Assets Planning and Delivery Group
Engineering

DESIGN STANDARD DS 60

Water Supply Distribution Standard
Pipelines Other than Reticulation

VERSION 5
REVISION 3

DECEMBER 2021

FOREWORD

The intent of Design Standards is to specify requirements that assure effective design and delivery of fit for purpose Water Corporation infrastructure assets for best whole-of-life value with least risk to Corporation service standards and safety. Design standards are also intended to promote uniformity of approach by asset designers, drafters and constructors to the design, construction, commissioning and delivery of water infrastructure and to the compatibility of new infrastructure with existing like infrastructure.

Design Standards draw on the asset design, management and field operational experience gained and documented by the Corporation and by the water industry generally over time. They are intended for application by Corporation staff, designers, constructors and land developers to the planning, design, construction and commissioning of Corporation infrastructure including water services provided by land developers for takeover by the Corporation.

Nothing in this Design Standard diminishes the responsibility of designers and constructors for applying the requirements of WA OSH Regulations 1996 (Division 12, Construction Industry – consultation on hazards and safety management) to the delivery of Corporation assets. Information on these statutory requirements may be viewed at the following web site location:

https://www.legislation.wa.gov.au/legislation/statutes.nsf/law_s4665.html

Enquiries relating to the technical content of a Design Standard should be directed to the Senior Principal Engineer, Water Conveyance Advisory Section, Engineering. Future Design Standard changes, if any, will be issued to registered Design Standard users as and when published.

Head of Engineering

This document is prepared without the assumption of a duty of care by the Water Corporation. The document is not intended to be nor should it be relied on as a substitute for professional engineering design expertise or any other professional advice.

Users should use and reference the current version of this document.

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Any interpretation of anything in the Standards/Specifications that deviates from specific Water Corporation Project requirements must be referred to, and resolved by, reference to and for determination by the Water Corporation's project manager and/or designer for that particular Project.

Revision Status

The revision status of this standard is shown section by section below:

REVISION STATUS						
SECT.	VER/ REV	DATE	PAGES REVISED	REVISION DESCRIPTION (Section, Clause, Sub-Clause)	RVWD	APRV
1	5/3	13/12/21	11-15	1.3: Philosophy of Design section added 1.6: Reference document list updated	PV	JD

2	5/2	07/09/18	23-24, 31	2.11.1 and 2.11.2 Added restrictions on the acceptability of PE pipe and fittings 2.11.6 deleted 2.13.1 Added guidelines for use of ZnAl DI	AA	JD
	5/3	13/12/21	18-25 27-30	2.4: Design pressure section added 2.4.2: System MAOP section added 2.4.3: System Test Pressure section added 2.4.4: Anchorage pressure capacity section added 2.4.5: Plastic pipeline pressure class selection section added to consolidate into a single section various plastic specific consideration required when determining plastic pipe pressure ratings 2.4.5.1: Overview section added 2.4.5.2: Fatigue assessment section relocated here 2.4.5.3: Temperature de-rating section relocated here 2.4.5.4: Oxidation section added 2.4.5.5: Long Term PVC Degeneration De-rating section added 2.4.6: Installation method de-rating section added 2.4.7: Example section added 2.5: Design for transient pressure section relocated 2.6: Transition between restraint and unrestrained pipeline component section amended 2.7: PVC section: acceptable PVC pipe sizes and PN rating amended 2.7.7: Considerations in PVC application section amended 2.8: PE section: amended to incorporation update bulletin 20-01	PV	JD

				2.9: MSCL section: Added Convex banded joint pressure ratings and updated Sintalock size ranges		

3	**5/2**	**07/09/18**	**37-39, 41**	**3.6.1 Added requirement to design crossings for replacement or relining** **Table 3.2, HDD added further expectations for the preliminary design of HDD, and** **Table 3.3 Revised limits on shallow HDD under roads**	**AA**	**JD**
	5/3	**13/12/21**	**39-41, 43, 45 – 46, 60-61, 65**	**3.3: Made requirements for under MRWA roads more clear** **3.4.2: Resolved ambiguity for pipes less than DN300 and DN300 to DN400.** **3.6: Retitled to Trenchless Crossings** **3.6.3: Clarified requirements for non-metallic spacers and end capping of un-grouted sleeves** **3.6.5: Clarified Maximum diameter of bore/cutter/reamer** **3.6.9: Retitled Water Crossings and specified minimum annual probability of exceedances for flood levels** **3.13.5.3: Limited use of bollards in road clear zones.** **3.13.6.4: Clarified requirement and use of double isolation valves for scours**	**PV**	**JD**

