

SPECIFICATION FOR THE CONSTRUCTION OF IRRIGATION RACES AND PIPELINES

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**ATTEWELL IRRIGATION
CONSULTANTS LIMITED**

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1.0 INSTRUCTIONS TO TENDERERS

1.1. MATTERS OF DOUBT

- ◆ Matters of doubt about the meaning or intent of any part of the documents may be referred in writing to **Dave Attewell, PO Box 723, Timaru, Fax 03 688 1187** who will as appropriate issue to all Tenderers a written statement setting out the interpretation to be applied for the purpose of this contract.

1.2. SITE INSPECTIONS

- ◆ The site may be inspected by the Tenderers by arrangement with Dave Attewell, Attewell Irrigation Consultants Limited Phone 025 4322259 or 03 688 3383

1.3. COMPETITIVE TENDERING

- ◆ The Principal does not bind itself to accept the lowest or any tender. Neither shall the Principal be responsible for or pay for expenses or losses which may be incurred by a Tenderer in the preparation of his Tender.
- ◆ The Principal may make its own assessment of the value of any conditions stipulated by the Tenderer relative to the Conditions laid down in the tender documents so that tenders can be compared on common basis as appropriate.
- ◆ The Principal requires a full and final price.
- ◆ The Principal may call upon the Tenderer to declare that such conditions or any part of them are entirely withdrawn.

1.4. STATUS OF DESIGN PROVIDED

- ◆ This Contract is being tendered on the basis of design and drawings provided as information to enable the contractor to prepare his tender for the construct contract. Tenderers shall accept the status of the design and drawings and neither corrections to the information or final design shall give grounds for changing the full and final lump sum price.

1.5. REVIEW BY OTHERS

- ◆ If required, Reviewer/s may be appointed by and paid for by the Principal and shall have full access to the site and all Contract Documents for their contract.

2.0 EXTENT OF CONTRACT AND GENERAL CLAUSES

2.1. EXTENT OF CONTRACT

- ◆ The works involve the construction of an irrigation scheme. It will be inclusive of all works necessary to construct the scheme including:

- I. Setting Out
- II. Earthworks construction;
- III. Removal of fencing;
- IV. Fencing;
- V. Structures;
- VI. Pipeworks;
- VII. Rock protection works;
- VIII. All other works described or implied in the drawings or this contact; and,
- IX. Maintenance of the works for 3 months from the canal becoming operational.

2.2. SITE OF WORKS

- ◆ The site of the works as shown on the drawings. Starting and ending at the co-ordinates given in on the plans.
- ◆ The generally exact plan position of the scheme is at the Contractor's discretion provided that:
 - I. The scheme stays within property boundaries for which agreement has been obtained to construct the canal;
 - II. The scheme begins and ends at the given co-ordinates; and,
 - III. The supply is available at all proposed properties at the agreed delivery points and head

2.3. ACCESS TO LAND

- ◆ Access to the majority of the site is through private property. The construction corridor shall be limited to 5m either side of the profile. Access outside of this is between the Contractor and the Landowner.

2.4. DRAWINGS

- ◆ Drawings included in this contact. The contractor may provide design variations for the Principal Representative to approve.

2.5. INSPECTION OF SITE

- ◆ All tenderers shall have satisfied themselves by a personal inspection of the site that the design requirements are clear and that the work visualised is possible of execution generally in the manner described in the design requirements and the drawings.
- ◆ Tenderers are also recommended to satisfy themselves before submitting a tender that the details of the design requirements sufficiently covered in the contract documents or have been clarified by the Principal's Representative. Incorrect interpretation of the design requirements or scope of works shall not be grounds for changing the full and final lump sum price.

2.6. OCCUPATIONAL HEALTH AND SAFETY REQUIREMENTS

- ◆ The Contractor shall at all times comply with the requirements of the Occupational Health and Safety Act 1992 and the Occupational Health and Safety Guidelines for Construction 1995. The Contractor shall also comply with any other relevant current legislation.
- ◆ Two weeks before beginning any work at the site, the Contractor shall provide to the Principal's Representative a copy of the Contractors, and any Subcontractors, health and safety plan for the site. It is the Contractors responsibility to ensure that this plan is followed at all times by all site personnel sub contractors and any site visitors.

2.7. SERVICES

- ◆ It is the Contractors responsibility to locate all services through the site and make provision with the appropriate service company to have the service moved or protected for the duration of the works.

2.8. LOCAL AUTHORITY ROADS

- ◆ At least 5 working days before commencement of work in any road reserve, the Contractor shall notify the appropriate Local Authority of the intention to work. The Contractor shall comply with any requirements the Authority has for retaining public access through the site.

2.9. MATERIAL SUPPLIED BY THE PRINCIPAL

- ◆ The Principal shall supply all pipes required for the scheme. Arrangements shall be made with the Contractor as to the timing of delivery of the pipes, based on the Contractors programme. The contractor takes responsibility for the pipes from delivery to the site and shall responsible with replacing any pipes damaged from that time until the completion of contract.

3.0 GUIDELINES FOR EARTHWORKS CONSTRUCTION

3.1. SCOPE

- ◆ This section covers all earthworks operations for this contract which fall into the following categories :
 - I. Earthworks to construct irrigation canal and access track;
 - II. Earthworks including excavation and backfilling for all pipework, but not including pipe bedding; and,
 - III. Earthworks to construct and backfill all intake structures.

- ◆ The following is intended as a guide for the Contractor to achieve the required standard specified by the designer and may be modified by the contractor's designer subject to peer review.

3.2. SITE PREPARATION

- ◆ All vegetation should be cleared from the site. The Contractor to make arrangements with the landowner for suitable areas to dump, bury or burn the material.

3.3. TOPSOIL

- ◆ Areas should be prepared for filling by scraping or grading the topsoil away. Any topsoil remaining in cut to fill material which is to be used, should be mixed throughout the material before filling begins.

3.4. RE-GRASSING

- ◆ The Contractor should re-topsoil then sow grass seed and spread fertiliser on all areas disturbed during the course of the work excluding the race invert and inside race batters. Unless other approved arrangements have been made with the landowners concerned, the following seed mixture should be applied at the suggested rate of 25kg/ha:
 - crested dogstail 2kg;
 - perennial rygrass 20kg; and,
 - white clover 3kg.

- ◆ Superphosphate should be spread over these areas at a rate of 140kg/ha.

3.5. EXCAVATION

3.5.1. General

- ◆ All excavation to be subject to the requirements of the relevant legislation. In particular the contractor must make themselves aware of OSH requirements and comply at all times.

3.5.2. Pipelines

- ◆ The base of each trench should be trimmed and compacted to a firm smooth bearing surface.
- ◆ Unsuitable foundation material encountered should be removed and backfilled with suitable material compacted as recommended in 6.6.2.

3.5.3. Structures

- ◆ The Contractor should excavate the minimum necessary to allow construction of all structures as detailed by the designer.

3.5.4. Race Construction / Canal Construction

- ◆ The Contractor should excavate the minimum amount of material to form the race/canal to the levels, grades and dimensions as detailed by the designer and to the tolerances specified elsewhere in this document.
- ◆ The plan position of the canal is to the Contractor's discretion provided that:
 - I. The canal is within property boundaries for which agreement to construct the canal has been obtained within 20 metres of the centreline indicated on the plans, unless otherwise agreed by the principals representative;
 - II. The canal starts and ends at the co-ordinates specified in Subsection 18.2 of the Appendices;
 - III. The canal does not vary from the stated canal invert level; and,
 - IV. The invert level must be between +0 and -50mm of the design level.
- ◆ Any over excavation not specifically instructed by the Principals Representative shall be reinstated to the Principals Representative's satisfaction at the Contractors own expense.
- ◆ Undercutting may be necessary in some instances to achieve adequate compaction for shallow depths of new fill.

3.5.5. Disposal of Surplus or Unsuitable Material

- ◆ Materials excavated by the Contractor which are unsuitable or surplus to requirements should be disposed of in hollows or low spots or at a dump site.
- ◆ The locations for the dump sites to be arranged between the Contractor and Landowner.
- ◆ The Contractor should strip all topsoil from dump areas and re-spread topsoil over completed areas to a depth at least equal to the original depth or as arranged with the Landowner. The areas should then be grassed as specified in Section 4.

3.6. FILL

3.6.1. General

- ◆ The Contractor to place and compact fill material from excavation to the levels and grades as shown on the drawings to form the race/canal shape shown on the appropriate typical race/canal cross section.
- ◆ The Contractor shall confirm the standard of foundation preparation and drainage before placing fill.
- ◆ The fill is to be placed in appropriate weather conditions.
- ◆ No new fill should be placed over substandard fill or fill which has deteriorated from its specified condition.
- ◆ Any foundation or fill subsequently found not to be to the specified standard to be reworked to the standard by the Contractor at the Contractor's own expense.
- ◆ Specialised purpose built compaction equipment should be used for compaction. It is expected that vibrating rollers will be most appropriate.
- ◆ The water content of materials should be controlled so that excessive weave is avoided. Excessive weave is permanent deflection greater than 40mm under a fully laden item of earthmoving plant or compactor, of the compacted fill surface.
- ◆ Assume at least 3 passes of the roller to ensure consistent compaction but allow for rolling trials to establish the most efficient acceptable compaction techniques.
- ◆ Fill adjacent to structures is to be raised at a uniform rate either side of the structure (where applicable) and within 2 m of walls, use light equipment and hand operated rollers.
- ◆ Heavy earthmoving equipment is to be kept at least 2 m away from the back of retaining walls and pipes.
- ◆ The fill shall be placed in horizontal layers not exceeding 300mm deep and compacted as specified in subsection 8.1.

3.6.2. Backfilling

- ◆ All backfill material placed around completed pipework or structures to be placed evenly on both sides of the pipes and structures in horizontal lifts not exceeding 300 mm and compacted as specified in 3.5.2.
- ◆ Only low permeability backfill should be used within 600 mm of all vertical walls and cut-offs on structures.
- ◆ Where suitable material is not available from the site excavation, suitable imported borrow material may be used for backfilling.

3.7. COMPACTION AND CONTROL OF MOISTURE CONTENT

3.7.1. Compaction

- ◆ All compaction within 2 m of any pipeline or structure shall be undertaken using only light handheld compaction equipment.
- ◆ The required standard of compaction for fill and backfill should be as follows:
 - I. The dry density of compacted materials should not be less than 95% of the maximum dry density at optimum moisture content as determined by NZS4402 test 4.1.1.; and,
 - II. The fill should not be compacted when the moisture content is above optimum.

3.7.2. Control of Moisture Content

- ◆ To reach the compaction standards specified, the moisture content of the material should be carefully controlled. The Contractor should, if required, increase or decrease the moisture content in the following manner:
 - I. Where the moisture content is too high, the Contractor should delay backfilling until the material has dried out sufficient to meet the standard required. The material may be spread out to assist the drying process; and,
 - II. Wetting of dry material should be carried out by using sprinkler equipment of a type which ensures uniform and controlled distribution of water. Immediately after wetting the material shall be diced or bladed to ensure uniform moisture content throughout the layer, then compacted.
- ◆ Failure to reach the required standard of compaction is to be made good by the Contractor at the Contractor's own expense.

3.8. RIP-RAP

- ◆ The rip-rap used as primary armour should have the following characteristics:

Table 1 : Rip-Rap minimum and maximum sizes.

<i>Size</i>	<i>Characteristic Dimensions (mm)</i>
Maximum	600
Average	450
Minimum	300

- ◆ The rip-rap is to be placed to the profiles and dimensions detailed on the final design drawings. All rock should be placed by machine. Placement by dumping should not be used. When placing the rock rip-rap the Contractor should do any hand work necessary to obtain a satisfactory nesting with each rock having a three point bearing and even thickness of rocks.

3.9. CONTROL TESTING

- ◆ The Contractor should establish the maximum dry density and optimum moisture content of a representative sample from the fill material before beginning the earthworks.
- ◆ Dry Density tests using a nuclear densimeter should be performed at the minimum test frequency of one test per 250 m³ of fill.

4.0 GUIDELINES FOR GABION CONSTRUCTION

4.1. SCOPE

- ◆ This guideline covers the construction of gabion baskets . They are intended as a guide to assist the Contractor to achieve the specified standards set by the designer. Any or all parts of this guideline may be modified by the designer subject to peer review.

4.2. GROUND PREPARATION

- ◆ Before construction of the gabions, the bearing surface shall be prepared to give a flat surface, angled to give the appropriate slope to the gabion wall as specified on the drawings or in the contract. The surface should have an allowable bearing capacity of not less than 100 kPa.

4.3. BASKET CONSTRUCTION

- ◆ The baskets shall be assembled following the method prescribed by the manufacturer of the gabion baskets.

4.4. FILLING THE BASKETS

- ◆ The rock size should be between 125 mm and 200 mm. No rock should be larger than 250 mm or smaller than the size of the mesh.
- ◆ The gabions should be constructed as specified by the manufacturer and in line with good gabion construction techniques.
- ◆ The gabions should have an even face, free from bulging, making sure the stones are tightly packed and have minimum voids.

5.0 GUIDELINES FOR CONCRETE

5.1. SCOPE

- ◆ These guidelines cover the materials, plant, mixing, placing and testing of concrete for civil engineering works and are intended as a guide for the Contractor to achieve the standard specified by the designer. The designer may modify any or all parts of these guidelines, subject to peer review.
- ◆ The requirements of NZS 3109: 1987 Concrete Construction to apply unless modified in this specification or elsewhere in the contract documents.
- ◆ The concrete production to comply with either NZS 3104: 1991 Concrete Production - High Grade and Special Grade or NZS 3108: 1983 - Concrete Production - Ordinary Grade.

5.2. CONCRETE PLANT

- ◆ The plant the concrete is supplied from is to hold a requisite current grading certificate from the New Zealand Ready Mixed Concrete Association or a requisite current grading certificate and assessor's report from an approved competent person.

5.3. MATERIALS

- ◆ Cement is to comply with NZS 3122.
- ◆ Aggregate to comply with NZS 3121.
- ◆ Admixtures to comply with NZS 3113.

5.4. CONCRETE

5.4.1. Concrete Grade

- ◆ Unless specified, the suggested concrete strength is to be 17.5MPa and supplied from an 'ordinary grade' concrete plant.
- ◆ Concrete with a specified strength greater than 40MPa should be supplied from a 'special grade' plant.
- ◆ Bonding concrete should have a minimum crushing strength of 10MPa.

5.4.2. Plant Grading

- ◆ The grading of a concrete manufacturing plant to be established on the following: either,
 - I. the current grading as determined by the Classification Committee of the New Zealand Ready Mixed Concrete Association; or,
 - II. a current recommendation based on a satisfactory assessor's report from an independent and experienced assessor approved by the Principal's Representative.

- ◆ The word current means that the inspection and grading determination must have been carried out within the preceding 12 months.

5.4.3. Admixtures, Additives or Surface Agents

- ◆ No concrete additives, admixtures or surface agents should be used in or on the concrete unless specified in the design or agreed in writing to by the Principal's Representative.
- ◆ The Contractor should have available to the Principal's Representative details of the proposed compound including rate and method of application.

5.4.4. Concrete Mix Design

- ◆ The Contractor shall supply to the Principal's Representative the following details of the mix, not later than two weeks before commencement of concreting operations:
 - I. concrete grade;
 - II. specified strength;
 - III. mix designation;
 - IV. batch weights of cement and aggregates;
 - V. the allowance made for moisture content of each size of aggregate;
 - VI. target slump;
 - VII. amount of air entrainment (if applicable);
 - VIII. yield;
 - IX. water cement ratio by weight; and,
 - X. admixtures.
- ◆ Ready mixed concrete plants concerned to maintain the confidentiality of their mix designs may supply the above information directly to the Principal's Representative clearly marking their statement "**Confidential**".

5.4.5. Delivery Records for Ready Mixed Concrete

- ◆ All delivery records shall list the mix designation or code (to enable the concrete to be identified with the mixing records) and details of any admixtures (name and amount) in addition to any information required by clause 303 of NZS3104.

5.5. ACCEPTANCE TEST DURING CONSTRUCTION

5.5.1. General

- ◆ It is the Contractor's responsibility to ensure that all concrete and materials associated with the laying of concrete meet the standards specified in NZS 3109 and any construction standards specified by the designer. Any work that is found not to meet these standards shall be made good at the Contractor's own expense.

5.5.2. Testing

- ◆ Testing shall be in accordance with Section 9 NZS 3109.
- ◆ All testing required by NZS 3109 or elsewhere in the contract documents to be carried out by trained staff using suitable equipment. The testing to be done at the Contractor's own expense.
- ◆ The Contractor to have the off-site testing carried out by an approved TELARC registered laboratory at the Contractor's own expense.

5.6. SURFACE FINISH

5.6.1. Basic Finish

- ◆ Except where a particular standard is specified the concrete surface finish on general construction work should comply with the requirements of NZS3114, F3 finish for formed surfaces, and UI finish for unformed surfaces.

5.6.2. Precast Concrete Units

- ◆ For all precast concrete units all surfaces except those against which concrete will subsequently be placed, should have a concrete surface finish complying with the requirements of NZS3114, F4 for formed surfaces and U3 finish for unformed surfaces.
- ◆ Surfaces of precast units against which concrete will be subsequently placed should be prepared as type B% construction joints (NZS3109, Clause 5.6.3).
- ◆ Precast bridge deck slabs, for which no concrete topping is to be laid should have a surface finish complying with the requirements of NZS3111, - for unformed surfaces.

5.7. REINFORCEMENT

5.7.1. General

- ◆ Section 3 of NZS3109 to apply, unless modified below.

5.7.2. Quality

- ◆ Reinforcing steel to comply with NZS3402.
- ◆ The Contractor to retain all manufacturers test certificates relating to all reinforcement supplied.
- ◆ Grade 430 steel is not an acceptable substitute for Grade 300 steel when Grade 300 steel has been specified in the design.

5.7.3. Stacking

- ◆ Reinforcing steel should be stacked clear of the ground in an orderly manner at all times, and should be protected and kept free from damage or contamination.

