.

Ends prepared for butt welding shall be subject to manufacturing tolerances in accordance with Table 6.3 of Std 5L or Table 6.2 of Std 5L/S.

Plain ends for use with mechanical joints or flange adaptor joints shall be truly circular with a diameter tolerance of + 1mm over a distance of 225 mm from the pipe ends.

2.5 Flanged Joints

All flanges shall be of steel, welded to the pipe by the electric arc process or other approved method. They shall conform in all respects with the requirements of BS 4504 or BS 5500 unless otherwise specified. They shall be of the raised face type and shall be truly faced over their whole width. Bolt holes shall be drilled off centre lines, truly in line end to end with the longitudinal axis. All flanges shall be rated as 16 bar. All flanges shall be adequate to withstand test pressures for the fittings to which they are attached.

All materials required for use in the making of flanged joints including nuts, bolts, washers and joint gaskets shall be supplied by the Contractor. The cost of this shall be deemed to be included in the Contract Rates. Joint gaskets shall be contained within the bolt pitch circle and shall be made from 4.5mm thick rubber to BS 1154 Class Y3 reinforced with two layers of fabric in accordance with BS 5292. Each bolt shall be supplied and installed with a nut and two washers and each bolt shall be of sufficient length to show two threads past the nut when so installed. All bolts and nuts shall be stainless steel.

Test certificates for the flange material shall be supplied. The finish on flange joint surfaces shall be in accordance with Clause 4.4 of BS 4504.

Blank flanges shall be designed and supplied by the Contractor for an end loading equivalent to the rating pressure of the flange. Lifting eyes or handles and air release cocks shall be provided where necessary.

Thrust flanges shall be designed to withstand a longitudinal force equal to the loading applied to a blank flange of equivalent diameter.

2.6 Mechanical Couplings, Flange Adaptors and Expansion Joints

Mechanical coupling for jointing plain ended pipes shall be of Viking Johnson Coupling type or approved make capable of maintaining a water tight joint over a range of axial movement between the pipe ends of at least 80mm and with up to 3 degrees angular deflection between the longitudinal axis of the pipes.

Flange adaptors for jointing plain ended pipes to fittings shall be of an approved make capable of maintaining a watertight joint over a range of axial movement of at least 25mm and an angular deflection.

All necessary couplers, joint rings, nuts, bolts and washers, etc. required for completing joints shall be supplied by the Contractor and deemed to be included in the Contract Rates.

Coupling shall be supplied with or without a central register or locating plugs as required. The central collar shall be at least 1.5mm thicker than the equivalent standard pipe thickness.

Every coupling, flange adaptor and expansion joint shall be capable of withstanding without leakage, the pressure required for the works hydraulic test of the section of pipeline in which it will be incorporated. The pressure rating shall be clearly stamped on all couplings and adaptors. The rubber joint rings shall be Type 1 to BS 2494 having a hardness range of 45-65 degrees measured in accordance with BS 903 and tensile stress-strain properties detailed in Table 3 corresponding to the relevant hardness.

All metallic parts are to be de-scaled to second quality standard in BS 4232 protected in accordance to the Specification.

All welding protrusion shall be machined finished. Mechanical couplings and flange adaptors shall be hydraulic tested at the place of manufacture one in every five for each size of coupling and adaptor.

2.7 Pipes for Closing Lengths

Pipes to be used for closing lengths shall be correctly sized over their full length so that accurate alignment for split collar joints can be obtained. All such pipes shall be clearly marked.

2.8 Collars

Collars shall be provided for jointing cut pipes closure pieces or by means of internal and external fillet welding. Minimum lengths of collars shall be 250mm. Collars may be provided as single split collars with temporary bolts and lugs.

Collars shall have two tapped and plugged holes of not less than 6mm diameter to permit air pressure testing of the joints after field welding, one on each side of the collar clear of the welding runs and approximately 24mm from the edge of the collar. The collar shall be 1.5mm thicker than the equivalent standard straight pipe thickness.

Collars shall make close contact around the circumferences of both pipes connected and the gap between the ends of a split collar after tightening shall not exceed 3mm. Split collar ends shall be prepared for butt welding in the same manner as plain ends of pipes prepared for butt welding in accordance with Std 5L/S. The tolerance of the collars shall be such that nowhere shall the gap between the inside surface of the collar and the outside surface of the pipe at fillet weld locations exceed the tolerances permitted for spigot and socket joints.