4	**5/3**	**13/12/21**		**No Change**	**PV**	**JD**

DESIGN STANDARD DS 60

Water Supply Distribution – Pipelines Other Than Reticulation

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1 GENERAL

1.1 Purpose

This design standard is intended to provide guidelines for the design and construction of pipelines to be taken over or operated by the Water Corporation.

The requirements are based on operation, safety, maintenance, water quality, durability and value for money considerations.

The Corporation's regions may have additional or specific requirements for their pipelines. These need to be identified on a case by case basis.

This part of the Standard shall be read in conjunction with the Water Supply Distribution – Pipelines other than reticulation - Drawings.

1.2 Scope

This design standard addresses issues for drinking water conveyance pipelines as referred to below:

a) Distribution Main – a pipeline which is a feeder to a reticulation network (normally DN 300 and larger, however smaller distribution mains may be applicable for small towns);

b) Outlet Main – an outlet from a storage that generally supplies distribution mains;

c) Supply Main – a pipeline generally smaller than DN 700 that supplies water from a source;

d) Trunk Main – a pipeline, normally DN 500 or larger, that supplies water generally from a major source to a major storage;

e) Rising or Pumping Main – a pipeline used essentially as a pump delivery line to another system or storage;

f) Transfer Main – a pipeline used to transfer water from one system, source or storage to another.

This design standard is not applicable to the following:

a) Pipelines that are not normally full and pressurised, for example pumped mains that drain and refill during normal operations, drainage or irrigation pipelines;

b) Pipelines which have standard water services connected. For requirements on subdivision reticulation pipelines of DN 250 and smaller refer to the Corporation's Water Reticulation Standard - DS 63;

c) Rural Water Strategy or similar low budget pipelines which provide non-standard levels of service;

d) Pipelines within Water Treatment Plants.

This design standard has limited application to bore collector mains, which have additional considerations for issues such as pigging the mains, for preventing air entrainment or allowing air release after pump startup.

1.3 Philosophy of Design

Designs must not only comply with the requirements explicitly identified in this Standard, they must also conform with the Corporation's design philosophy.

For a design to be deemed compliant, it must comply with the following tenets:

a) prioritise safety.

b) prioritise whole-of-life costs of the asset over just initial construction costs.

c) be accessible and conducive to operational and maintenance activities.

d) yield assets that the people of Western Australia can rely upon for a dependable supply of water and sanitation services.

e) enhance social and environmental benefits as much as practical.

f) consider potential future requirements and make reasonable allowances for them.

g) maximise time to failure and/or replacement. and

h) minimise maintenance.

Where there is any significant conflict between these tenets that meaningfully influences the design outcome, then advice shall be sought from the Water Corporation Design Manager or Standard Custodian.

1.4 Occupation Safety and Health

Legislation compels employers and employees to follow safe practices regarding health and safety in the workplace. Accordingly, all assets shall be designed to facilitate safe operational and maintenance practices.

Prior to 1985 bitumen tape wrap pipe system had been used. As some of these pipe wrapping materials have been found to contain asbestos fibres (hazardous material), all procedure regarding the removal, handling and disposal of pipe coatings containing asbestos shall be in accordance with the relevant Water Corporation OSH Procedures and the Code of Practice for the management and Control of Asbestos in Workplaces.

The Corporations Safety in Design (SID) process as outlined in the Engineering Design Process and the Corporations OHS procedures, policies and requirements are in addition to any requirements noted in this design standard.