5.7.4. Reinforcing Bar Bending

- ◆ All reinforcement should be straight between the bends shown and bars which are not straight should be straightened before bending.

- ◆ All bends to be made cold over freely rotating rollers so that binding between the rollers and steel is prevented. No bar to be bent more than once in the same location unless specifically detailed on the drawings.

5.8. FORMWORK

5.8.1. General

- ◆ All formwork to meet the requirements of NZS3109 Section 5.

5.8.2. Tolerances on Dimensions

- ◆ All shown dimensions of the concrete for both cast in-situ and precast work should be established accurately within the tolerances given in table 4 of NZS 3109, unless detailed otherwise on the drawings or as specified in the following:
 - I. Departure from established alignment :20mm
 - II. Variations from the level or from the grades indicated on the drawings:
 - a) Overall 15 mm; and,
 - b) In beams, slabs, decks, floors 10 mm but not more than 5 mm in horizontal grooves, railings and variation from a 3 m template similar: or straight edge.
 - III. Variations from the plumb or specified batter in the lines and surfaces of columns, piers, walls and similar:

a) Dimensions up to 3 m, variation	= 10 mm
b) Dimensions up to 6 m, variation	= 15 mm
c) Dimensions up to 12 m, variation	= 25 mm
- ◆ In addition to the foregoing the standard of tolerance should be such that attachments, equipment etc, can be installed accurately in accordance with the drawings and specifications. It is stressed that the acceptance of tolerances does not absolve the Contractor from obligations to work within the boundaries of properties and to avoid encroachment.
- ◆ For tolerances on reinforcing steel and concrete cover see section 3.8 of NZS 3109.

6.0 GUIDELINES FOR HELICAL LOCK-SEAM CORRUGATED ALUMINIUM PIPES ASSEMBLY AND INSTALLATION

6.1. SCOPE

- ◆ The following clauses give recommendations for transportation, handling, storage and installation of helical lock-seam corrugated aluminium pipes.

6.2. TRANSPORTATION

- ◆ Due to the light weight of aluminium pipe, care should be taken during transportation to eliminate the possibility of damage. Specific points to consider are:
 - I. Strapping: When metal strapping is used, it should not come into direct contact with a pipe. Use of a 'soft' packer between strapping and pipe is recommended; and,
 - II. Packing of Pipes: Aluminium pipes should not be packed pipe to pipe. Dunnage should be placed in the vertical and horizontal planes between pipes to obtain a complete separation.
- ◆ Aluminium pipes should not be freighted inside galvanised steel pipes.
- ◆ Aluminium pipes can be nested for transportation.

6.3. STORAGE

- ◆ Pipes stored outside should be well secured to prevent movement by wind.

6.4. HANDLING

6.4.1. General

- ◆ Care should be taken when handling the pipe to eliminate damage. Aluminium pipe is susceptible to minor damage through impacts against hard objects.

6.4.2. Lifting

- ◆ For diameters less than 900mm pipes can usually be manhandled without lifting equipment.
- ◆ Larger diameter pipes may require light lifting equipment. For these pipes, when 6m or less in length, a single rope strap around the centre of the pipe is sufficient support for lifting. For larger pipes, two lifting points, between 1/3 and 1/5 of the pipe length in from each end is recommended.

6.5. INSTALLATION

6.5.1. General

- ◆ The successful use of aluminium pipe depends greatly on selection and placement of bedding and backfill material. It is recommended that the following considerations be taken into account prior to installation.

6.5.2. Assembly

- ◆ Pipes shall be carefully aligned during laying, and connected using standard coupling bands. When pipes are end marked, laying should proceed as recommended in 6.5.3.

6.5.3. End Matching of Pipes

- ◆ For pipes 1200mm diameter and larger, pipes should be end marked, in alphabetical sequence by the manufacturer and laid in sequence.
- ◆ This practice will ensure a correct joint is attained between pipes when using the coupling band system.
- ◆ When two or more culverts are supplied to one site, different colour end markings will indicate each individual culvert pipe.

6.5.4. Coupling Bands

- ◆ Coupling band systems are used to join pipe sections, preserve pipe alignment, resist separation and deter root penetration and infiltration of normal backfill materials.
- ◆ Coupling bands shall also:
 - I. be assembled so that they overlap equally on each pipe; and,
 - II. be assembled so that the gap between the ends of the pipes shall not be greater than 25mm.

1.1.1.1. Sealed Coupling Bands

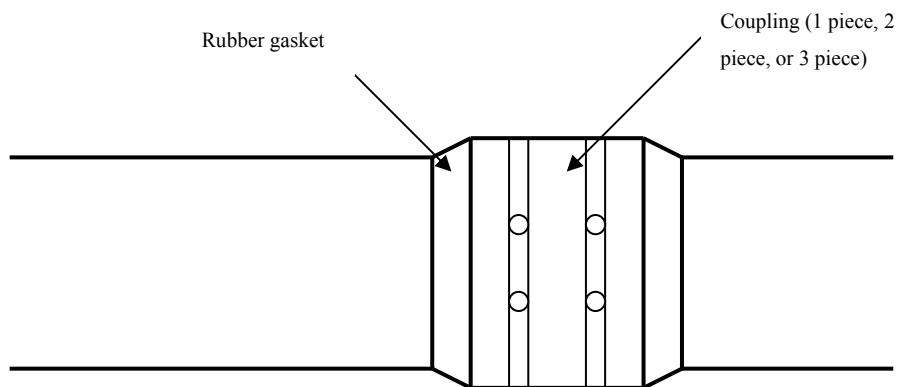
- ◆ Where water tightness is required sealed coupling bands are recommended. Sealing is obtained with the use of a neoprene rubber gasket placed around the ends of each pipe. Installation of sealed coupling bands should follow the manufacturers recommendation.

One Piece Bands (Pipe Diameter 300mm – 900mm)

1. Lubricate inside surface of band with non oil based grease. Slide band over next pipe to be laid.
2. Fold rubber gasket over pipe end as shown, prior to placement in trench.
3. Align pipes in trench and roll rubber gasket over end of incoming pipe to cover pipe joint. Hold band open and slide into final position.
4. Ensure band and pipe corrugations are aligned and tighten with bolts provided.

Two or Three Piece Bands (Pipe Diameter 1050mm – 2400mm)

1. Fold rubber gasket over pipe end prior to placement of pipe in trench. Relieve bedding material immediately in vicinity of joint.
2. Align pipes in trench and roll rubber gasket over end of incoming pipe to cover pipe joint.
3. Lubricate inner surface of band corrugations and lay lower band segment over top of joint. Check alignment of corrugations and rotate lower band segment through 180° to the bottom of the joint.
4. Lay upper band segment over the top of the joint and align with lower segment. Draw segments together using the bolts supplied and tighten progressively on alternate sides.
5. After tightening the band replace the relieved bedding under the joint and tamp down.



[Figure 1 : Sealed Coupling Band](#)

6.5.5. Field Connections

- ◆ Aluminium pipe can be easily cut in the field with hand saw, power saw, or gas torch. No special treatment is required at cut edge for protection against corrosion.

6.5.6. Side Line Connections

- ◆ Tapping saddles are used to join side line pipes into the aluminium pipe. Tapping saddles are suitable for side line pipe diameters of 100, 150, 200 and 225mm N.D. in both PVC and Asbestos cement.

[Side Line Tapping Saddle Method of Installation](#)

1. Lay tapping saddle over ALUFLO in required position. Back-mark outline of incoming pipe on ALUFLO.
2. Cut hole in ALUFLO using either a saw or gas torch.
3. Place sealant on face of tapping saddle and position on ALUFLO. (Silicon or bitumen based sealants are suitable).
4. Drill through ALUFLO at holes provided in tapping saddle.
5. Rivet tapping saddle to ALUFLO. (Blind aluminium rivets are recommended).

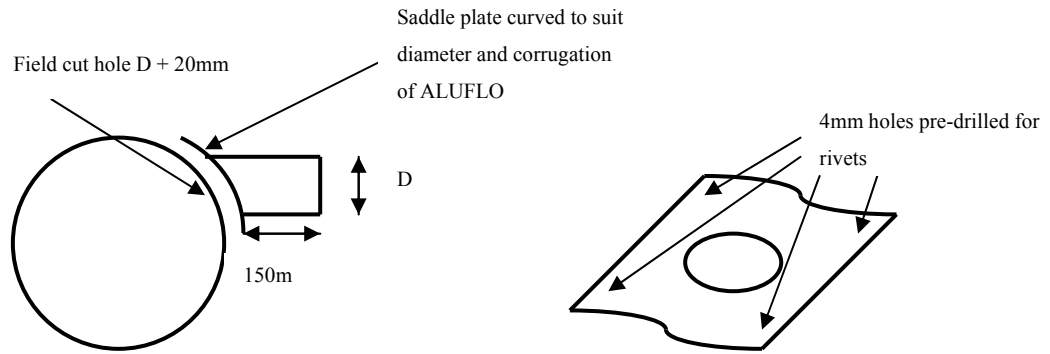


Figure 2 : Taping Saddle Layout

Table 2 : Tapping Saddle

Sideline Pipe (N.B. mm)	Diameter, D (mm)
100	140
150	190
200	250
225	275

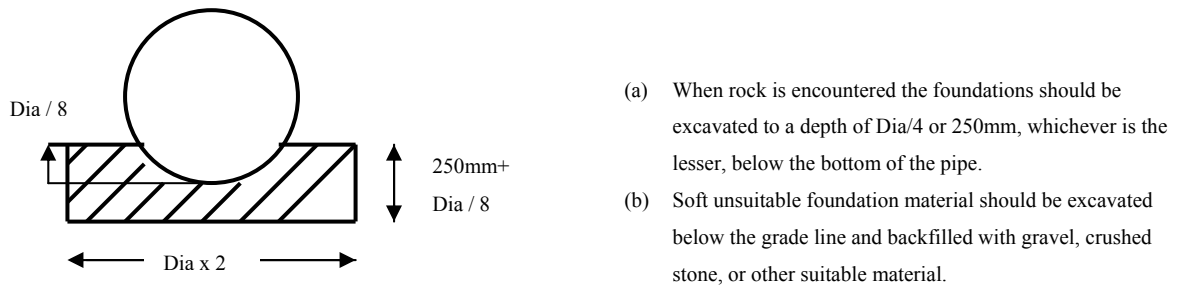
6.6. INSTALLATION OF PIPE

6.6.1. Trench Formation

- Where the pipe is installed in a trench, the width of trench shall be diameter + 600mm and recommended cover is as shown in this specification.

6.6.2. Foundation Preparation and Bedding

- Unsuitable soil shall be removed and replaced with suitable material thoroughly compacted to provide adequate support for the installation. Otherwise special construction methods shall be adopted.
- Where rock is encountered in the foundation, the rock shall be removed below the pipe over a width which will ensure that the pipe will not bear on rock. The rock shall be replaced with a bed of compacted granular material of thickness not less than $Dia/4$ or 250mm, whichever is lesser.
- A uniform blanket of loose granular material of 12mm maximum aggregate size shall cover the shaped bedding to a depth sufficient to allow the corrugations to become filled with material.



[Figure 3 : Foundation Preparation and Bedding](#)

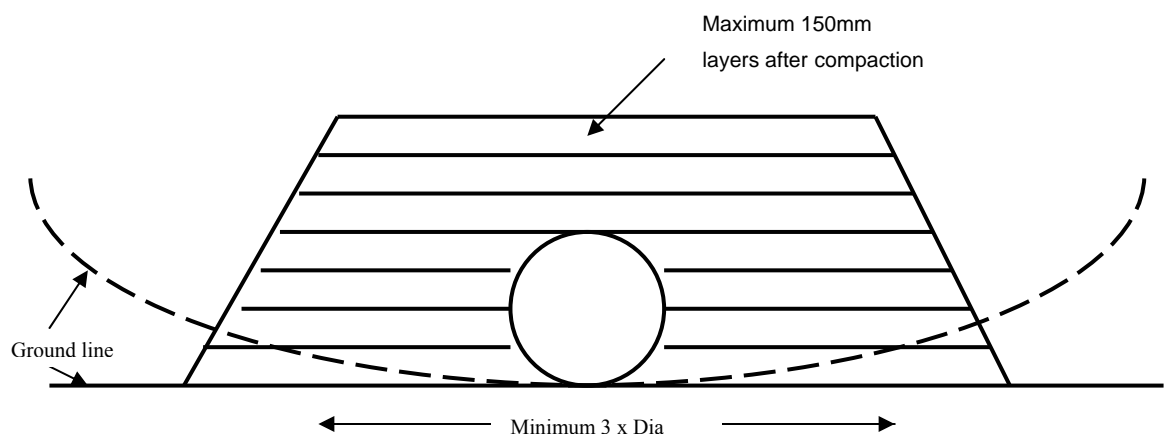
6.6.3. Installation Under Embankments

6.6.3.1. Backfilling

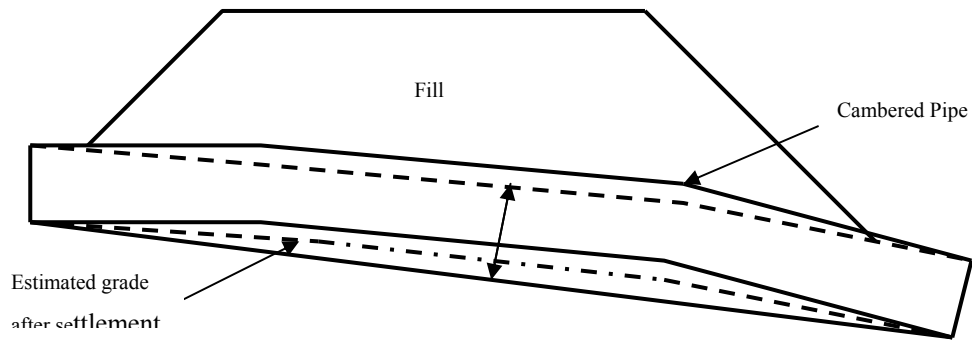
- ◆ For pipes placed under embankments, backfilling shall generally conform with **Error! Reference source not found.** Choice of backfill material shall follow 6.7.2 for backfill up to the crown level of the pipe. Filling over the structure shall be completed using materials essentially the same as those used for the surrounding backfill, following good engineering practice for selection and placement of materials in embankments.

6.6.3.1. Camber

- ◆ Where the installation is laid under a high embankment and settlement of the foundation is expected, the need to provide a longitudinal camber along the foundation to allow for the expected settlement should be considered. The amount of camber will depend on the height of the embankment and on the supporting strength of the solid in the foundation. The upstream half of the pipe may be laid on an almost flat grade and the downstream half on the remaining slope. The mid-ordinate of the curve should be determined by an estimate of the embankment settlement.



[Figure 4 : Backfilling Pipe](#)



N.B. Camber Allows for possible settlement of a pipe under a high embankment.

[Figure 5 ; Camber](#)

6.7. BACKFILLING

6.7.1. Design

- ◆ To support adequately the pavement or track above it, a stable composite structure is essential. Stability in a soil structure interaction system requires not only adequate design of the pipe but also a properly engineered backfill retaining shape and structural function. This depends greatly on the selection, placement and compaction of the backfill surrounding the pipe and distribution of pressure to the abutting soil.

6.7.2. Material Selection

- ◆ The fill material should be free from rocks, and foreign matter in excess of 75mm in size that could cause hard spots in backfill or which could decompose and create voids.
- ◆ Metal objects in the fill that could create bi-metallic corrosion should not be in contact with the pipe surface. Backfill material should preferably be well graded, granular material. Local site material is often adequate provided it is sufficiently compacted at controlled moisture content. Cohesive materials should be placed and compacted at optimum moisture content to develop adequate shear strength.
- ◆ Bank run sand and gravel compacted to 95-100 percent maximum dry density provides ideal backfill. Highly plastic silts, highly plastic clays, organic silts, organic clays and peats should not be used as backfill materials.
- ◆ To attain the required low compressibility and high strength, silty and clayey soils (SM, SC, GM, ML and CL) should be compacted at water contents which are not more than 2% wetter than the optimum water content. The best backfill properties will be obtained by compacting the backfill soil at optimum or slightly dry of optimum water content. Lime stabilised soils should not be used as backfill around the pipe.

6.7.3. Placement of Backfill

- ◆ Backfill shall be placed symmetrically on each side of the structure in 150-200mm layers. Each

layer is to be compacted to the specified density, as given in *Table 3*, except in conditions described below. Puddling or jetting is not recommended.

[Table 3 : Suitable Soil Types and Densities](#)

Soil Description	Soils Classification*	Minimum Acceptable Dry Density**
Free-draining sands, gravels, and mixtures of sands and gravels.	SW, SP, GW, GP	90%
Sands and gravels with small amounts of silt or clay.	SM, SC, GM, GC	90%
Silts and clays of low plasticity	ML, CL	90%

N.B. * Unified Soil Classification System

**In percent of the maximum dry density, as determined by the Standard Compaction Test, No. 14, NZS 4402.

6.7.3.1. Minimum Cover

- ◆ The minimum cover required varies according to pipe diameter and live loading above pipe.

Table 4 : Minimum Cover in mm Required over Crown of Pipe

Pipe Diameter (mm)	Type of Live Loading		
	Highway HN-HO-72	Construction Vehicles	No traffic Loading
300	300	600	300
375	300	600	300
450	300	600	300
600	300	600	300
750	375	600	300
900	450	600	300
1050	525	600	300
1200	600	750	300
1350	600	750	350
1500	600	750	350
1650	600	900	400
1800	600	900	450
1950	600	900	500
2100	600	1000	500
2250	600	1000	600
2400	600	1000	600

7.0 GUIDELINES FOR REINFORCED CONCRETE PIPE ASSEMBLY AND INSTALLATION

7.1. SCOPE

- ◆ These guidelines are intended as a guide for the Contractor to achieve the standard required by the designer and may be modified by the designer subject to peer review.