The overlap on each pipe shall not be less than 75mm. Collar joints shall not be required to take any deflection.

3.0 FITTINGS AND SPECIALS

3.1 Bends, Tees, Tapers etc.

Special items such as bends, tapers, tees, etc. shall be formed from completely lined pipes as specified by suitable insertion of rubber spacers during lining operation. The coating and lining on the straight pipes shall be cut back from the ends to be welded or cut for a sufficient distance to ensure that no material which is intended to remain part of the coating/lining is damaged or affected by the welding or cutting process.

Pipe specials shall be designed to withstand the full specified factory test pressures. Compensation plates and gusset plates shall be in accordance with BS 5500.

Welding shall be of a standard equal to that of straight pipes. Fillet welds shall be subjected to air tests where appropriate and/or magnetic crack detection tests.

The outside diameter of specials shall conform to the outside diameters of the standard straight pipes and each butt weld subjected to a 100% radiographs test. The ends of plain ended specials shall be truly circular and shall conform to the tolerance required for the fitting of mechanical couplings and flange adaptors.

4.0 PIPELAYING AND HANDLING

4.1 Pipe-work for Laying Above Ground

Uncoated steel pipes and fittings required for installation above ground shall be protected by painting as specified in Section N.

4.2 End Protection

The concrete lining and the external coating of pipes and fittings to be jointed by welding shall be omitted for a sufficient distance from the ends to prevent damage to the protection during site welding.

The unlined surfaces shall be protected with a suitably approved ensis oil or similar material during manufacture so that extensive cleaning of the surface is not required before and after jointing on site.

4.3 Handling

Coated pipes shall be lifted and moved only by wide non-abrasive slings or by other means acceptable to the S.O. Wire ropes, chains and hooks shall not be permitted to come in contact with the coating. No pipe shall be moved by rolling.

Coated pipes shall be stacked in one layer only and in such a manner that the coating is not damaged. Adequate packing between pipes for this purpose must be supplied by the Contractor. Coated pipes must be kept clear of the ground and rested on padded sleepers or supports.

The pipes shall be so handled, stored and transported as to prevent undue distortion and shall not be moved in any manner involving rotation of the pipes about the longitudinal pipe axis.

The pipes shall be lifted by means of two reinforced canvas slings at least 300mm suspended from a lifting beam so that the slings are positioned at a distance of one-fifth of the pipe length from each end of the pipe.

The Contractor shall provide suitable timber end struts and sufficient intermediate struts to strengthen the pipes to the S.O.'s approval to prevent distortion during handling and delivery.

4.4 Protection in Transit

All pipes and fittings shall be protected prior to dispatch from the manufacturer's works. All flanges shall have wooden discs bolted on. All other ends of pipes and fittings shall be protected against impact damage and entry of foreign matter. The

protection shall take into account the end use intended for the pipes and whether or not the final protection has been completed.

Pipes and fittings shall be wrapped or cushioned so that no load is taken directly on the external coating.

4.5 Inspection

All pipes and fittings to be supplied under the Contract shall be inspected by the S.O. at the Contractor's premises or at the places of manufacture if manufactured at other premises.

The Contractor shall provide such office facilities, assistance, labour, materials, electricity supply, fuel, stores, apparatus and instruments ultrasonic thickness indicators and high voltage holiday detectors as may be necessary to allow a thorough and extensive inspection to be carried out.

The S.O. shall be entitled at all times during manufacture to inspect, examine and test on the Contractor's premises or at the places of manufacture if manufactured at other premises, the materials and workmanship of the pipes and fittings. Such inspection, examination or testing including the inspection by the S.O. shall not relieve the Contractor from any of his obligations under the Contract.

4.6 Markings of Pipes and Fittings

Each standard length of pipe, pipe specials and truly circular pipes shall have the following information painted outside:-

- The word SYABAS (50mm high) in capital letter
- The diameter, length and consecutive number and Bill of Quantities item number.
- The weight in kilogram.
- The item number and its consecutive number if more than one in the item
- Diameter of branch in the case of tees and angle in the case of bends and angle branches.