1.5 Engineering Design Process

The Corporation's Engineering Design Manual shall be used in the design of Water Corporation's engineering assets. The manual describes the roles of the Corporation's Design Manager and Designer in the design process and provides or references:

a) Design process guidance notes

b) Templates for process documents and design outputs

Any submission of design work to the Water Corporation shall be carried out and delivered in accordance with the current Engineering Design Manual as agreed with the Water Corporation's design representative. Design work shall not be delegated to equipment suppliers or other contractors. For issue of Engineering Design Manual and associated documents email request to Engineering.StandardsEnquiries@watercorporation.com.au

1.6 Reference Documents

AS

AS 1210........................ Pressure vessels

AS 1281........................ Cement mortar lining of steel pipes and fittings

AS 1579........................ Arc-welded steel pipes and fittings for water and waste-water

AS 1646........................ Elastomeric seals for waterworks purposes

AS 2129........................ Flanges for pipes, valves and fittings

AS 3996........................ Access covers and grates

AS 4041........................ Pressure piping

AS 4321........................ Fusion-bonded medium-density polyethylene coating and lining for pipes and fittings

AS 4799........................ Installation of underground utility services and pipelines within railway boundaries

AS/NZS

AS/NZS 1365............... Tolerances for flat-rolled steel products

AS/NZS 2280............... Ductile iron pipes and fittings

AS/NZS 2566.1............ Buried flexible pipelines - Structural design

AS/NZS 2566.2............ Buried flexible pipelines - Installation

AS/NZS 4020............... Testing of products for use in contact with drinking water

AS/NZS 4087............... Metallic flanges for waterworks purposes

AS/NZS 4130............... Polyethylene (PE) pipes for pressure applications

AS/NZS 4158............... Thermal-bonded polymeric coatings on valves and fittings for water industry purposes

AS/NZS 4331.1............ Metallic flanges - Steel flanges

AS/NZS 4331.2............ Metallic flanges - Cast iron flanges

AS/NZS 4331.3............ Metallic flanges - Copper alloy and composite flanges

AS/NZS 4765............... Modified PVC (PVC-M) pipes for pressure applications

AS/NZS 4998............... Bolted unrestrained mechanical coupling for waterworks purposes

Water Corporation Documents

DS23............................. Pipeline AC interference and substation earthing

DS38-02 .... Flanged connections

DS62............................. Site Security Treatments

DS63............................. Water reticulation pipelines DN 250 and smaller

DS65............................. Pipe fittings standard drawings

DS95............................. Standard for the selection, preparation, application, inspection and testing of protective coatings on water corporation assets. Includes B1 - Inorganic Zinc Silicate Coating on Steel or Cast Iron and M8 - Cement Mortar Lining Requirement.

SPS 100........................ Steel pipe for waterworks purposes

SPS 106........................ Ductile Iron Pipe Fittings for Pressure Applications

SPS 116........................ Modified Polyvinylchloride – PVC-M – Pipe for Pressure Applications

SPS 125 .... Polyethylene and Polypropylene Pipe and Pipe Fittings

WS-1 .... Welding specification metal arc welding

WS-2 .... Welding joining specification thermoplastics

S151.............................. Prevention of falls

PIPA (Plastics Industry Pipe Association of Australia)

PIPA Guideline POP006 .... Derating requirements for fittings

PIPA Guideline POP007 .... Metal Backing Flanges For Use with Polyethylene (PE) Pipe Flange Adaptors

PIPA Guideline POP010A .... Part 1: Polyethylene pressure pipes design for dynamic stresses

PIPA Guideline POP010B.......... Part 2: Fusion fittings for use with polyethylene pressure pipes design for dynamic stresses

PIPA Guideline POP016 .... High stress crack resistant PE100

PIPA Guideline POP101 .... PVC Pressure pipes design for dynamic stresses

Other References

- Austroads Bridge Design Specification
- Criteria for regulated water supply (August 2004)
- Engineering Design Process Manual
- Utility Providers Code of Practice for Western Australia
- American Water Works Association M11 Steel Pipe: A Guide for Design and Installation
- MRWA Functional Road Hierarchy
- DIN PAS 1075 Pipes made from polyethylene for alternative installation techniques – dimension, technical requirements and testing

1.7 Definitions and Abbreviations

Standard Drawing: .... A drawing that shows exactly how to construct something. No changes should be made.

Example Drawing: .... Shows a preferred arrangement. Minimum design requirements are shown. The suitability of the example requires checking and modifying for the site specific application.

AHBP .... Allowable Horizontal Bearing Pressure

AOP....................................... Allowable Operation Pressure

ARI.. Average Recurrence Interval

CP.. Cathodic Protection

CSE.. Confined Space Entry

DAV .... Double Air Valve

DCVG .... Direct Current Voltage Gradient

DI... Ductile Iron

DN .... Nominal Diameter

EPDM.................................... Ethylene Propylene Diene Monomer is a type of synthetic rubber used in seals.