7.2. PIPES

- ◆ The pipes to conform to the requirements for class, type of joint, diameter and length.
- ◆ Concrete pipes to comply in all respects with the requirements specified in NZS 3107:1978 for “Precast Concrete Drainage and Pressure Pipes”.
- ◆ Specials, made by cutting and rejoining sections of pipe, to comply with NZS 3107:1978.

7.3. EXCAVATION

- ◆ Trenches should be cut in a manner that will ensure that the pipes will be laid true to depths and grades and lines specified in the design but the width of trench should not exceed one external diameter of the pipe plus 800 mm, up to 150 mm above the crown of the pipe. The sides of the trench should be left as near vertical as possible. Excavated materials may be used for “selected fill” or “ordinary fill”.

7.4. BEDDING

- ◆ Unless otherwise shown on the plans, pipes, including sockets and joints should be bedded on a 75 mm thick layer of sand or fine granular material and compacted to the standard specified for backfilling. The bed should be carefully shaped to ensure uniform contact with the pipe over its full length.

7.5. JOINTING AND LAYING

- ◆ Pipe jointing should be carried out in such a manner that finished joints are watertight and present a smooth internal surface.
- ◆ Rubber ring jointed pipes should be laid in the manner specified by the manufacturer. Pipes should be laid with the socket ends facing upstream.
- ◆ The pipes are to be laid true to the levels, grades and lines specified in the design.

7.6. UNSUITABLE FOUNDATION MATERIAL

- ◆ Unsuitable foundation material below the invert level of the pipe should be removed for a depth of at least 600 mm. Unsuitable material should be disposed of at the dump site and should be replaced with suitable material placed in layers of 150 mm loose depth and compacted to the standard specified for backfilling.

7.7. FILL AND BACKFILL

- ◆ The Contractor shall supply QA documentation stating that the pipes have been laid and backfilled in accordance with the contract specifications and manufacturers requirements.
- ◆ Hand operated mechanical rammers or plate compactors only, should be used to compact material within 2 m of the sides or 600 mm above the pipe. Material within this zone should be placed simultaneously on each side of the pipe in layers not exceeding 150 mm loose depth.
- ◆ All backfilling should be compacted to 95% of the maximum dry density obtained in the New Zealand Standard Compaction Test as specified in NZS 4402:Test 4.1.
- ◆ “Selected fill” should have a minimum of 10% and not more than 25% by weight finer than 0.075 mm and no particles should be larger than 75 mm.
- ◆ “Ordinary fill” to be excavated material, with no particles exceeding 100 mm in the zone of hand compaction. Outside this zone, “Ordinary fill” to be placed.
- ◆ Backfilling should be to the level of the adjacent ground unless specified otherwise.

8.0 INSTALLATION SPECIFICATION FOR CONCRETE PIPES USED IN INVERTED SYPHONS

Introductory Note: The following clauses are not intended to be a complete specification for pipe installation, but are essential clauses which are required if the installation is to conform with the requirements of AS3725-1989.

8.1. EXCAVATION

- Prior to completion of excavation, the soil type in which the trench is excavated shall be assessed for density and stiffness, to the satisfaction and approval of the superintendent.

If it is established that the natural ground will provide effective side support, the trench width for both trench condition and embankment condition shall be as shown on the drawings.

(Note to Specifier – The figures used on the drawings are those selected from the column headed “Trench Width” on the appropriate “Pipe Selection and Installation” Type HS3 Chart).

- ◆ For an embankment installation, the positive projection of the pipe shall be 0.3 times the pipe outside diameter, or less. Where the projection of the pipe above natural ground surface is greater than 0.3 times pipe outside diameter, it will be necessary to construct the embankment to a height above top of bed level at least equal to 0.7 times pipe outside diameter, prior to laying the pipe, and to a width equal to at least 2.5 times pipe nominal diameter on each side of the proposed trench width.
- ◆ The embankment shall be constructed in accordance with the specification for Refilling, Side Zone. A trench is then to be cut through the constructed embankment.
- ◆ For a trench installation, if in the opinion of the superintendent, the natural ground is not considered effective in providing the necessary side support, the trench shall be excavated to a width of 6.0 times pipe nominal diameter to the top of bed level.
- ◆ The wide trench excavation shall then be refilled in accordance with the specification for Refilling, Side Zone.

8.2. EXCAVATION CONT...

- ◆ Refiling in embankment or wide trench shall be placed in layers not exceeding 150mm when compacted and, if cohesive material is used, the moisture content shall be controlled to within the range 85 percent to 115 percent of the optimum moisture content. Compaction by tamping, rolling and/or vibration shall be carried out to achieve a minimum Relative Density (RD) of 95% of standard maximum dry density, or a minimum Density Index (DI) of 70 for cohesionless material.
- ◆ Density achieved shall be monitored by field testing as directed by the superintendent.
- ◆ The required trench for the installation, to the width and depth shown on the drawings shall be excavated centrally through the above compacted refilled select material.
- ◆ Excavation shall be to line and level shown on the drawings, to provide a pipe bed zone, for the trench width and thickness

of 100mm for pipe nominal diameter \geq 1500mm

or 150mm for pipe nominal diameter $>$ 1500mm

- ◆ Should the excavation to the required foundation at the bottom of the bed level reveal material, which in the opinion of the superintendent is unsuitable, the trench shall be over-excavated to a depth required to remove the suitable material and refilled with compacted material conforming to the requirements for the Bed Zone.

8.3. BEDDING

- ◆ Bed Zone material shall consist of sand and/or gravel complying with the following grading:

Sieve Size (mm)	19.0	2.36	0.60	0.30	0.15	0.075
% Mass Passing	100	100-50	90-20	60-10	25-0	10-0

and with the material passing the 0.075mm sieve having low plasticity as described in Appendix D of AS1726.

- ◆ Alternatively, select fill as defined in AS3725 which does not conform with the above grading limits may be used provided that it is cement stabilised. Details of the proposed stabilised material shall be approved by the superintendent prior to installation.

8.4. BEDDING CONT...

- ◆ The Bed Zone shall be placed to the final required thickness of 100mm for pipe nominal diameter less than or equal to 1500mm or 150mm for pipe nominal diameter greater than 1500mm. The bed material shall extend over the full width of the trench and shall be compacted by tramping, rolling and/or vibration to a minimum Density Index (DI) of 70.
- ◆ Compaction achieved shall be monitored by field testing as directed by the superintendent.
- ◆ The bed level shall be graded to provide for a uniform fall to the discharging end of the pipeline, with line and level as shown on the drawings.
- ◆ For pipes with sockets protruding beyond the barrel outside surfaces, chases shall be dug in to the bed foundation if necessary, in the appropriate positions, so that each pipe is supported along the full length of the barrel and the socket is not subjected to point loading.

8.5. REFILLING

- ◆ The refilling shall be carried out in four stages and these are to be identified as Haunch Zone, Side Zone, Overlay Zone, and Backfill or Embankment fill.
- ◆ The Haunch Zone shall extend from the top of the Bed Zone up to 0.3 times pipe outside diameter and shall be fill material complying with the requirements shown above for the Bed Zone.
- ◆ The material shall be placed over the full width of the trench either in layers not exceeding 150mm compacted thickness and compacted by conventional methods or compacted in one operation by saturation and vibration to achieve a minimum Density Index (DI) of 70.
- ◆ Compaction achieved shall be monitored by field testing as directed by the superintendent.
- ◆ The Side Zone shall extend from the top of the Haunch Zone up to 0.7 times pipe outside diameter and shall consist of fill material complying with the following grading:

Sieve Size (mm)	75	9.5	2.36	0.60	0.075
% Mass Passing	100	100-50	100-30	50-15	25-0

8.6. REFILLING CONT...

- ◆ The material shall be placed over the full width of the trench in layers not exceeding 150mm compacted thickness and compacted by tamping rolling or vibration to an minimum Relative Density (RD) of 95% or a minimum Density Index (DI) of 70.

Compaction achieved shall be monitored by field testing as directed by the superintendent.

- ◆ The Overlay Zone shall extend from the top of the Haunch Zone up to 300mm above the top of the pipe and around the pipe measured radially from any point and shall be fill material consisting of material from the excavation or elsewhere. It shall not contain any stones larger than 150mm, nor more than 20% with a size between 75mm and 150mm.
- ◆ The material is to be compacted as necessary to prevent excessive settlement in the ground surface level over the installed pipeline.
- ◆ Backfill or Embankment fill is to be the remainder of the refilling and shall consist of any available material up to finished levels as shown on the drawings.
- ◆ Refilling of sheeting trenches shall be carried out to the following requirements:

No struts, waling or other supports shall be removed until the top of compacted refilling has reached the level of these supports.

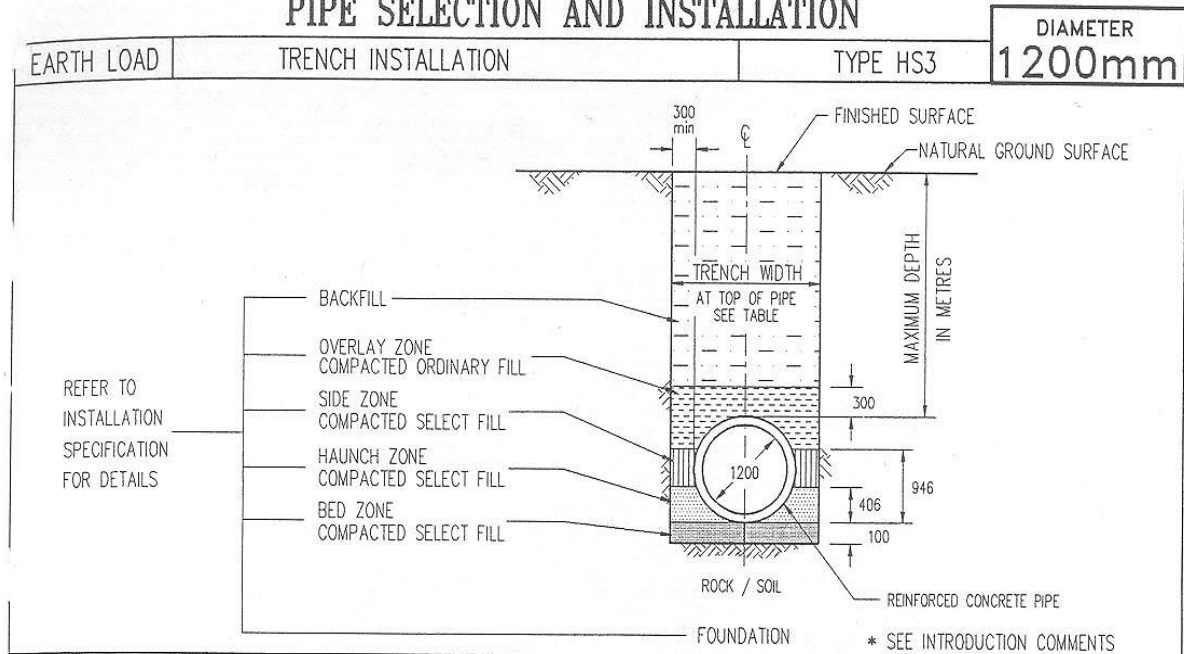
No wall sheeting is to be totally removed from the trench until the level of the compacted refill is within 1500mm of the surface.

No wall sheeting is to be removed, in dewatered trenches, until the level in water table between natural ground and refill material is less than 500mm.

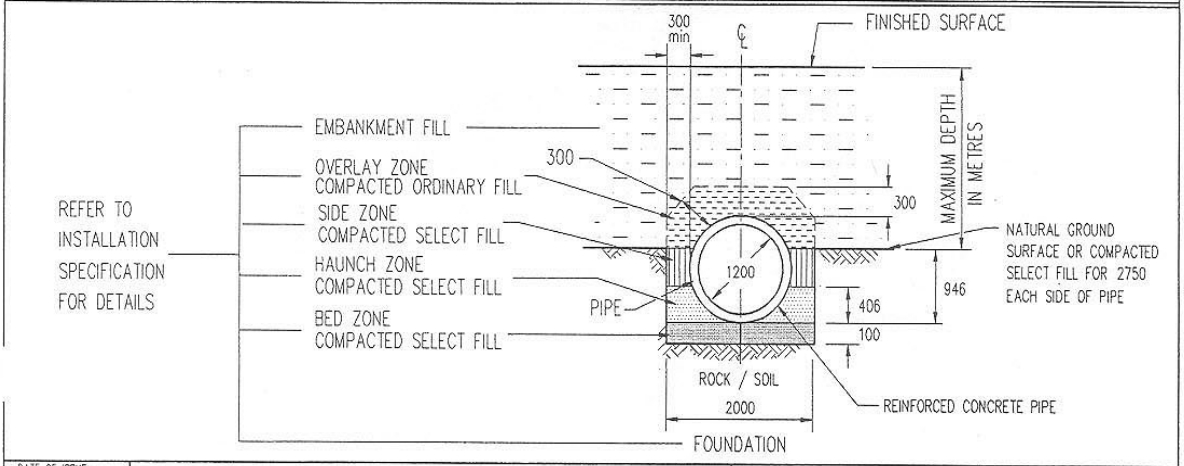
The wall sheeting is to be withdrawn or removed in such a manner that the pipe and compacted bed, haunch and side support are not distributed during such withdrawal or removal.

The above clauses do not cover multiple lines or Construction Loads. If these are relevant refer to AS3725 Clauses 6.3.6 and 6.5.5 and Clause C6.5.5 in the commentary

CONCRETE PIPE ASSOCIATION OF AUSTRALIA
PIPE SELECTION AND INSTALLATION



		MAXIMUM DEPTH IN METRES																	
TRENCH INSTALLATION	TRENCH WIDTH	PIPE CLASS																	
		2	3	4	6	8*	10*	2	3	4	6	8*	10*	2	3	4	6	8*	10*
		1.8	2.0	2.2	2.4	2.6	2.8	2.6	3.0	3.4	3.8	4.0	2.2	2.4	2.6	2.8	3.2	3.4	
		>25	>25	>25	>25	>25	>25	17.4	>25	>25	>25	>25	>25	8.0	22.6	>25	>25	>25	>25
		>25	>25	>25	>25	>25	>25	9.6	>25	>25	>25	>25	>25	6.4	12.8	>25	>25	>25	>25
		14.0	>25	>25	>25	>25	>25	7.2	22.0	>25	>25	>25	>25	5.4	9.8	18.0	>25	>25	>25
		9.0	>25	>25	>25	>25	>25	6.0	12.8	>25	>25	>25	>25	-	8.0	13.2	>25	>25	>25
		7.0	>25	>25	>25	>25	>25	-	9.8	20.6	>25	>25	>25	-	-	10.6	>25	>25	>25
		-	13.6	>25	>25	>25	>25	-	-	14.2	>25	>25	>25	-	-	-	18.8	>25	>25
SOIL DESCRIPTION		SAND AND GRAVEL						CLAYEY SAND						WET CLAY					
TRENCH WIDTH GREATER THAN		2.6	3.0	3.4	4.0	4.4	4.4	2.4	2.6	3.0	3.4	3.8	4.0	2.2	2.4	2.6	2.8	3.2	3.4
EMBANKMENT INSTALLATION		6.0	9.0	12.2	18.2	24.2	>25	5.6	8.4	11.2	16.8	22.4	>25	5.2	7.8	10.4	15.6	20.8	>25
		X	Y	Z	1.5Z	2Z	2.5Z	X	Y	Z	1.5Z	2Z	2.5Z	X	Y	Z	1.5Z	2Z	2.5Z



DATE OF ISSUE JUNE 1980	EMBANKMENT INSTALLATION	TYPE HS3	1200mm
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9.0 INSTALLATION SPECIFICATION FOR POLYETHYLENE PIPES

9.1 DESIGN CONSIDERATION

1. Where PE Pressure Pipes are selected the designer must consider:
 - the use of straight or coiled pipes
 - the jointing method
 - rehabilitation
 - burial method
 - directional drilling
 - narrow trench
 - mole ploughing
 - impact moling

2. PE Pressure pipes are available either in coils or straight lengths depending upon pipe size and material selected. Straight pipes are usually produced in 12m lengths or to suit specific applications and MDPE coils and drums are currently available in sizes up to 160mm.

3. Trenchless techniques such as directional drilling and impact moling are specifically designed for PE systems and significantly reduce reinstatement cost. Open trench pipelines must allow for the jointing, cooling and snaking of the pipe. When using 'normal' trench widths, this can mean greater inconvenience to traffic but allows flexibility to overcome unforeseen obstructions and also ensures the ability to bed and surround the pipe properly. Narrow trenching with PE has the considerable advantages of reduced reinstatement costs and less spoil to handle. Not all subsoils are conducive to such a technique and proper laying, bedding and compaction is not always possible at the required depths of cover.

4. The flexibility of PE allows the accurate alignment of the pipeline to awkwardly contoured kerb races on housing sites. The reinstatement or replacement of pipes in established areas will minimise disruption for major cost advantages.

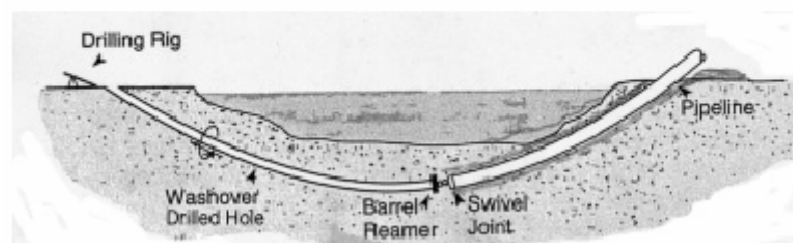
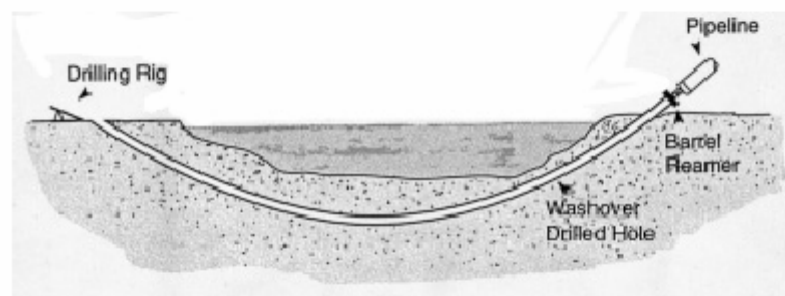
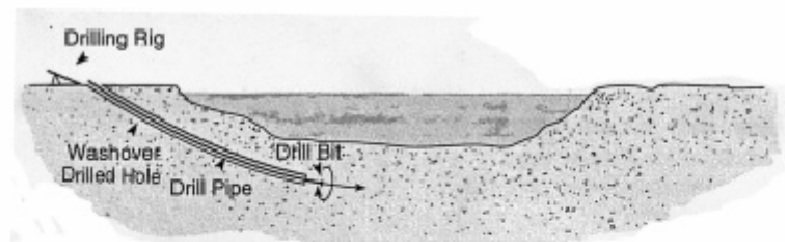
9.2 INSTALLATION

- ◆ Before installation, each pipe and fitting should be inspected to see that its bore is free from foreign matter and that its outside surface has no large scores or any other damage. Pipes of the required diameter and pressure rating should be identified and matched with their respective fittings and placed ready for installation.