Truly circular pipes shall be marked with two longitudinal parallel bands throughout their whole length.

The diameter and its consecutive number of standard length pipes shall be repeated on the lining just inside on both ends of the pipes.

The item number and diameter of branch in the case of tees and the angle in degrees in case of bends shall similarly be repeated on the lining.

4.7 Measurement

The quantities set out in the Bill of Quantities are provisional only and they are not to be taken as the actual, limiting and correct quantities of the pipes and fittings to be supplied by the Contractor in fulfillment of his obligations under the Contract. For the purpose of this clause, spigot and socket ended pipes shall be measured and paid in effective length. The effective length shall mean the net length of the pipe as laid, i.e. after deduction of the length of overlap at any spigot and socket joint to be made with the pipe. Plain ended pipes shall be measured and paid by the gross length and pipe specials shall be measured by numbers. All pipes and specials shall only be measured for payment after they have been laid and incorporated in the

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works. Any excess pipes and specials supplied to the Site shall not be measured for payment.

The cost of all works testing and all other requirements of the Specification including lining, coating, wrapping, etc, involved in the manufacture and delivery of the steel pipes shall be deemed to be included in the Contract Rates.

4.8 Miscellaneous

All flanged pipe ends, flanged branches and plain ends for use with mechanical couplings or flange adaptors shall have a 6mm steel retaining ring welded into the bore of the pipe flush with the end of the pipe after which the ring shall be zinc chromate coated as specified followed by two coats of bituminous paint. The radial thickness of the rings shall be similar to the thickness of the concrete lining and shall not be less than 6mm.

4.9 Physical Testing

Unless otherwise specified physical testing of the pipes shall also be in accordance with Section 4 Std 5L/S.

4.10 External Coating

The pipe shall be coated with bitumen generally in accordance with Clauses 29 of BS 534 except that the protection shall have a minimum thickness of 6mm for pipes over 324mm o.d. The bitumen shall be Type 2 of BS 4147 and there shall be not less than 2mm of bitumen between the inner and outer wraps, and between the pipe and the inner wrap.

The coating shall be stopped short as shown on the Drawing for ends of all spigot and socket pipes, and 250mm from the ends of all plain ended pipes for use with mechanical couplings or flange adaptors. The edge of the wrapping shall be chamfered at 25 degrees.

4.11 Wrapping

The wrapping materials shall be spirally wound onto the pipes and fittings simultaneously with the bitumen coating. Each wrap shall be from 150-225mm

wide and the edges shall overlap by 12-25mm. Care shall be taken to ensure that the inner wrap does not come into contact with the pipe metal or with the outer wrap.

The inner wrap shall be a glass fibre resin-bonded tissue reinforced in the longitudinal direction with parallel glass threads space 10mm apart. The nominal thickness shall be 0.5mm and the minimum weight shall 0.046kg/m².

The outer wrap shall be of glass fibre resin-bonded tissue reinforced in the longitudinal direction with parallel glass threads spaced 10-25mm apart. It shall be

impregnated with a material fully compatible with the bitumen coating to give a finished thickness of 0.75mm.

Peel-Off Test and Holiday Test in accordance to BS 534 shall be carried out at a frequency of 1 in every 50 completed wrapping joints.

4.12 Inspection of External Pipe Coating

All coated pipes and fittings shall be rigidly inspected for defects. Thickness shall be determined by a pit gauge, continuity with a holiday detector and coating quality by cutting out 75mm square samples at the rate of the one sample per 5 lengths of pipe manufactured.

The whole coated surface area of all pipes and fittings shall be tested for pinholes or other invisible defects in the coating using an approved holiday detector at a potential of 14,000 volts.

Any lengths on which the coating is, in the opinion of the S.O. poorly applied shall be cleaned to bare metal and re-coated. Minor defects may be repaired by touching up. All repairs shall be checked for thickness and continuity.

4.13 Painting Coated Pipes and Fittings

All coated pipes and fittings shall be painted as specified below:

- a) 75 micron minimum thick primer after surface (at factory) preparation.
- b) 150 micron minimum dry finished thickness surface iderant epoxy (after lay)
- c) 100 micron minimum dry finished thickness of polyurethane (after laying)

5.0 SPUN CONCRETE LINING AT FACTORY

All pipes and specials shall be lined with concrete. Cement for lining shall be Ordinary Portland Cement to BS 12. Aggregate shall be well-graded clean fine aggregate and the maximum particle size shall not exceed 8mm or one-third the thickness of the lining, whichever is the lesser. All materials used in concrete for lining shall comply with the requirements for concrete.