ESJ.. Elastomeric Seal Joint

FEA .... Finite Element Analysis

FRP... Fibre Reinforced Polymer

FSL .... Finished Surface Level

GRP .... Glass fibre Reinforced Polymer

IZS .... Inorganic Zinc Silicate

MAOP .... Maximum Allowable Operating Pressure

M-PVC .... Modified Polyvinyl Chloride

MRWA.................................. Main Roads Western Australia

MSCL.................................... Mild Steel Cement Lined

NBR.. Acrylonitrile Butadiene Rubber is a type of synthetic rubber used in seals.

O-PVC................................... Oriented Polyvinyl Chloride

PE .... Polyethylene

PIPA .... The Plastics Industry Pipe Association of Australia

PN.. Nominal Pressure

PoF .... Prevention of Falls

PRV .... Pressure Reducing Valve

PSV... Pressure Sustaining Valve

RRJ .... Rubber Ring Joint

RRJ-WR................................. Rubber Ring Joint – Welded Restraint

S.. Steel

SCADA .... Supervisory Control and Data Acquisition

SEAA .... Safety, Environment & Aboriginal Affairs

SID .... Safety in Design

SPS .... Strategic Product Specification

SSSI.. Surveying & Spatial Sciences Institute

U-PVC................................... Unplasticised Polyvinyl Chloride

WJ... Welded Joint

1.8 Acceptance of Materials

All materials or components shall comply with the relevant Water Corporation’s Strategic Product Specification (SPS), or where a SPS is not applicable, the latest edition of the relevant Australian Standard. The Corporation may require, from time to time, manufacturers’ certificates, test results and guarantees. New pipes and fittings shall be used unless specifically approved by the Corporation. Materials shall be handled in accordance with the manufacturer’s specifications. Damaged material shall not be used.

Where a product is part of a product category maintained in the Water Corporation’s Strategic Product Register, the product supplied shall be listed in the latest revision of the register and the approval expiry date will not have passed by the product delivery date.

All materials or products which will be in contact with the water supply shall comply with AS/NZS 4020. Wherever requested by the Corporation, documentary evidence of material or product certification to AS/NZS 4020 shall be provided.

The Corporation retains the right, for commercial, logistic or any other reason, not to accept any material or component.

2 PIPE DESIGN

2.1 Selection Factors

The choice of pipe material depends upon many design factors which are listed in the Pipeline Design section.

2.2 Acceptable Pipe Material

The following materials are currently acceptable subject to size limitations specified elsewhere:

a) Polyvinylchloride, Modified (PVC-M)

b) Polyethylene (PE)

c) Steel (S) or Mild Steel Cement Lined (MSCL)

The following materials are not frequently used and require specific project by project acceptance:

a) Polyvinylchloride, Oriented (PVC-O)

b) Glass/Fibre Reinforced Plastic (GRP/FRP)

c) Zinc/Aluminum or PE coated Ductile Iron (DI)

The following materials are generally not acceptable:

a) Uncoated Ductile Iron

2.3 Pipe Structural Design

Pipelines shall be designed to withstand all the forces and load combinations to which they may be exposed including internal forces, external forces, temperature effects and settlement.

The design of buried flexible pipelines shall be in accordance with AS/NZS 2566.1.

For pipeline conditions where any of the following apply, a summary of the design and outcomes shall be included in the design summary report.

a) Native soil is other than sand;

b) Embedment material is other than sand;

c) Proposed cover is less than, or more than specified in this standard;

d) Under pavements where the loading is or may be greater than normal highway loading;

e) The compaction of the embedment material cannot be controlled or confirmed (including installation by horizontal directional drilling)

f) Construction loads, other than for construction of the embedment and trenchfill, will be imposed over the pipe.

In no case shall the pipe PN rating or its equivalent corresponding stiffness, be less than otherwise required by this standard or the manufacturer's recommendation. Sand is defined as having less than 12% fines.