9.2.1. Installation Techniques for Buried Pipe

1. Directional Drilling

- ♦ The major advantage is that PE is either a continuous coil or can be butt welded into a continuous pipe string, enabling the pipe to be directional drilled. The technique was developed for the oil and gas wells. It is now increasingly important and used to limit reinstatement work in developed city and business areas, under motorways, traffic intersections, roads, rivers or other objects which can be drilled under without disturbance.
- ♦ It basically involves drilling a hole, whereby the drill bit is steered by the driller using information supplied by hand held locators on the surface above the drill head. The hole is then back cut using a barrel reamer and a wash-over pipe or the PE pipe which is attached with a swivel to the barrel reamer to pull back the pipe. A variety of special cutting and slip fluids are used as the cut rate, the soil type and the depth need to be assessed by the driller as the removed material has to flow from the drill or relief holes. Significant pressure is created at the drill head so the appropriate SDR pipe needs to be selected to avoid the pipe being crushed or the ground disturbed.



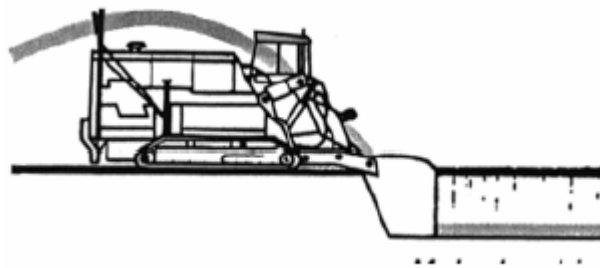
2. Trenching/Narrow/Chain

- ◆ With the PE pipe string jointed above the ground the need to trench joint is eliminated and the width of the excavation can be minimised thus reducing labour, the amount of backfill required and reinstatement costs.



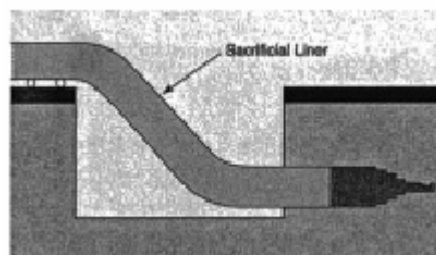
3. Moleploughing

- ◆ Developed for laying land drainage and adapted to installation of gas and water pipes in rural areas. It enables pipe to be laid across rural landscapes with minimal disruption to the land use and the ground is reinstated virtually in prime condition.



4. Impact Moling

- ◆ Moling is suitable where a pit can be dug at both the beginning and the end of the pipe line to accommodate the drilling equipment. A bore hole is launched between the two pits, leaving the ground undisturbed. A sacrificial liner is attached to the mole and the PE pipe is inserted in the liner.

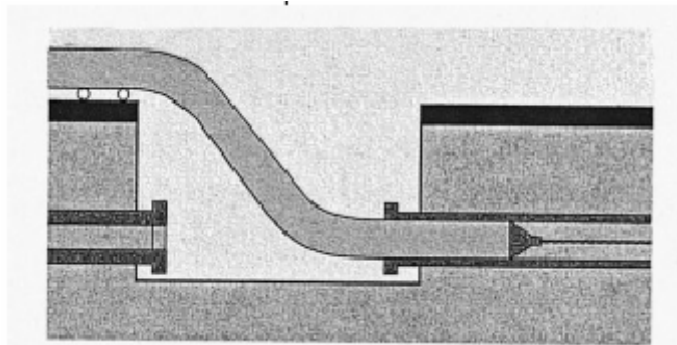


9.3. TRENCHLESS INSTALLATION

9.3.1. Rehabilitation

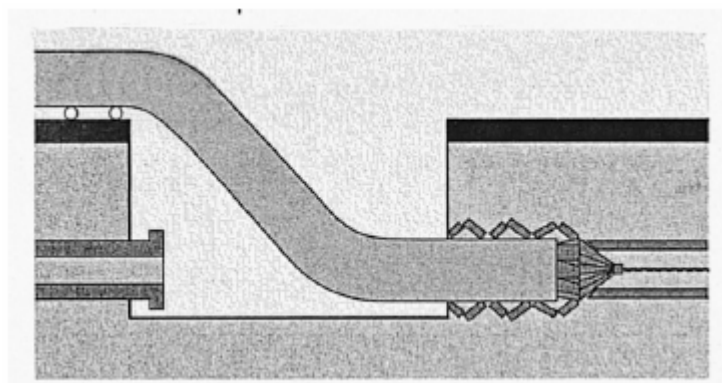
Sliplining

- ◆ In slip lining a replacement PE pipe string of a smaller size is inserted into an existing decommissioned pipeline. Pressure grouting can enable the existing pipe to be rehabilitated structurally while reinforcing the pressure rating of the new line.
- ◆ Some reduction of flow capacity is inevitable. This can be minimised with careful preparation and cleaning of the old pipeline. The average annular clearance can be approximately 5%. In pressure the reduction in capacity can often be overcome with increased pressure in the new line, or in gravity the exclusion of ground water entering the line if a significant reduction in flow is required.



Pipe Bursting

- ◆ Size for size replacement, or upsizing of existing cast iron pipelines can be achieved with significant savings by the pipe bursting method. With this method an existing main is burst and the bore hole is simultaneously expanded by a mole. Modern pipe bursting mole with hydraulic expanders can crack open unserviceable pipelines even with repair collars or concrete surrounds.



9.4. LOADS ON PIPES

9.4.1. Soil and Traffic Loads

- ◆ Loads are exerted on buried pipe due to:
 - Soil pressures
 - Superimposed loads
 - Traffic loads
- ◆ For normal water supply systems, the minimum depths of burial (cover) stipulated in AS/NZ 2033 should be observed. Under these conditions and up to a maximum of 3 metres cover, soil and traffic loadings are of little significance and design calculations are not necessary. This applies to all classes of pipe.
- ◆ For depths shallower than those recommended, traffic loading may be of significance. At greater depths, soil loadings may control selection of pipe class. In these instances, lighter pipe classes may not be suitable and specific design calculations and/or special construction techniques may be required. Wet trench conditions may also require further investigation.
- ◆ For design purposes, AS/NZS 2566 Plastics Pipelaying Design sets out procedures to be adopted. Special construction techniques can involve backfill stabilization, load bearing overlay or slab protection. It should be noted that cover of less than 1.5 diameters may result in flotation of empty pipes under wet conditions. Low covers may also result in pipe “jacking” (lifting at vertically deflected joints) when pressurized.

9.4.2. Bending Loads

- ◆ Under bending stress PE Pressure pipes will bend rather than break. However, the following precautions are very important.
 1. In below ground installations, the pipes must have uniform, stable support.
 2. In above ground installations, proper, correctly spaced supports must be provided.
 3. In above ground installations, pumps, valves and other heavy appendages must be supported independently.

9.4.3. External Pressure

- ◆ All flexible pipe materials can be subject to buckling due to external pressure and PE pipes behave in a similar fashion to PVC and steel pipes. For a uniform section pipe the critical buckling pressure P_c can be calculated as follows:

$$P_c = \frac{2380E}{(SDR - 1)^3}$$

Where:

E = modulus of elasticity (Gpa)

Where pipes are buried and supported by backfill soil the additional support may be calculated from:

$$Pb = 1.15(P_c E')^{0.5}$$

Where:

E' = soil modulus from AS2566-Plastic Pipelaying Design.

- ◆ Tabulations of the value of E' for various combinations of soil types and compactions are contained in AS/NZS2566. The development of any restraint from the surrounding soil is governed by the depth of installation and for installations less than 3 pipe diameters deep, the effect should be disregarded. The value of Pc calculated requires a factor of safety to be applied and a factor of 1.5 may be applied for those conditions where the negative pressure conditions can be accurately assessed. Where soil support is taken into account then a factor of 3 is more appropriate. In general terms PN9 pipe should be used as a minimum for pump suction lines or when negative pressure will be generated due to the gradient the pipe is laid to.
- ◆ Where the individual installation conditions result in negative pressure conditions that are not present in operation, then regard must be paid to construction techniques. For example pipes may need to be filled with water during concrete encasement when being used as vertical or horizontal ducting. In operation, fluid may be removed from the pipeline faster than it is supplied from the source. This can arise from valve operation, draining of the line or rupture of the line in service. Air valves must be provided at high points in the line and downstream from control valves to allow the entry of air into the line and prevent the creation of vacuum conditions. Generally, in long pipelines air valves should be provided each 250 metres along the line.

9.5. EXTERNAL LOADING

- ◆ AS/NZS2566 – Plastics Pipelaying Design provides a methodology of calculating these loads operating on buried pipes under various installation conditions. The basis of the AS/NZ2566.1 and 2566.2 is that developed by Marston in the USA and for each of the load sources listed in "Loads on Pipes" section 1,2 and 3 is as follows:

4) Earth Loads

Trench

a) Embankment

$$b) W = C_e w D^2$$

1) Imposed Loads

Uniformly distributed load

2) Trench

$$W = C_u B U$$

3) Embankment

The load U is expressed as an equivalent height of fill and added to the embankment height.

$$h = \frac{U}{w}$$

4) Traffic Loads

$$W = C_p \frac{M \alpha}{I}$$

The symbols expressed in these formulate for evaluating the loads acting on the pipes are contained in AS/NZ2566 and are as follows:

W = load on pipe (kN/m)

C = load coefficient

α = impact factor

l = length of pipe over which concentrated load acts (m)

M = concentrated load (kN)

D = mean pipe outside diameter (m)

B = trench width (m)

U = uniformity distributed load (kPa)

w = density of fill (t/m³)

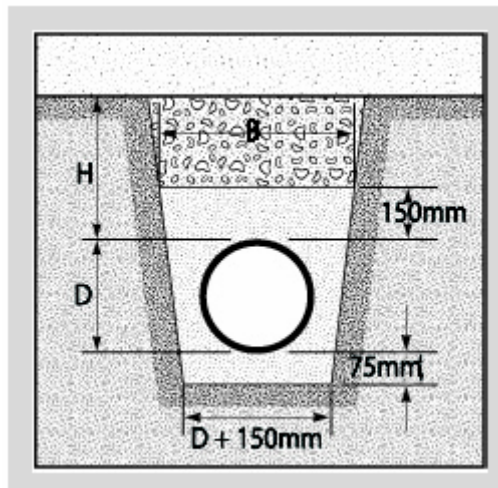
9.6. DEFLECTION

- ◆ Flexible pipes resist external loading by a combination of ring stiffness of the pipe and the soil support developed as a result of deflection of the pipe under loading.
- ◆ This deflection invokes passive support and provides the major portion of the total installed pipe strength. The amount of passive support is determined by the type of soil and the amount of compaction in the soil at the side of the pipe. The determination of this support is contained in the various sections of AS/NZS2566 and is specific to each installation.
- ◆ For flexible pipes the maximum load bearing capacity is determined by the deflection of the pipe from the original diameter. Traditionally, in New Zealand the maximum allowable deflection has been 5% of the pipe outside the diameter and this value has been adopted AS/NZS2566. This value originally related to the limit applied to cement lined steel pipe as being the limit before the lining cracked and failed under loading. In the case of homogeneous flexible pipes this limit has no engineering basis and may be exceeded without structural damage. The actual maximum design value adopted may be selected by the designer taking into account the particular requirements of the installation, such as the need to pass mechanical cleaning equipment down the bore of the pipe.
- ◆ For the pipe deflected at 5% of the outside diameter the hydraulic capacity of the pipe is 99.9% of the capacity of the same pipe as a perfect circle. The calculation of the deflection of the pipe caused by the external loading is performed in AS/NZS2566 using the approach developed by Spangler in the USA at Iowa State College. A computer program is available to accurately calculate maximum depth for pipe installations and soil loads on pipe.
- ◆ The major support in the installed pipeline is derived from the supporting soil and the attention of the designer is drawn to modifying the type of standard compaction as the preferred method of increasing the load resistance of the pipeline.
- ◆ The standard levels of compaction contained in AS/NZS2566 and the intended usage areas are as follows:
 - a) Type 1
The highest level of compaction as used in highway and road pavements and requires mechanical compaction techniques.
 - b) Type 2
The level of compaction attained by thorough hand tamping methods normally used in trench and embankment conditions for sewer and drain applications.
 - c) Type 3
The level of compaction attained where the sidefill is not compacted and side support arises from natural soil consolidation. Normally used in stormwater and pressure pipe applications where no additional external loads are encountered.

9.7. TRENCH INSTALLATION

9.7.1. Preparing the Trench

- ◆ PE pipe can be damaged or deformed if the bed support is not made as uniform as possible. The trench bottom should be compacted and examined for irregularities and any hard projections removed. The minimum trench width should allow for adequate tamping of side support material and should be not less than 150mm greater than the diameter of the pipe. In very small diameter pipes this may be reduced to a trench width of twice the pipe diameter.



- ◆ The maximum trench width should be as restricted as possible depending on the soil conditions. This is necessary for both economics and to develop side support. Where wide trenches or embankments are encountered then the pipe should be installed on a 75mm layer of tamped or compacted bedding material as shown on the cross section diagrams. Where possible a sub trench should be constructed at the base of the main trench to reduce the soil loads developed. AS/NZS2566 provides full details for evaluating the loads developed under wide trench conditions.

Recommended Trench Widths

SIZE DN	MINIMUM (mm)	MAXIMUM (mm)
100	320	800
125	340	825
150	360	825
175	400	875
200	425	900
225	450	925
300	515	1000
375	600	1200

- ◆ The width of trenches used with PE pipe may be reduced by jointing above ground in the case of butt or electrofusion welding and then feeding the jointed pipe into the trench. Similarly, small diameter pipe in coil form can be welded or mechanically jointed above ground and then fed into the trench.

9.7.2. Trench Depths

- ◆ The recommended minimum trench depth is determined by the loads imposed on the pipe such as the mass of backfill material, the anticipated traffic loads and any other superimposed loads. The depth of the trench should be sufficient to prevent damage to the pipe when the anticipated loads are imposed upon it.

9.7.3. Minimum Covers for Trenches

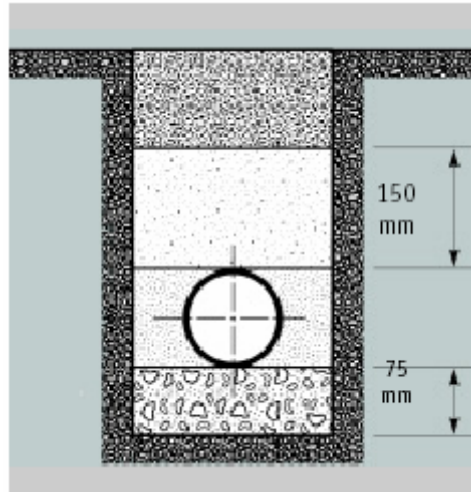
- ◆ Trenches should be excavated to allow for the specified depth of bedding, the pipe diameter and the minimum recommend cover and overlay plus backfill above the pipes. Table below provides recommendations for minimum cover to pipe crown.

Minimum Cover

Loading	Cover (mm)
Roads and streets	750
Driveways and similar areas subject to traffic	600
Footpaths, gardens	500
Construction traffic	750

- ◆ The above cover requirements will provide adequate protection for all pipes. Where it is necessary to use lower covers, several options are available.

1. Provide additional structural load bearing bridging over the trench. Temporary steel plates may be used in the case of construction loads.
2. Use a high quality granular backfill e.g. crushed gravel or road base.
3. Use a higher class of pipe than required for normal pressure or other considerations.



9.7.4. Bedding Material

- ◆ Preferred bedding materials are listed in AS/NZ2655.1 and are as follows:
 - a) Suitable sand, free from rock or other hard or sharp objects that would be retained on a 13.2 mm sieve.
 - b) Crushed rock or gravel evenly graded up to a maximum size of 20 mm.
 - c) The excavated material may provide a suitable pipe underlay if it is free from rock or hard matter and broken up so that it contains no soil lumps having any dimension greater than 40 mm which would prevent adequate compaction of the bedding.
- ◆ The suitability of a material depends on its compactability. Granular materials (gravel or sand) containing little or no fines, or specification graded materials, requiring little or no compaction, are preferred.
- ◆ Clays and sands containing fines are difficult to compact and should only be used where it can be demonstrated that appropriate compaction can be achieved.

9.7.5. Pipe Side Support

- ◆ Material selected for pipe side support should be adequately tamped in layers of not more than 75mm for pipes up to 250mm diameter and 150mm for pipes of diameters 300mm and above. Care should be taken not to damage the exposed pipe. Tamp evenly on either side of the pipe to prevent pipe distortion and not to disturb the line or grade. Side support and pipe overlay material used should be identical with the pipe bedding material.