The final aggregate grading and concrete mix proportions shall be such that a hard, durable and dense concrete lining is obtained that satisfied the tests laid down in Clause 33 of BS 534. Unless otherwise approved, the minimum cement content shall be 380kg/m³ and the water cement ratio of the mix loaded into the pipe shall not exceed 0.42. Tests shall be carried out during the lining of pipe to demonstrate that the concrete lining has a strength equal to or greater than the minimum figures stated in Clause 33.5 of BS 534. The frequency of these tests shall be at least once every 250m length of pipe lined or during each working shift, whichever is the greater.

The testing of concrete cubes shall be conducted at the factory of manufacture.

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All straight pipes shall be concrete lined by the use of a lining machine designed and built for the purpose of rotating the pipe and centrifugally applying the lining at sufficient speeds to meet the requirements set out below. The support or holding device for the pipe shall be such as to avoid damage to the pipe coating during the spinning operation. If the pipe is rotated by direct contact drive from the machine it shall be supported over at least 90 degrees of its circumference and driven by non-metallic surfaced belts of sufficient width to avoid coating damage. The speed of rotation of the pipe during the lining compaction stage shall be such as to provide a radial acceleration of at least 250m/s^2 . The rotational drive shall be capable of close control and provide smooth acceleration and deceleration when working up to and down from the compaction spinning stage.

Immediately before lining commences, the pipe bore shall be cleaned of all loose scale, rust, oil, grease or any other foreign matter likely to contaminate or harm the concrete. Areas where an approved primer coat has bonded to the pipe such that wire brushing does not cause areas to flake off will be acceptable as a base for applying the lining.

The entire quantity of concrete required for the lining shall be continue until the specified thickness is evenly distributed over the inside of the pipe, all surplus water has been removed and the greatest possible density of concrete has been obtained. Tolerance on the thickness of lining shall be as follows :-

- +3mm to -2mm for 25mm and above
- +2mm to -1mm for 19mm and above

Temporary or semi-permanent end restraints shall be fixed to the pipe ends on completion of lining and before removal of the pipe from the lining machine. The pipe shall not be rotated about its longitudinal axis after the fixing of the storage yard and subsequently to the site.

Fittings shall be concrete lined at the factory in such a manner that the lining shall be of the specified thickness and comparable in density and smoothness to the spun

lining in straight pipes and generally applied in accordance with Clause 33.2 of BS 534. During the lining process, all rebound materials, dribbles, etc. shall be removed so that the lining is applied in a homogeneous mass to a clean surface.

Inspection of the lining shall be carried out any time prior to and after installation of the pipes. Any pipe with lining that is broken, defective or otherwise not in accordance with the Specification may be rejected. The Standard of the remedial lining shall satisfy the requirements of this Specification.

Surface crazing of the lining will be acceptable unless cracks are severe enough that they can be penetrated to a depth of 2mm by a 250 microns feeler gauge at 10

points or more over a length of 300mm when measured with the lining in a saturated condition. These cracks shall be cut back to full depth and sealed with approved epoxy resin filler.

Linings applied to pipes shall be cured in such a manner as will enable concrete to obtain and subsequently retain optimum strength, density and durability.

Linings shall be kept moist by continuous water spraying for a period of at least 3 days. They shall then be protected from sunlight and kept damp by spraying with water or other means approved by the S.O. for a further period of 7 days. Pipes shall not be removed from the factory until at least 14 days have elapsed from the date of lining.

6.0 INTERNAL PROTECTION AT PIPE ENDS

Concrete shall be omitted at the following location:

Spigot and socket ends

- The edge of the lining shall be angled back at 3mm to the pipe axis in order to provide a positive key for in-situ joint protection

Plain ends

- For butt straps or collar joints the lining shall terminate 90mm back from the pipe end. The edge of the lining shall be angled back at 3mm.
- For mechanical coupling and flange adaptor joints, the lining shall be brought right against the retaining rings.