9.7.6. Backfill

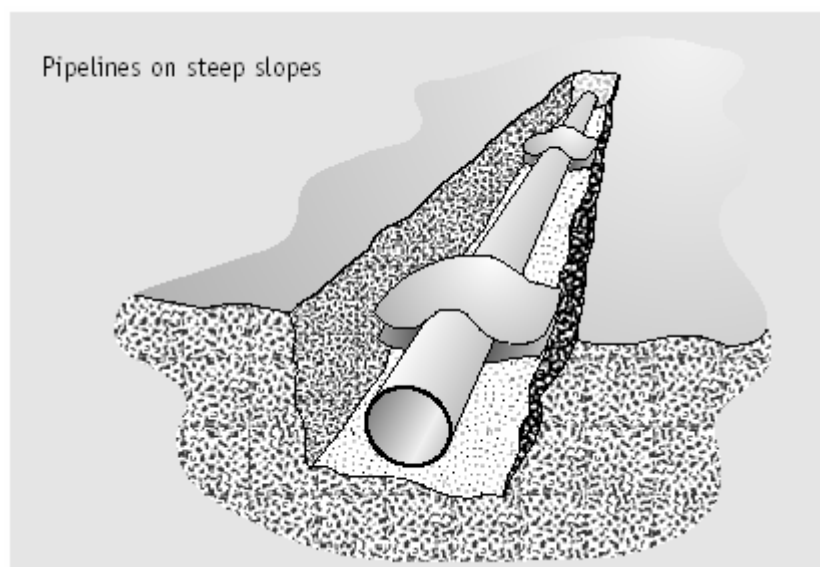
- ◆ Unless otherwise specified, excavated material from the site should constitute the back fill. Gravel and sand can be compacted by vibratory methods and clays by tamping. This is best achieved when the soils are wet. When flooding the trench, care should be taken not to float the pipe. All ground should be compacted back to 91-95%. The loads arise from two sources; the static or pressure force and the kinetic or velocity force.

9.8. THRUST SUPPORT

- ◆ A major advantage of PE is that the length of pipe can be butt or electrofusion jointed to form a continuous string of pipe and there is normally no need for thrust blocks. It is advisable to ensure that soil support or bracketing will sustain pipe movement due to thrust loads. Valves and pumping equipment should be appropriately mounted to sustain thrust loads. This, together with the material's inherent flexibility, makes polyethylene suited to a wide range of pressure and nonpressure application and innovative installation techniques.

9.9. TRENCHED PIPELINES ON STEEP SLOPES

- ◆ When pipes are trenched on steep slopes, i.e. slopes steeper than 20% (1:5), trenched backfill around the pipe may be scoured out by water movement. Clay stops or sandbags should be placed at appropriate intervals above and below the pipe to stop erosion of the backfill.
- ◆ Directional drilling is recommended on steep slopes to maintain environment.



9.10. PIPELINE BUOYANCY

- ◆ Pipe under wet conditions can become buoyant in the trench. HDPE pipes should be covered with sufficient overlay and backfill material to prevent inadvertent flotation and movement. A depth of cover over the pipe of 1.5 times the diameter is usually adequate. Pipelines on steep slopes

9.11. PIPELINE DETECTION

- ◆ HDPE pipes are electrically non-conductive and cannot be detected by metallic detection devices in underground installations. Several techniques are available to detect buried pipelines.

9.11.1. Metal Detector Tapes

- ◆ Foil based tapes may be located in the trench on top of the pipe overlay material (150-300mm above the pipe crown). These tapes can be detected at depths up to 600mm by metal detection equipment operating in the 4-20MHz frequency range. The tape backs may also be colour coded and printed in order to provide early warning of the presence of the pipeline during later excavation.

9.11.2. Tracer Wires

- ◆ Pipes installed deeper than 600mm may be detected by the use of tracer wires placed on, or taped to, the top of the pipes. Application of a suppressed current allows the detection of pipes up to a depth of three metres. However, both ends of the tracer wire must be accessible, and a complete electrical circuit present over the entire length of the pipeline.

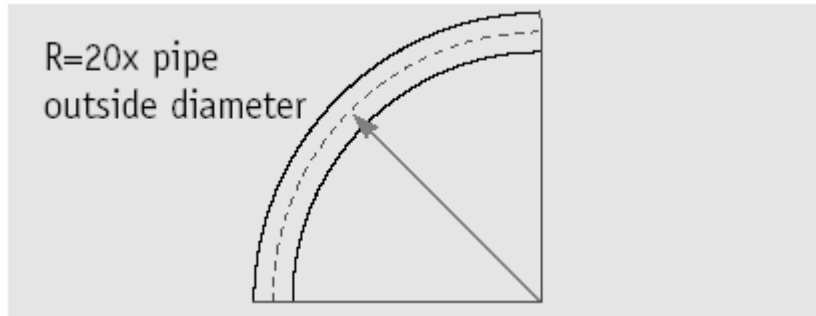
9.11.3. Audio Detection

- ◆ Acoustic, ultrasonic or Ground Penetrating Radar noise detection devices are available which use either the noise from water flowing in the pipes, or an introduced noise signal, to detect the presence of buried pipelines.

9.12. BENDS AND BENDING

9.12.1. Bending MDPE Pipes

1. The bending of PE pipe is permissible and the properties of fusion jointed systems enable changes of direction without recourse to the provision of special bends or anchor blocks. SDR11 and 17 PE pipe can normally be cold bent to a radius 20 times the outside diameter of the pipe, increasing to 30 in very cold conditions. For SDR26 these values need to be increased by 50%. No joints or tappings should occur on the bend.



2. A full range of standard preformed bends are available and are preferable for the larger sizes. Special configurations are similarly available upon request.

9.13. CONCRETE ENCASEMENT

9.13.1. Pipe Entry Into Structures

1. Wherever pipework meets or passes through rigid structures, careful consideration should be given to:
 - ♦ the need to effect a watertight seal at the pipe/ structure interface;
 - ♦ the extent to which the structure itself is required to withstand forces transmitted from the pipe;
 - ♦ where there is rigid connection between pipe and structure, whether the adaptation of standard fittings influence the degree to which compressive, tensile, bending and shear forces are generated;
 - ♦ where differential settlement may occur, the extent to which the pipe and fittings flexibility can normally be relied upon to withstand the bending and shear stresses set up.
 - ♦ an annular space of not less than 6mm should be left around the pipe or fitting. This clearance should be maintained and sealed with a flexible sealant such as loosely packed felt, a rubber convolute sleeve or other suitable flexible sealing material.
 - ♦ if the pipeline has to pass through a fire rated wall, advice on suitable fire stop methods is available from our Product Manager.

2. Where pipe is to be connected to a large rigid structure, movement and bending will occur and can be accommodated by using a Friafit manhole connector.



Friafit manhole connector

9.14. ABOVE GROUND INSTALLATION

- ◆ Pipes may be stored above ground for pressure and non pressure applications in both direct sunlight and protected conditions.
- ◆ Black PE pipes made to AS/NZS 4130 requirements may be used in direct sunlight conditions without any additional protection. However, special attention is required to the pipe ends before welding. Where PE pipes of colours other than black are used in exposed conditions, then the pipes may need to be protected from sunlight. Localized temperature build up conditions such as proximity to steam lines, radiators or exhaust stacks must be avoided unless the pipes are suitably protected. Where lagging materials are used, these must be suitable for external exposure applications. For above ground pipework anchoring and support is essential.

9.14.1. Support and Spacing

- ◆ The spacing of supports for a PE pipeline depends on factors such as the diameter of the pipe, the density of the fluid being conveyed and the maximum temperature likely to be reached by the pipe material. Table below, shows the support spacing in metres for PE pipe carrying water at 20°C. These spacings do not allow for additional extraneous loading.

RECOMMENDED SUPPORT SPACING FOR MDPE PIPES

Nominal Pipe OD (mm)	Maximum Recommended Spacing (m)
16	0.25
20	0.30
25	0.35
32	0.38
40	0.43
50	0.45
63	0.50
75	0.60
90	0.67
125	0.75
140	0.85
160	1.00
200	1.10
225	1.15
250	1.25
280	1.30
355	1.50

- ◆ If temperatures are in excess of 20°C the horizontal spacing should be reduced by 25% for every 10°C. At 60°C, continuous horizontal support is required.

9.14.2. Vertical Installation

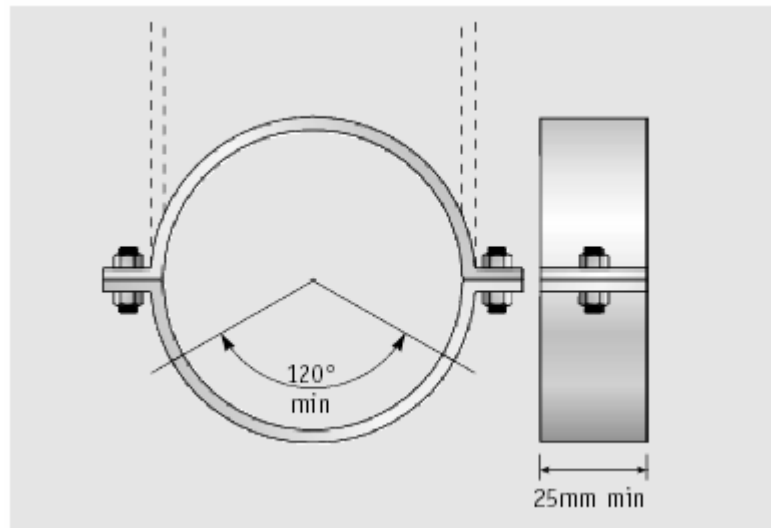
- ◆ Generally, vertical runs are supported by spring hangers and guided with rings or long U-bolts which restrict movement of the rise to one plane. It is sometimes helpful to support a long riser with a saddle at the bottom.

9.14.3. Brackets and Clips

- ◆ For either free or fixed pipelines supports using brackets or clips, the bearing surface should provide continuous support for at least 120° of the circumference.

9.14.4. Straps

- ◆ Metal straps used as supports should be at least 25mm wide, preferably plastic coated with no sharp edges or burrs. If a strap is fastened around a pipe, it should not distort the pipe in any way.



- ◆ Location and type of support must take into account provision for thermal movement, if required. If the supports are to resist thermal movement, an assessment of the stress induced in pipes, fittings and supports may need to be made.

9.14.5. Free Support

- ◆ A free support allows the pipe to move without restraint along its axis while still being supported. Prevent the support from scuffing or damaging the pipe as it expands and contracts. Lag with a layer of PE pipe material or Hippolon sheet.

9.14.6. Fixed Support

- ◆ A fixed support rigidly connects the pipeline to a structure totally restricting movement in a least two planes of direction. Such a support can be used to absorb moments and thrusts.

9.14.7. Placement of Support

- ◆ Careful consideration should be given to the layout of piping and its support system. Even for non pressure lines the effects of thermal expansion and contraction have to be taken into account. In particular, the layout should ensure that thermal and other movements do not induce significant bending moments at rigid connections to fixed equipment or at bends or tees.

9.15. INSTALLATION CONSIDERATIONS

9.15.1. Expansion and Contraction

- ◆ PE Pipe will expand or contract if it is installed during very hot or very cold weather, so it is recommended that the final pipe connections be made when the temperature of the pipe is stabilized at a temperature close to that of the backfilled trench. PE lines can be laid directly on the natural surface by snaking the pipe during installation and allowing the pipe to move freely in service. Where the final joint connections are made in high ambient temperature, sufficient pipe

length must be allowed to permit the pipe to cool, and hence contract, without pulling out of non end load bearing joints.

9.15.2. Heat Sources

- ◆ Pipes and fittings should be protected from external heat sources which would bring the continuous pipe material service temperature above 60°C. Where the pipes are installed above ground, the protection system used must be resistant to ultra violet radiation and the effects of weathering. Pipes running across roofing should be supported above the roof sheeting in order to prevent temperature build up. Due to heat being generated by continuously running pumps under load, the pipe's pressure rating needs to be appropriate.

9.15.3. Vibration

- ◆ Direct connection to sources of high frequency vibration should be avoided. All fabricated fittings manufactured by cutting and welding techniques must be isolated from vibration. Where high frequency vibration sources exist in the pipeline, the sections should be connected using a wire reinforced rubber bellows joint.

9.15.4. Conductivity

- ◆ HDPE is non-conductive and cannot be used for electrical earthing purposes or dissipating static electricity charges. When pipes are used to replace existing metal water pipes, the designer must consider any existing systems used for earthing. In these cases the appropriate electrician must be consulted to determine the requirements.

9.15.5. Fire Rating

- ◆ HDPE pipes systems will support combustion and as such are not suitable for use in fire rated zones in buildings without suitable protection.

9.16. PNEUMATIC DESIGN

9.16.1. Pneumatic Flow

- ◆ HDPE pipe systems are ideal for the transmission of gases both in the high and low pressure range. The use of compressible fluids in PE pipes requires a number of specific design considerations as distinct from the techniques adopted for fluids such as water. In particular:
- ◆ Safety factor for different gases should be considered in any design.
 - Natural gas 2.0
 - Compressed air 2.0
- ◆ Compressed air may be at a higher temperature than the ambient air and PE pipes require temperature re-rating accordingly, especially at source. For air cooled compressors the air temperature averages 15°C above the surrounding air temperature. For water cooled compressors the air temperature averages 10°C above the cooling water temperature.

- ◆ For underground applications the surrounding temperature may reach 30°C and the pipe properties require adjustment accordingly.
- ◆ High pressure lines must be protected from damage, especially in exposed installations.
- ◆ Valve closing speed must be reduced to prevent a build up of pressure waves in the compressible gas flow.
- ◆ Where gaseous fuels such as propane, natural gas or mixtures are carried the gas must be dry and free from liquid contamination which may cause stress cracking in the PE pipe walls.
- ◆ MDPE pipes should not be connected directly to compressor outlets or air receivers. A 20 metre length of metal pipe should be inserted between the air receiver and the start of the PE pipe to allow for cooling of the compressed air.
- ◆ Dry gases and gas/solids mixtures may generate static electrical charges and these must be dissipated to prevent the possibility of explosion.
- ◆ Compressed air must be dry and filters installed in the line to prevent stress cracking in the PE pipe.
- ◆ The fitting systems used must be pressure compatible with the pipe and where metal couplings and shouldered ends are used, the maximum pressure is limited to 0.6MPa. Several empirical flow formulae are in widespread use and any of these e.g. Weymouth, Spitzglass or Harris, may be used to calculate the flow of gas through PE pipes.

9.16.2. Compressed Air Formula

- ◆ It is customary to determine the required inside diameter of the pipe by using formulas such as that shown below. The formulas used are generally for approximation purposes only, surmising that the temperature of the compressed air corresponds roughly to the induction temperature. You will obtain an acceptable approximation through the following equation.

$$di = \sqrt[5]{\frac{450.l.\frac{dV^{1.85}}{dt}}{\Delta p.p}}$$

Where:

Δp = pressure decrease (bar)

p = working pressure (bar)

V = volumetric flowrate (l/s)

dV/dt = atmosphere (l/s)

l = pipe length (m)

di = inside diameter (mm)

- ◆ The values are specific to each fluid type and the properties should be available from testing.

10.0 GUIDELINES FOR STEELWORK AND METALWORK

10.1. SCOPE

- ◆ This guideline covers the steelwork and metalwork in the contract, for flow control gates and related components.
- ◆ This guideline is intended as a guide to assist the contractor to achieve the standards specified by the designer. Any or all parts of this guideline may be modified by the designer, subject to peer review.

10.2. STANDARD SPECIFICATIONS

- ◆ Unless another Standard is specifically mention in the Contract, all steelwork and metalwork shall be designed, manufactured and tested in accordance with current editions of the relevant standards issued by standards authorities in New Zealand or Australia.
- ◆ The requirements of the following standard specifications and any standards quoted therein shall apply except where modified by this guideline. The standards shall be the current versions including all applicable amendments, at the time of pricing:

I.	BS 4360:	Specification of Weldable Structural Steel;
II.	AS 1204:	Structural Steels, Ordinary Weldable Grades;
III.	NZS 3404:	Code for Design of Steel Structures;
IV.	NZS/AS 1111:	ISO Metric Hexagon Commercial Bolts and Screws;
V.	NZS/AS 1112:	ISO Metric Hexagon Nuts;
VI.	AS 1538:	SAA Cold Formed Steel Structures Code;
VII.	AS 1237:	Flat Metal Washers for General Engineering Purposes;
VIII.	AS 1252:	Grade High Strength Steel Bolts with Associated Nuts and Washers for Structural Engineering;
IX.	AS 1553:	Covered Electrodes for Welding;
X.	AS 1554:	Structural Steel Welding;
XI.	AS 1163:	Welded & Seamless Steel Hollow Sections for General Structural Purposes;
XII.	NZ 4701:	Metal-arc Welding of Steel Structures;
XIII.	AS 1214:	Hot-dip galvanised coatings on threaded fasteners (ISO metric coarse thread series);
XIV.	AS 3679:	Hot rolled structural steel bars and sections;
XV.	AS 1449:	Stainless and heat resisting steel plate, sheet and strip (coils and cut length);
XVI.	AS 1511:	SAA high strength structural bolting code;
XVII.	AS 1594:	Hot-rolled steel flat products;
XVIII.	AS 1650:	Galvanised coatings on ferrous articles;

XIX.	AS 1796:	SAA Welding Certification Code;
XX.	AS 3678:	Hot Rolled Structural Steel Plates, Floorplates and Slabs;
XXI.	AS 1397:	Steel sheet and strip – Hot dipped zinc-coated or aluminium/zinc coated;
XXII.	AS 1627:	Metal Finishing - Preparation and Pre-treatment of Surfaces;
XXIII.	AS 2177:	Radiographic examination of welded butt joints in metal;
XXIV.	BS 4504:	Flanges and Bolting for Pipes, Valves and Fittings; and,
XXV.	AS4711:	Qualification tests for metal arc welders.

10.3. SHOP DRAWINGS AND SHOP INSPECTIONS

- ◆ Any drawings provided with the contract documents are to general arrangement level only.
- ◆ The Designer is to provide the Contractor with sufficient details such that shop drawings for fabrication and assembly can be prepared. Once these are completed and fully checked for accuracy two sets shall be provided to the person responsible for quality assurance at the site.
- ◆ The Contractor is responsible for any inspection or testing required by the Designer or any of the standard specifications. The inspections or testing will be at the Contractor's cost. It will be the contractor's responsibility to make good any defects, which will be at the Contractor's expense.

10.4. MATERIALS

10.4.1. Steel

- ◆ Unless stated otherwise on the Drawings, all steel for the works should be as follows:
 - I. gate plate AS 3679-250, AS 1594-HA250 or BS 4360-43C;
 - II. structural sections NZS 3404-250;
 - III. rectangular hollow sections AS 1163-C350; and,
 - IV. steel tube AS 1163-C250 or C350.
- ◆ Mill certificates cross identifiable with all plates and sections, should all be provided prior to any fabrication involving plates and sections. Plates should be trimmed in such a manner that the identifying marks remain on the structure.
- ◆ The certificates shall include both chemical analysis and the mechanical tests results corresponding to the grade of steel. The certificates shall be identifiable with marking on each plate. The location of each plate or section shall be identified on the 'As-Built' drawings.
- ◆ All materials incorporated in the equipment shall be new and unused. They shall be free from all flaws which would adversely affect the performance, safety or appearance of the finished article. Any rusting shall be limited to surface staining only, and no pitted steel shall be used in the works.
- ◆ It is the Contractor's responsibility to ensure all materials used in the works meet the specified standards. Any materials found not to meet the standard will be rejected.

10.4.2. Rubber for Seals

- ◆ Rubber gate seals should be neoprene with a Shore hardness of 60°.

10.4.3. Purlins and Girts

- ◆ Purlins and girts should be manufactured from galvanised strip steel, complying with AS 1397. The shapes should conform to AS 1538.

10.4.4. Nuts, Bolts and Washers

- ◆ All nuts, bolts and washers to be galvanised.

10.4.5. FABRICATION AND ERECTION

10.4.6. General

- ◆ All structural steelwork should be fabricated and erected in accordance with NZS 3404 Section 13 & 14. Work is to conform to best trade practice and work in any area to only be carried out by tradesmen skilled in that type of work. Welding and surface coatings should comply with Subsection 10.6 of this Guideline.
- ◆ Methods of fabrication and handling of sections shall be arranged so that distortions due to self weight are minimised.

10.4.7. Defects Found During Fabrication

- ◆ If at any time during the fabrication work, laminations or other defects are found, all further work on the item in question is to be suspended. In particular, a careful visual check for laminations in the plate edges is to be made as soon as each plate is cut to size.
- ◆ Where the plate does not meet the required specification, the Contractor is to replace the complete plate or undertake remedial work in the case of small defects.

10.4.8. Avoidance of Site Welding

- ◆ As much of the welding as is possible should be completed in the factory of manufacture. Extreme care should be taken in fabrication to ensure that parts to be mated in the field and bolted together, match within specified tolerances.

10.4.9. Tolerances

- ◆ Except where tolerances are shown on the Drawings, tolerances should not exceed those given below. The component parts should be assembled in such a manner that they are neither twisted nor otherwise damaged.

10.4.10. General

- | | |
|---------------------------------------|------------|
| ◆ Straightness | length/500 |
| ◆ Structural dimensions | ± 3 mm |
| ◆ Plan position of structural members | ± 5mm |

- ◆ Level of structural members ± 5mm
- ◆ External circumference of cylinders ± 6 mm from computed circumference and tapers based on nominal diameter
- ◆ Difference between diameters of
Cylinders and tapers at a cross-section ± 0.5% nominal diameter
- ◆ Squareness of ends of pipes ± 3 mm from normal to pipe axis
- ◆ Location of attachments ± 10 mm

10.4.11. Weld Preparation

- ◆ Root face of joint ± 2 mm
- ◆ Root opening of joints ± 2 mm
- ◆ Groove angle ± 5 degrees
- ◆ Radius of J and U joints ± 2mm

10.4.12. Cutting and Forming

- ◆ Steel may be cut by shearing, cropping, sawing or machine flame cutting. Hand flame cutting can be used provided tolerances are achieved. The cut edges should be free of gouges, burrs and other defects which could adversely affect the serviceability of the member or its protective coatings. Plates cut by cold shearing should have the sheared edge cut back by machining or chipping or flame cutting by at least 3 mm. Plate edge surfaces forming part of a welded joint should be prepared by machining or machine flame cutting and grinding smooth.
- ◆ Plates should be thoroughly examined for any surface defects including indentations, projections and laminations. All plates should be checked for plate thickness. The acceptance of plates with score marks to be subject to the approval of the Quality Assurance requirements. Plates with laminations or pit marks should not be accepted.
- ◆ Items shall be formed to the proper curvature for the entire length by a process which does not impair the quality of the material.
- ◆ As far as possible hot and cold forming should be by machine. Forming by local heating or hammering without heat is not recommended.
- ◆ Where parts are hot formed, the Contractor shall demonstrate for the Quality Assurance requirements that the material has retained its specified properties and has not otherwise been rendered unsuitable for service. Parts which have to be formed to an internal radius of less than ten times the material thickness should subsequently be given an appropriate heat treatment unless it is demonstrated under the Quality Assurance requirements that this is unnecessary.
- ◆ Curved plates should be formed to the correct contour up to the extreme edge of the plate. Where rolling of plates is required, plates and rolls should be free from all hard lumps or patches of scale before making each pass of plate through the rolls.

10.4.13. Inaccessible Surfaces

- ◆ Surfaces not in contact but inaccessible after shop assembly to receive the full specified protective treatment before assembly. The requirement does not apply to the interior of sealed hollow sections.

10.4.14. Dimensions

- ◆ Before ordering or cutting steel, the Contractor should check and verify all dimensions shown on the Drawings.

10.4.15. Bolting

- ◆ All bolts, studs, nuts, screws and washers should comply with the relevant metric standards. The use of fastenings conforming with other standards to be subject to approval under the Quality Assurance requirements.
- ◆ All bolts, studs, nuts, screws and washers should be made from corrosion resistant materials or be protected by hot dip galvanising or electro-galvanising.
- ◆ Nut threads should be tapped oversized before galvanising to ensure good fit with bolts.
- ◆ The material for stainless steel bolts, nuts and washers should comply with the requirements of AS 1444 Grade 304.

10.4.16. Holes

- ◆ Holes should be drilled or punched and reamed with 2 mm tolerance between the bolt and the hole between aligned members.

10.4.17. Bolts

- ◆ Bolts in their position should be perpendicular to the assembled members.
- ◆ Where necessary, washers should be tapered or otherwise suitably shaped to ensure the heads and nuts of bolts have complete bearing.
- ◆ The threaded portion of each bolt should project through the nut at least one complete thread.

10.4.18. Washers

- ◆ Bolts or nuts bearing on steelwork should be provided with a flat washer.

10.4.19. Snug Tight Nuts

- ◆ Nuts should be tightened sufficiently to draw the members firmly together.
- ◆ Wherever there is a risk of nuts becoming loose due to vibration or reversal of stress, they should be securely locked.
- ◆ Nuts should be tapped oversize to allow for galvanising.
- ◆ Bolts should always be tightened progressively in a staggered pattern.

10.4.20. Finish

- ◆ All surfaces should be finished smooth. Sharp edges, weld spatter and burrs should be removed

and sharp corners radiused. Residual grinding marks should be kept to a minimum and should be normal to the axis of the section.

10.4.21. Transport, Handling and Erection

- ◆ Transport, handling and erection should use methods which ensure that fabrication items are not stressed beyond anticipated levels and shop applied coatings are prevented from damage to the maximum practicable degree. In particular, where lifting and bearing points are detailed on the Drawings, the Contractor should not depart from these unless and adoption of a variation clearly leads to reduced handling and erection stresses.

10.5. WELDING

10.5.1. General

- ◆ All welding work should be in accordance with New Zealand Standard NZS 4701:1981 Class S unless otherwise specified on the Drawings.

10.5.2. Welding Consumables

- ◆ Electrodes for manual arc welding should comply with AS 1210 for Class 2A vessels.

10.5.3. Shielding Gas

- ◆ A gas or gas mixture used for shielding in gas metal arc welding or flux-cored arc welding should be of a welding grade having a dew point of minus 35 degrees centigrade or lower and be suitable for the intended application.

10.5.4. Practices to be observed

- ◆ Where practicable, automatic or semi-automatic welding equipment should be used. Weld preparations for butt welds should be in accordance with Table 13 of NZS 4701.
- ◆ No permanent backing straps should be used when making root runs in butt joints, and for that reason an appropriate method shall be adopted for making such root runs.

10.5.5. Testing of Welded Joints

- ◆ The fabricator of particular components is be responsible for all required non-destructive testing of component welds by a laboratory accredited by TELARC in the types of tests required. The independent laboratory should be instructed to provide a copy of all tests for approval under the Quality Assurance requirements. Any defective welding shall be made good and confirmed by re-testing that it meets acceptance criteria, and where the tests indicate widespread defects, all welding shall be redone by a replacement qualified welder.
- ◆ All joints shall be examined by surface methods, radiographic or ultrasonic methods as specified in Appendix E or NZS 4701:1981, or as shown on the Drawings.
- ◆ Butt welds shall be radiographed. Fillet welds shall be ultrasonically examined.
- ◆ The permissible level of weld imperfections shall be determined from Tables 10 and 11 of NZS

4701:1981 for Class A welds in Appendix E or NZS 4701:1981, except the requirements for Class S welds shall apply for the following:

- I. Undercut;
- II. lack of fusion;
- III. incomplete penetration; and,
- IV. Wormholes.

10.5.6. Records

- ◆ The Contractor is to keep records in sufficient detail to be able to trace operators, equipment and consumables used in making any weld made in accordance with AS 1210.
- ◆ Test records for all visual and non destructive tests to be maintained and submitted as part of the Quality Assurance documentation.

10.5.7. Cleaning and Finishing

- ◆ Surface defects including accidental arc strikes should be ground clean and filled with weld metal.
- ◆ After all welding operations are completed one each component, the surface shall be cleaned of all foreign matter including flux, slag, weld spatter and loose metal.
- ◆ The surfaces of welds shall be finished to a uniform and smooth profile. Grinding shall only be used where the height of the irregularity exceeds 2 mm above the required finished surface. Residual grinding marks shall be kept to a minimum and shall be normal to the section axis. Internal corners shall be radiused. External corners shall be radiused to facilitate painting, if applicable, and/or eliminate injury to personnel.
- ◆ Where the members of a joint are misaligned but within the specified tolerance, this misalignment shall be blended to adjacent areas by slopes not steeper than 1 in 10.

10.5.8. Surface Coatings in Weld Area

- ◆ In the case of surfaces to be welded after surface treatment has been completed, the steel shall not be painted or metal coated within suitable distance of any edges to be welded if the paint specified or the metal coating would be harmful to welders or impair the quality of the weld.
- ◆ Welds and the adjacent parent metal shall not be painted prior to de-slagging, and full preparation as required in Section S8.

10.5.9. Weld Symbols

- ◆ Weld symbols on the Drawing generally follow NZ 4701. In the event of any uncertainty, the matter shall be referred to the Supervisor for clarification.

10.6. SURFACE COATINGS

10.6.1. General

- ◆ All steel web grating, sag and tie rods, all bolts, including holding down bolts, and other items as described in the Drawings, shall be hot dip galvanised as described in the following subsections.

10.6.2. Preparation and Coating

- ◆ Parts shall be thoroughly pickled before galvanising. Matter likely to resist removal by pickling such as welding slag, paint and grease shall be removed prior to pickling by blast cleaning to AS 1627 Pt 9 Grade Sa1.
- ◆ Coatings shall be unbroken and of a minimum thickness of 90 microns.
- ◆ Galvanising shall be applied by the hot dip process in accordance with AS 1650.
- ◆ Any distortion resulting from galvanising or handling should be removed so that the tolerance requirements are met.
- ◆ Care should be taken to prevent Hydrogen embrittlement of the steel.
- ◆ Appropriate representative non-destructive testing of the thickness of the galvanising should be carried out by an independent TELARC registered laboratory.

10.6.3. Repair after Execution

- ◆ After erection or installation of galvanised steel components, all damaged areas where steel is exposed or rusting is visible should be treated as follows:
- ◆ Thoroughly remove all defects and rust by hand wire brushing, scraping, chipping and degreasing as necessary to expose a bright steel surface and immediately follow with the first two coats of approved inorganic zinc silicate paint. This work is to be undertaken in dry conditions.
- ◆ Apart from accidentally damaged areas, this treatment should also apply generally to bolts and nuts where the galvanising has been affected by tools.

11.0 GUIDELINES FOR A SEVEN WIRE FARM FENCE

11.1. SCOPE

- ◆ The seven wire and timber post fences should be constructed in accordance with good fencing practice. The following is given as a guide to achieve the desired result. The details may be altered by the designer. Any variances the designer chooses to make must be ratified by the principals' representative.
- ◆ The final result should be neat, evenly spaced vertically placed posts with correctly tensioned, evenly spaced wires. Gates should hang straight, with sufficient ground clearance for free movement.

11.2. POST AND WIRE FENCING

11.2.1. Posts

- ◆ The posts, excluding strainer posts to be 125mm diameter, H4 treated radiated pine. The posts should be 1.85m long and driven into the ground 0.7m.
- ◆ The recommended spacing is no more than 7m.

11.2.2. Wiring

- ◆ 2.5mm high tensile with A grade galvanising is suggested, at spacing as shown on the attached drawing. Tension of the wires should not exceed 1500N. Either a figure eight or a reef knot is suggested to join the wires.

11.2.3. Staples

- ◆ The suggested staples are 50mm x 4mm barbed with A grade galvanising.
- ◆ The suggested method of construction is to drive the staples into the post on an angle to the post grain to minimise post splitting. The wire should be free to run inside the staple.

11.2.4. Strainer Assemblies

- ◆ The suggested strainer assembly consists of a single span post and rail type with double strands of 2.5mm high tensile wire as braces. This arrangement is shown on the drawing.
- ◆ Strainers should be placed not more than 200m apart.

11.2.5. Battens

- ◆ Four battens of the type sprung steel lightning wire droppers of similar should be placed between each two posts.

11.2.6. Fence Dips and Angles

- ◆ To hold the fence in position at dips and angles it is suggested that the posts should be 150mm

diameter. H4 treated radiata pine, 2.35m long and driven into the ground 1.2m. The angle posts should be stayed.

11.2.7. Tie Downs

- ◆ In accordance with good fencing practice, tie downs should be used in depressions.

11.3. GATES AND GATE POSTS

- ◆ The suggested size for gate posts is 150mm diameter H4 treated radiata pine, driven 1.5m into the ground.
- ◆ Gates should be metal, 4.25m wide and 1m high, with A grade galvanising and of a standard equivalent to “Hurricane” medium weight gates with cross corner bracing.
- ◆ The fastening for each gate should be a galvanised “G” latch and chain welded to the gate, or a similar arrangement.
- ◆ Galvanised “bolt through” type gudgeons are suggested.

11.4. BOARD FENCES

- ◆ Where the fences cross the race/canal, at an angle which is not part of a general fence line, board fences should be built. Posts should shall be 150mm half round. H4 treated radiata pine at 2.5m centres. 150 x 25mm radiata pine H3 treated rails should be attached to the posts using 100mm A grade galvanised flat head nails, driven on an angle to the post grain and staggered.

11.5. CONNECTION TO EXISTING FENCES

- ◆ Existing fences should be joined to the race/canal fence with strainer assemblies at a post in accordance with good fencing practice.
- ◆ Existing fences can be continued over crossings in their current form providing this is in the opinion of the principals’ representative a reasonable standard.

12.0 GUIDELINES FOR INSTALLATION OF UPVC AND MDPE PIPELINES

12.1. DESIGN CONSIDERATION

1. Where plastic pipes are selected the designer must consider:

- ◆ The use of straight or coiled pipes
- ◆ The jointing method
- ◆ The trench width (standard or narrow)
- ◆ Directional drilling – no trench installation

2. Plastic pipes are available either in coils or straight lengths depending upon pipe size and material selected.

Straight pipes are usually produced in 6m or 12m lengths and MDPE coils are currently available in sizes up to 125mm.

3. Open trench pipeline must allow for the jointing, cooling and snaking of the pipe. When using “normal” trench widths, this can mean greater inconvenience to traffic but allows flexibility to overcome unforeseen obstructions and also ensures the ability to bed and surround the pipe properly. Narrow trenching with PE has the considerable advantages of reduced reinstatement costs and less spoil to handle but not all subsoils are conducive to such a technique and proper laying, bedding and compaction is not always possible at the required depths of cover. Trenchless techniques such as directional drilling and impact moling can be used particularly well with PE systems.

11.1 LOADS ON PIPES

11.1.1 Soils and Traffic Loads

Loads are exerted on buried pipe due to:

- Soil Pressures
- Superimposed loads
- Traffic loads

For normal water supply systems, the minimum depths of burial (cover) stipulated in AS/NZ 2053 should be observed. Under these conditions and up to a maximum of 3 metres cover, soil and traffic loadings are of little significance and design calculation are not warranted. This applies to all classes of pipe.

For depth shallower than those recommended, traffic loading may be of significance.

At greater depths, soil loadings may control selection of pipe class. In these instances, lighter pipe classes may not be suitable and specific design calculations and/or special construction techniques may be required. Wet trench conditions may also require further investigation.

For design purposes, AS 2566 (Australian Standards 2566 plastics pipelaying design) sets out procedures to be adopted.

Special construction techniques can involve backfill stabilisation, load bearing overlay or slab protection. It should be noted that cover of less than 1.5 diameters may result in floatation of empty pipes under wet conditions. Low covers may also result in pipe “jacking” (lifting at vertically deflected joints) when pressurised.

As indicated previously, the major support in the installed pipeline is derived from the supporting soil and the attention of the designer is drawn to modifying the Type of standard compaction as the preferred method of increasing the load resistance of the pipeline.

The standard levels of compaction contained in AS/NZS2566 and the intended usage areas as follows:

a) Type 1

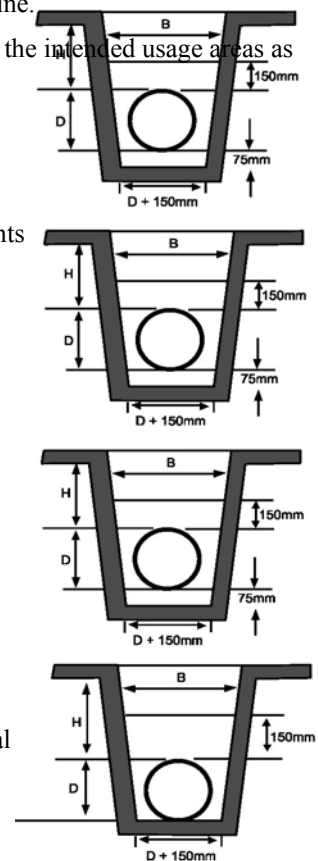
The highest level of compaction as used in the highway and road pavements and requires mechanical compaction techniques.

b) Type 2

The level of compaction attained by thorough hand tamping methods normally used in trench and embankment conditions for sewer and drain applications.

c) Type 3

The level of compaction attained where the sidefill is not compacted and side support arises from natural soil consolidation. Normally used in stormwater and pressure pipe applications where no additional external loads are encountered.



11.2 BELOW GROUND INSTALLATION

11.3.1 Preparing the Pipes

Before installation, each pipe and fitting should be inspected to see that it's bore is free from foreign matter and that its outside surface has no large scores or any other damage. Pipe ends should be checked to ensure that the spigots and sockets are free from damage.

Pipes of the required diameter and pressure rating should be identified and matched with their respective fittings and placed ready for installation.

11.3.2 Preparing the trench

HDPE pipe can be damaged or deformed if its support by the ground on which it is laid is not made as uniform as possible. The trench bottom should be examined for irregularities and any hard projections removed.

The minimum trench width should allow for adequate tamping of side support material and should be not less than 200mm greater than the diameter of the pipe. In very small diameter pipes this may be reduced to a trench width of twice the pipe diameter.

The maximum trench width should be as restricted as possible depending on the soil conditions. This is necessary for both economics and to develop side support.

Where wide trenches or embankments are encountered then the pipe should be installed on a 75mm layer of tamped or compacted bedding material as shown on the cross section diagrams.

Where possible a sub trench should be constructed at the base of the main trench to reduce soil loads developed.

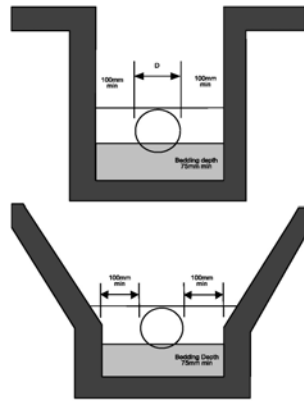
AS/NZS2566 provides full details for evaluating the loads developed under wide trench conditions.

Recommended Trench Widths

Size DN	Minimum (mm)	Maximum (mm)
100	320	800
125	340	825
150	360	825
175	400	875
200	425	900
225	450	925
300	515	1000
375	600	1200

Trench Widths

In general, the width of trenches should be kept to the minimum that enable construction to readily proceed.

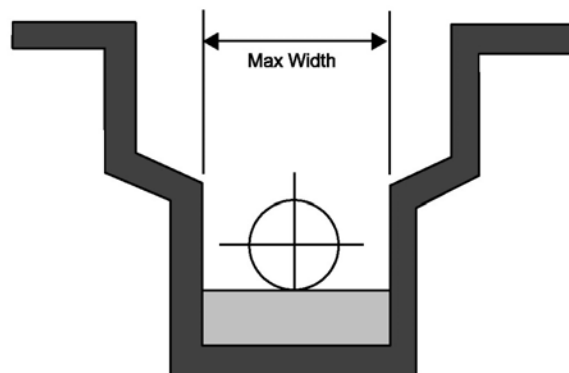


The width of trenches used with PE pipe may be reduced from those used with PVC by jointing above ground in the case of butt or electro fusion welding and then feeding the jointed pipe into the trench. Similarly, small diameter pipe in coil form can be welded or mechanically jointed above ground and then fed into the trench.

11.3.3 Wide Trenches

For deep trenches where significant soil loading may occur, the trench should not exceed the widths given in 11.3.2 without further investigation.

Alternatively the trench should be widened until stability is reached. At this point, a smaller trench may then be excavated in the bottom on the trench to accept the pipe. In either case do not exceed the maximum trench width at the top of the pipe unless allowance has been made for the increased load.



11.3.4 Trench Depths

The recommended minimum trench depth is determined by the loads imposed on the pipe such as the mass of backfill material, the anticipated traffic loads and any other superimposed loads. The depth of the trench should be sufficient to prevent damage to the pipe when the anticipated loads are imposed upon it.

11.3.5 Minimum Cover

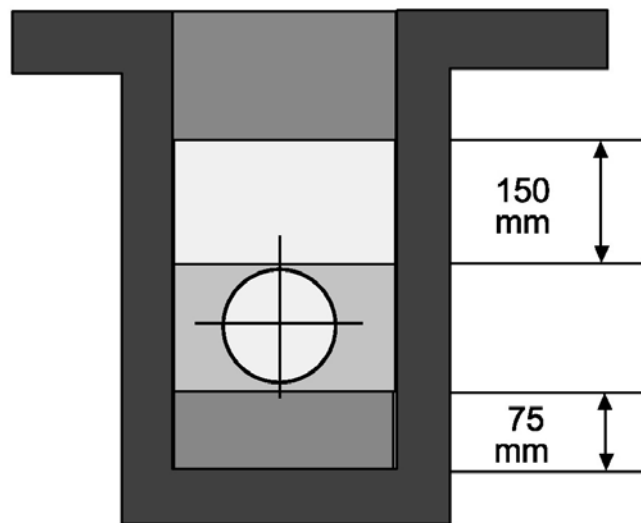
Trenches should be excavated to allow for the specified depth of bedding, the pipe diameter and the minimum recommend cover, overlay plus backfill, above the pipes. Table below provides recommendations for minimum cover to pipe crown.

Minimum Cover

Loading	Cover (mm)
Roads and streets	750
Driveways and similar areas subject to traffic	600
Footpaths, gardens	500
Construction Traffic	750

The above cover requirements will provide adequate protection for all pressure ratings of pipe. Where it is necessary to use lower covers, several options are available.

- Provide additional structural load bearing bridging over the trench. Temporary steel plates may be used in the case of construction loads.
- Use a high quality granular backfill e.g. crushed gravel or road base.
- Use a higher class of pipe then required for normal pressure or other considerations.



11.3.5 Bedding Material

Preferred bedding materials are listed in AS/NZS2566.1 and are as follows:

- Suitable sand, free from rock or other hard or sharp objects that would be retained on a 13.2mm sieve.
- Crushed rock or gravel evenly graded up to a maximum size of 20mm.

- The excavated material may provide a suitable pipe underlay if it is free from rock or hard matter and broken up so that it contains no soil lumps having any dimension greater than 40mm which would prevent adequate compaction of the bedding.

The suitability of a material depends on its compatibility. Granular materials (gravel or sand) containing little or no fines, or specification graded materials, requiring little or no compaction, are preferred.

Sands containing fines, and clays, are difficult to compact and should only be used where it can be demonstrated that appropriate compaction can be achieved.

Variations in the hard bed should never exceed 20% of the bedding depth. Absolute minimum underlay should be 50mm.

11.3.6 Pipe Side Support

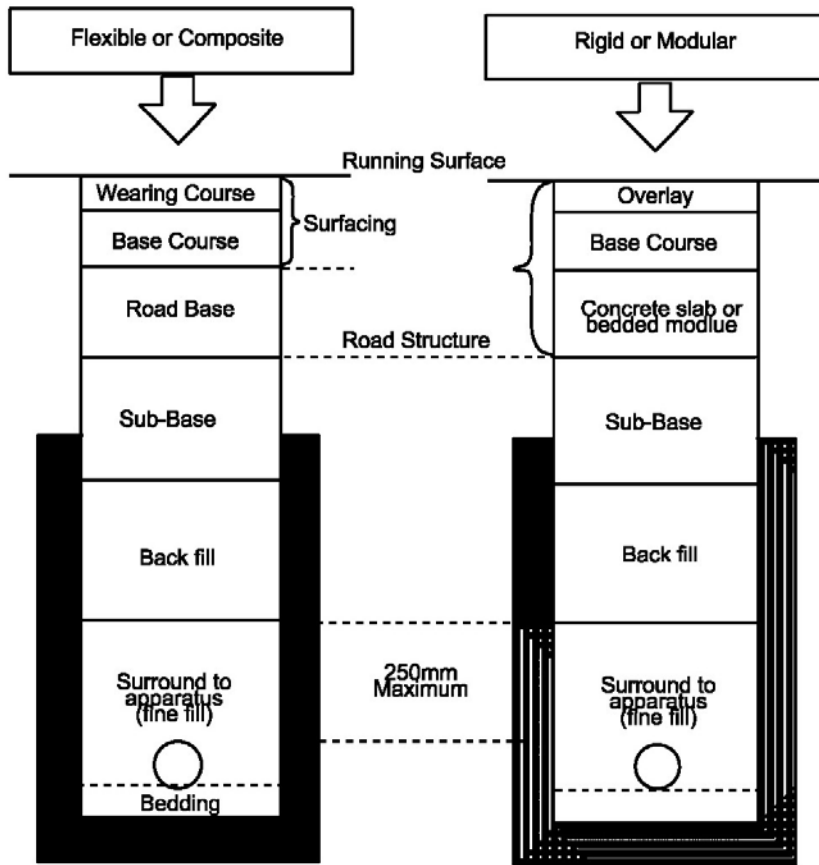
Material selected for pipe side support should be adequately tamped in layers of not more than 75mm for pipes up to 250mm diameter and 150mm for pipes of diameters 300mm and above. Care should be taken not to damage the exposed pipe and to tamp evenly on either side of the pipe to prevent pipe distortion. Care should also be taken not to disturb the line or grade of the pipeline, where this is critical, by excessive tamping.

Unless otherwise specified, the pipe side support and pipe overlay material used should be identical with the pipe bedding material.

Compaction should be brought evenly to the design value required by AS/NZS2566 for the specification installation.

11.3.7 Backfill

Unless otherwise specified, excavated material from the site should constitute the back fill. Gravel and sand can be compacted by vibratory methods and clays by tamping. This is best achieved when the soils are wet. If water flooding is used and extra soil has to be added to the original backfill, this should be done only when the flooded backfill is firm enough to walk on. When flooding the trench, care should be taken not to float the pipe, or wash fines into rear joints. All ground should be compacted back to 91 – 95%. The loads arise from two sources; the static or pressure force and the kinetic or velocity force.



Trench Reinstatement Zone Terminology

11.4 THRUST SUPPORT

An imbalanced thrust is developed by a pipeline at:

- Direction changes ($>10^\circ$), e.g. tees and bends
- Changes in pipeline size at reducers.
- Pipeline terminations, e.g. at blank ends and valves.

The support system or soil must be capable of sustaining such thrusts.

Pressure thrust results from internal pressure in the line acting on fittings. Velocity thrust results from inertial forces developed by a change in direction or flow. The latter is usually insignificant compared to the former.

11.4.1 Anchorage and Thrust Blocks MDPE

- One of the fundamental features of fully integrated Butt welding PE pipe systems is that they are end-load resistant and anchorage is not normally required at junctions or bends.
- However, for push-fit systems or where individual non end-load resistant fittings are used, anchor blocks to withstand the resultant thrusts must be provided in the traditional manner. For pipes greater than 63mm, the use of concrete anchor blocks should be specified.

11.4.2 Anchorage and Thrust Blocks PVC

Underground PVC pipelines jointed with rubber ring joints require concrete thrust blocks to prevent movement of the pipeline when a pressure load is applied. In some circumstances, thrust support may also be advisable in solvent cement jointed systems. Uneven thrust will be present at most fittings. The thrust blocks transfers the load from the fitting, around which it is placed, to the larger bearing surface of the solid trench wall.

11.4.3 Anchorage at Fittings

It is advisable to rigidly clamp at valves and other fittings located at or near sharp directional changes, particularly when the line is subjected to wide temperature variations. Fittings should be supported individually and valves should be braced against operating torque.

Pressure Thrust

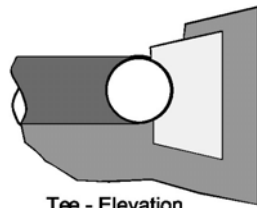
The pressure thrust developed for various types of fittings can be calculated as follows:

Blank ends, tees, valves	$F = A P 10^3$
Reducers and tapers	$F = (A^1 - A^2) P 10^3$
Bends	$F = 2 A P \sin (O/2) 10^3$

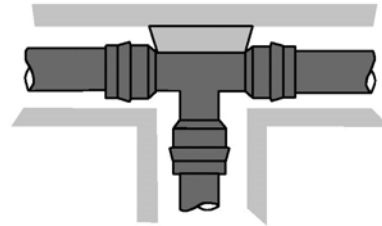
Where:

F = Resultant thrust force	(Kn)
A = Area of pipe taken at the OD	mm
P = Design internal pressure	(MPa)
O = Included angle of bend	(degrees)

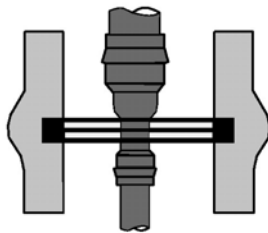
The design pressure used should be the maximum pressure, including water hammer, to be applied to the line. This will usually be the field test pressure.



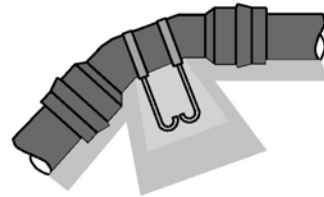
Tee - Elevation



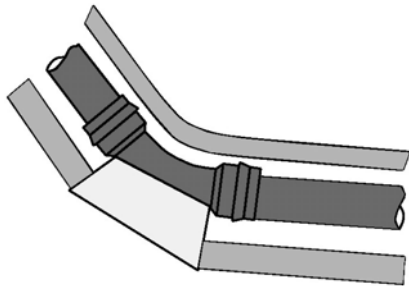
Tee - Plan



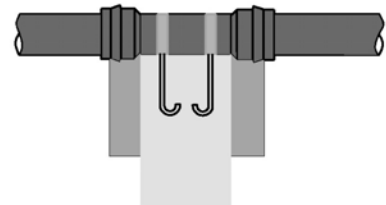
Reducer - Plan



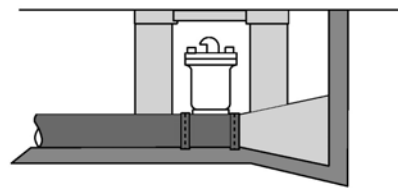
Vertical Bend - Elevation



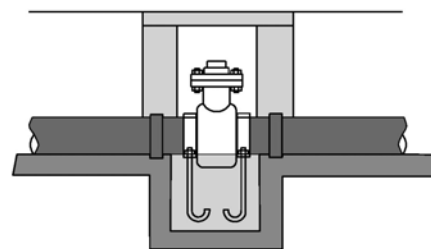
Horizontal Bend - Plan



Blank End- Elevation



Hydrant at end of line - Elevation



Valve - Elevation

Pressure Thrust at Fittings in kN for Each 10 Meters Head of Water

Size DN	AREA (mm ²)	BENDS				TEES ENDS
		11Qr°	22 Qw°	45°	90°	
15	363	.01	.01	.03	.05	.04
20	568	.01	.02	.04	.08	.06
25	892	.02	.03	.07	.12	.09
32	1410	.03	.05	.11	.20	.14
40	1840	.04	.07	.14	.26	.18
50	2870	.06	.11	.22	.40	.28
65	4480	.09	.17	.34	.62	.44
80	6240	.12	.24	.47	.87	.61
100	6240	.20	.39	.77	1.43	1.01
125	10300	.30	.59	1.16	2.15	1.52
150	20200	.39	.77	1.52	2.80	1.98
200	40000	.77	1.53	3.00	5.55	3.92
225	49400	.95	1.89	3.71	6.85	4.84
250	61900	1.19	2.37	4.65	8.58	6.07
300	78400	1.51	3.00	5.88	10.87	7.69
375	126000	2.42	4.82	9.46	17.47	12.36

11.4.4 Construction of Thrust Blocks

Concrete should be placed around the fitting in a wedge shape with its widest part against the solid trench wall. Some forming may be necessary to achieve an adequate bearing area with a minimum of concrete. The concrete mix should be allowed to cure for seven days before pressurisation. A thrust block should bear firmly against the side of the trench and to achieve this, it may be necessary to hand trim the trench side or hand excavate the trench wall to form a recess. The thrust acts through the centre line of the fitting and the thrust block should be constructed symmetrically about this centre line.

Pipes and fittings should be covered with a protective membrane of PVC, polyethylene or felt when adjacent to concrete so that they can move without being damaged.

The designer should consider all aspects of the system, including the unbalanced loads imposed by testing procedures, unusual configurations, large temperature variations, etc and where excessive load on the pipe system is envisaged, additional anchorage should be considered. To establish thrust block size establish the pressure to be applied to the line, calculate thrust developed consider the safe bearing capacity of the soil type using one 3 x safety factor.

In shallow (<600mm) cover, installations or in unstable conditions of fill, the soil support may be considerably reduced and a complete soil analysis may be needed.

The velocity thrust is generally small in comparison to the pressure thrust.

The pressure used in the calculations should be the maximum working or test pressure applied to the line.

Where pipes are installed on steep slopes (greater than 1.5) then bulkheads may need to be placed along the pipeline to prevent movement of the pipes, these can be placed at such support points as flange locations. Additional supports, such as sand bags, may be required to prevent scouring of bedding and backfill materials down the trench floor.

11.4.5 Bearing Loads of Soils

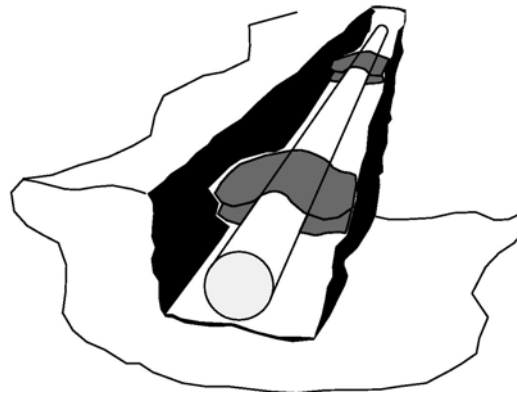
The indicative capacities of various soil types are tabulated below:

SOIL TYPE	Safe Bearing Capacity (Newtons per square metre)
Rock and sandstone (hard thick layers)	100 x 10 ⁵
Rock – solid shale and hard medium layers	90 x 10 ⁴
Rock – poor shale, poor limestone, ect	24 x 10 ⁴
Gravel and coarse sand (mixed)	20 x 10 ⁴
Sand – Compacted, firm, dry	15 x 10 ⁴
Clay – hard, dry	15 x 10 ⁴
Clay – readily indented by thumb but penetrated with difficulty	12 x 10 ⁴
Clay – easily penetrated several inches by thumb, sand loam	9 x 10 ⁴
Peat, wet alluvial soils, silt, etc	nil

11.5 PIPELINES ON STEEP SLOPES

Two problems can occur when pipes are installed on steep slopes, i.e. slopes steeper than 20% (1:5).

- 1) The pipes may slide downhill so that the witness mark positioning is lost. It may be necessary to support each pipe with some cover during construction to prevent the pipe sliding.
- 2) The generally coarse backfill around the pipe may be scoured out by water movement in the backfill. Clay stops or sandbags should be placed in appropriate intervals above and below the pipe to stop erosion of the backfill.



11.6 PIPELINE BUOYANCY

Pipe under wet conditions can become buoyant in the trench. HDPE pipes, being lighter than most pipe materials should be covered with sufficient overlay and backfill material to prevent inadvertent flotation and movement. A depth of cover over the pipe of 1.5 times the diameter is usually adequate.

11.7 EXPANSION JOINTS

For above ground installations with solvent cement joints provision should be made in the pipeline for expansion and contraction. If the ends are constrained and there is likely to be significant thermal variation, then a rubber ring joint should be installed at least every 12m to allow for movement within the pipeline, or such spacing as determined by calculation.

11.8 PIPELINE DETECTION

HDPE pipes are electrically non-conductive and cannot be detected by metallic detection devices in underground installations.

Several techniques are available to detect buried pipelines.

11.8.1 Metal Detector Tapes

Foil based tapes may be located in the trench on top of the pipe overlay material (150 – 300mm above the pipe crown), these tapes can be detected at depths up to 600mm by metal detection equipment operating in the 4-20MHz frequency range.

The tape backs may also be colour coded and printed in order to provide early warning of the presence of the pipeline during later excavation.

11.8.2 Tracer Wires

Pipes installed deeper than 600mm may be detected by the use of tracer wires placed on, or taped to, the top of the pipes.

Application of a suppressed current allows the detection of pipes up to a depth of three metres.

However, both ends of the tracer wire must be accessible, and a complete electrical circuit present over the entire length of the pipeline.

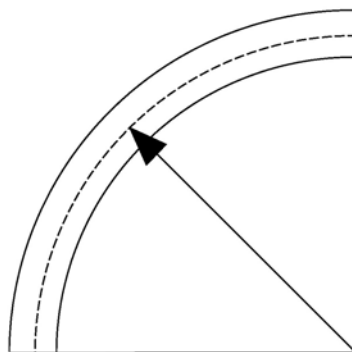
11.8.3 Audio Detection

Acoustic, or ultrasonic, noise detection devices are available which use either the noise from water flowing in the pipes, or an introduced noise signal, to detect the presence of buried pipelines.

11.8.4 BENDS AND BENDING

11.9.1 Bending MDPE Pipes

1. The bending of PE pipe is permissible and the properties of fusion jointed systems enable changes of direction without recourse to the provision of special bends or anchor blocks. However, for PE materials the pipe should not normally be cold bent to a radius less than 20 times the outside diameter of the pipe. No joints or tappings should occur on the bend.



2. Full ranges of standard preformed bends are available and are preferable for the larger sizes. Special configurations are similarly available upon request.

11.9.2 Bending PVC Pipes

When installing PVC pipes on a curve, the pipe should be jointed straight and then laid to the curve.

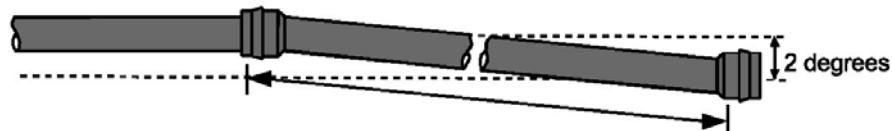
Significant bending moments should not be exerted on the joints, since this introduces undesirable stresses in the spigot and socket that may be detrimental to long term performance. To avoid this, the joints in curved lines must be thoroughly supported by compacted soil, with the bending occurring primarily at the centre of each pipe.

Some changes in the alignment of the pipe may be achieved without the use of direction-change fittings such as elbows and sweeps. PVC pipe is capable of controlled longitudinal bending within acceptable limits. A combination of axial flexure and joint deflection can achieve further longitudinal deviation of the pipeline. As a guide, PVC pipe can be bent to a radius equal to 130 times the diameter. However, AIC recommends that pipe under pressure should be bent to a radius not less than 300 times the diameter, e.g. a 100mm pipe should have a minimum radius of curvature of 30 meters.

11.9.3 Joint Deflection

PVC Solvent cement joints have no flexibility but rubber ring joints can provide some joint deflection. The allowable deflection at the pipe Z socket should not be greater than a deflection of 2°.

Angular deflection of a single pipe joint (shown exaggerated for clarity)



Flexural Stress

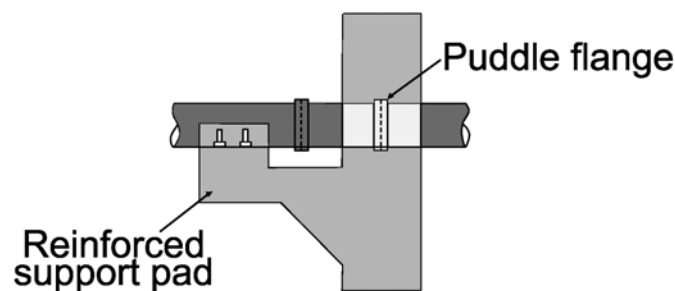
One critical limit to the bending of PVC pipe is long term flexural stress. Axial bending causes only a small amount of ovalisation or diametric deflection of the pipe, which indicates some change in circumferential stress. PVC pipe has short term strengths of 48 – 55 MPa in tension and 75 – 100 MPa in flexure. The long term strength of PVC pipe in tension, compression or flexure can conservatively be assumed to equal the ultimate hydrostatic design stress of 11.0 MPa for PVC pipe at 20°C be used for the allowable long term flexural stress in rubber ring pipe that is free of longitudinal stress from longitudinal pressure thrust. However, when the joints are restrained as they are when solvent cemented, and the pipe is not snaked in the trench, then the end thrust from internal pressure imposes a longitudinal tensile strength equal to one half of the hoop stress.

11.10 CONCRETE ENCASEMENT

11.10.1 Pipe Entry Into Structures

- 1) Wherever pipe work meets or passes through rigid structures, careful consideration should be given to:
 - The need to affect a water tight seal at the pipe/structure interface;
 - The extent to which the structure itself is required to withstand forces transmitted from the pipe;
 - Where there is rigid connection between pipe and structure, whether the adaptation of standard fittings influence the degree to which compressive, tensile, bending and shear forces are generated;
 - Where differential settlement may occur, the extent to which the pipe and fittings flexibility can normally be relied upon to withstand the bending and shear stresses set up;
 - An annular space of not less than 6mm should be left around the pipe or fitting. This clearance should be maintained and sealed with a flexible sealant such as loosely packed felt, a rubber convolute sleeve or other suitable flexible sealing material.
 - If the pipeline has to pass through a fire rated wall, advice on suitable fire stop methods is available from our product manager.

- 2) Where pipe is to be connected by a flange to a large rigid structure, localised movement and bending at the flange can be prevented by a reinforced support pad as shown below. This pad should extend one pipe diameter or a minimum of 300mm from the flanged joint. The strapping should be provided with a compressible protection to the pipe.



Flanged entry into a large rigid structure

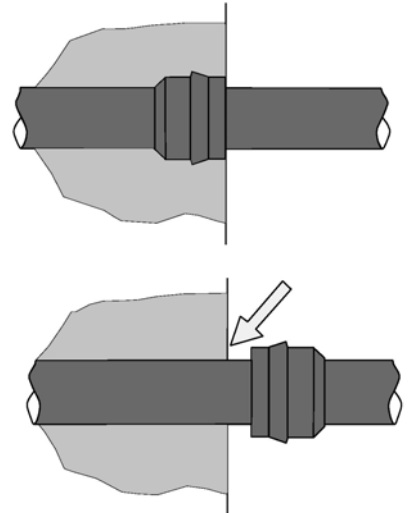
- 3) Although the flexibility and toughness of PE is advantageous in these situations it is recommended that before filling:
 - All bolts should have a check retightening before final backfill;
 - Particular attention is paid to the compaction around and several diameters beyond, all fittings associated with the connection. Compaction to 90% Proctor density or greater in these areas should be ensured.

- 4) These points of detail are important since these connections are often deep and sometimes associated with under drainage, (e.g. outlets to reservoirs). This usually means any subsequent defect is difficult to identify, expensive to locate and very costly to remedy.

11.10.2 Setting of Pipes in Concrete

When PVC pipes are encased in concrete, certain precautions should be taken:

- 1) Pipes should be fully wrapped with a compressible material such as felt or poly film.
- 2) Alternatively, flexible (rubber ring) joints should be provided at entry to and exit from the concrete as shown. This procedure also allows for possible differential movement between the pipeline and concrete structure. It must be borne in mind, however, that without a compressible membrane stress transfer to the concrete will occur and may damage the concrete section.
- 3) Expansion joints coinciding with concrete expansion joints should be provided to accommodate movement due to thermal expansion or contraction in the concrete.



PE pipes behave as flexible structure when externally loaded, and care needs to be exercised by the designer when using concrete encasement so that the effective strength of the pipeline is not reduced.

11.11 ABOVE GROUND INSTALLATION

Pipes may be stored above ground for pressure and non pressure application in both direct exposure and protected conditions.

Black PE pipes made to AS/NZS 4130 requirements may be used in direct sunlight exposure conditions without any additional protection. Where MDPE pipes of colours other than black are used in exposed conditions, then the pipes may need to be protected from sunlight. PVC pipes all have 1.5PHR of Titanium Dioxide to act as a UV absorber. Localised temperature build up conditions such as proximity to steam lines, radiators or exhaust stacks must be avoided unless the pipes are suitably protected. Where lagging materials are used, these must be suitable for external exposure applications.

11.11.2 Support Spacing

The spacing of supports for a u PVC pipeline depends on factors such as the diameter of the pipe, the density of the fluid being conveyed and the maximum temperature likely to be reached by the pipe material. The table below shows the support spacing in metres for u PVC pipe carrying water at 20°C. These spacings do not allow for additional extraneous loading.

Recommended Support Spacing

– for PVC pipes

Maximum support Spacing

SIZE	Horizontal (m)	Vertical (m)
15	0.60	1.20
20	0.70	1.40
25	0.75	1.50
32	0.85	1.70
40	0.90	1.80
50	1.05	2.10
65	1.20	2.40
80	1.35	2.70
100	1.50	3.00
125	1.70	3.40
150	2.00	4.00
175	2.20	4.40
200	2.30	4.60
225	2.50	5.00
300	3.00	6.00

- For MDPE pipes

Nominal Pipe OD (mm)	Maximum Recommended Spacing (m)
16	0.25
20	0.30
25	0.35
32	0.38
40	0.43
50	0.45
63	0.50
75	0.60
90	0.67
125	0.75
140	0.85
160	1.00
200	1.10
225	1.15
250	1.25
280	1.30
355	1.50

If temperatures are in excess of 20°C the horizontal spacing should be reduced by 25% for every 10°C. At 60°C, continuous horizontal support is required.

11.11.3 Vertical Installation

Generally, vertical runs are supported by spring hangers and guided with rings or long U-bolts which restrict movement of the rise to one plane. It is sometimes helpful to support a long riser with a saddle at the bottom.

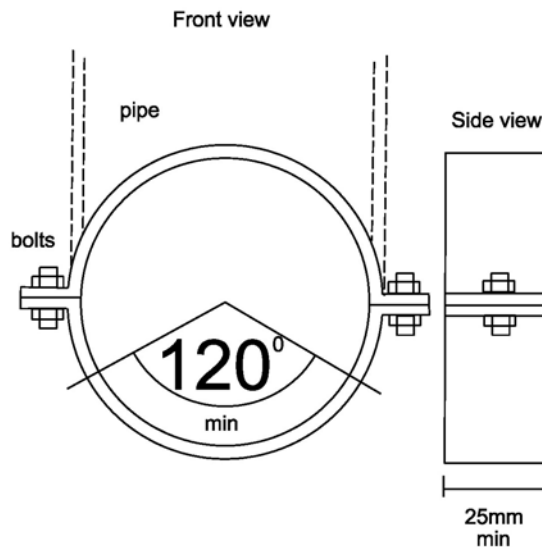
11.11.4 Brackets and Clips

For either free or fixed pipelines supports using brackets or clips, the bearing surface should provide continuous support for at least 120° of the circumference.

Straps

Metal straps used as supports should be at least 25mm wide, either plastic coated or wrapped in a protective material such as nylon, PE, PVC or rubber sheet. If a strap is fastened around a pipe, it should not distort the pipe in any way.

Location and type of support must take into account provision for thermal movement, if required. If the supports are to resist thermal movement, an assessment of the stress induced in pipes, fittings and supports may need to be made.



Free Support

A free support allows the pipe to move without restraint along its axis while still being supported. To prevent the support from scuffing or damaging the pipe as it expands and contracts, a 6mm thick layer of felt or lagging material is wrapped around the support. Alternatively, swinging type of support can be used and the support strap, protected with felt or lagging, must be securely fixed to the pipe.

Fixed Support

A fixed support rigidly connects the pipeline to a structure totally restricting movement in at least two planes of direction. Such a support can be used to absorb moments and thrusts.

Placement of Support

Careful consideration should be given to the layout of piping and its support system. Even for non pressure lines the effects of thermal expansion and contraction have to be taken into account. In particular, the layout should ensure that thermal and other movements do not induce significant bending moments at rigid connections to fixed equipment or at bends or tees.

For solvent cement jointed pipe any expansion coupling must be securely clamped with a fixed support. Other pipe clamps should allow for movement due to expansion and contraction. Rubber ring jointed pipe should have fixed supports behind each pipe socket.

11.12 INSTALLATION CONSIDERATIONS

11.12.2 Expansion and Contraction

Pipe will expand or contract if it is installed during very hot or very cold weather, so it is recommended that the final pipe connections be made when the temperature of the pipe is stabilized at a temperature close to that of the backfill trench.

Will MDPE lines laid directly on the natural surface by snaking the pipe during installation and

allowing the pipe to move freely in service. Where the final joint connections are made in high ambient temperature, sufficient pipe length must be allowed to permit the pipe to cool, and hence contract, without pulling out of non end load bearing joints.

For solvent cemented systems, the lines should be free to move until a strong bond has been developed (see solvent cement jointing procedures) and installation procedure should ensure that contraction does not impose strain on newly made joints.

For rubber ring jointed pipes, if contraction accumulates over several lengths, pull out of a joint can occur. To avoid this possibility the preferred technique is to back fill each length, at least partially, as laying proceeds. (It may be required to leave joints exposed for test and inspection.)

It should be noted that rubber ring joint design allows for contraction to occur. Provided joints are made to the witness mark in the first instance, and contraction is taken up approx. evenly at each joint, there is no danger of loss of seal. A gap between witness mark and socket of up to 10mm after contraction is quite acceptable.

Further contraction may be observed on pressurisation of the line (so-called Poisson contraction due to circumferential strain). Again this is anticipated in joint design and quite in order.

11.12.3 Heat sources

Pipes and fittings should be protected from external heat sources which would bring the continuous pipe material service temperature above 60°C.

Where the pipe are installed above ground, the protection system used must be resistant to ultra violet radiation and the effects of weathering, pipes running across roofing should be supported above the roof sheeting in order to prevent temperature build up.

11.12.4 Vibration

Direct connection to sources of high frequency such as pump outlet flanges should be avoided. All fabricated fittings manufactured by cutting and welding techniques must be isolated from vibration. Where high frequency vibration sources exist in the pipeline, the sections should be connected using a flexible joint such as a repair coupling, expansion joint, or wire reinforced rubber bellow joint. When used above ground such joints may need to be restrained to prevent pipe end pullout.

11.12.4 Conductivity

HDPE pipes are non-conductive and cannot be used for electrical earthing purposes or dissipating static electricity charges.

When pipes are used to replace existing metal water pipes, the designer must consider any existing systems used for earthing. In these cases the appropriate electrician must be consulted to determine the requirements.

11.12.5 Fire Rating

HDPE pipe systems will support combustion and as such are not suitable for used in fire rated zones in buildings without suitable protection.

11.12.6 Ploughing In

MDPE pipe may be ploughed directly into the ground. The pipe must be stationary in relation to the surrounding soil and care must be taken to ensure that the pipe is not excessively tensioned during the ploughing activities.

Ploughing should not be attempted where the soil contains rock or sharp stones or shale outcrops.

11.13 TRENCHLESS INSTALLATION

Plastic pipes are a versatile material and particularly through their toughness and flexibility they are able to be used with a range of cost effective “no dig” methods for ht pressure pipelines installation.

In particular:

- Guided drilling – directional drilling
- Pipe cracking
- Close – fit lining – Slip lining.