2.4 Design Pressures

2.4.1 Maximum Allowable Operating Pressure

Maximum Allowable Operating Pressure (MAOP) is defined per AS/NZS 4087 as the maximum internal pressure, including surge that a component can safely withstand in service. (ie. the maximum pressure to which a pipe or fitting may be subjected to under transient surge conditions).

2.4.2 System MAOP

The MAOP of a pipeline system is determined by the lowest MAOP of its components, i.e. the lowest MAOP of the:

a) pipe (After application of modifications as required by this standard);

b) joints;

c) fittings, valves and appurtenances; and

d) anchorage (e.g. thrust/anchor blocks, welded lengths of pipe).

The designers shall ensure that the MAOP of the pipeline system is equal to or greater than the minimum required MAOP of the system based on current and planned future operating pressures (including surge). The minimum required MAOP is usually nominated by Water Corporation.

The designer shall specify the MAOP of the pipeline system and the System Test Pressure on the drawings.

The minimum PN rating for any components in the pipeline system (except for Anchorage) is PN16.

A pipeline system (including fittings, valves, and appurtenances) shall be designed with a consistent system MAOP and avoid different sections of the pipeline featuring different MAOPs.

2.4.3 System Test Pressure

The System Test Pressure shall be one of the following: PN16; PN21; PN25; or PN35.

The System Test Pressures shall be equal to the lowest PN rating of system components. Both pipe as well as fittings/appurtenances must be considered.

In the case of plastic pipes, any increases to the required PN for Long term degeneration (refer Clause 2.4.5.5) and damage from installation method (refer Clause 2.4.6) are not required to be considered for System Test Pressure. For example, should a PE pipe require an additional pressure class due to installation damage (e.g. PN25), the System Test Pressure for the pipe would be PN20.

Note: The System Test Pressure is not necessarily the same as the System MAOP. The System Test Pressure will always be equal to or higher than the System MAOP as the System test pressure does not have some of the pipe deratings applied.

2.4.4 Anchorage Pressure Capacity

Pipeline anchorage (e.g thrust and anchor blocks) shall be designed for the higher of the MAOP and also the System Test Pressure.

2.4.5 Plastic Pipeline Pressure Class Selection

2.4.5.1 Overview

Care should be taken to not confuse the PN rating for plastic pipe with maximum pressure the pipeline will be able to withstand for the life of the pipeline. The PN rating of a plastic pipe does not take several factors into account which reduce the pipe's ability to withstand internal hydrostatic pressure over the long term.

When selecting the suitable pressure class for a pipe, the design of plastic pipes must consider:

a) fatigue;

b) temperature;

c) oxidative damage;

d) long-term degeneration; and

e) installation method

These aspects are discussed in the following subclauses.

2.4.5.2 Fatigue

Plastic pipes shall be assessed for fatigue effects in accordance with Table 2.1.

Table 2.1: Methods for design of plastic pipes and fittings for dynamic stresses

Pipeline System Items	Guideline
PVC pressure pipes	PIPA Guideline POP101 : PVC pressure pipes – Design for dynamic stresses
PE pressure pipes	PIPA Guideline POP010A : Polyethylene pressure pipes – Design for dynamic stresses
PE fusion fittings	PIPA Guideline POP010B : Fusion fittings for use with polyethylene pressure pipes – Design for dynamic stresses
GRP pipes and fittings	GRP pipe design shall be validated in accordance with criteria provided by the pipe and fitting manufacturer.

Notes:

a) PIPA Guidelines may be downloaded from pipa.com.au.

b) Pipe fittings for PVC and PE pipelines shall generally be ductile iron.

2.4.5.3 Temperature

Plastic pipe pressure rating and other characteristics are for a baseline temperature of 20°C. Where the time weighted 12 month average temperature of water within the distribution system exceeds 20°C, the pipe class shall be de-rated to the time weighted 12 month average temperature. The temperature de-rating factor, t, shall be in accordance with Table 2.2.

Table 2.2: Temperature de-rating factors for plastic pipes operating at elevated temperatures

Pipe material	De-rating factor[1],t				
	Time weighted 12 month average temperature, °C				
	20	25	30	35	40
PVC-M	1.0	0.94	0.87	0.79	0.7
PVC-O	1.0	0.94	0.87	0.79	0.7
PE 100	1.0	1.0	0.94	0.89	0.84
GRP[2]	1.0	1.0	1.0	1.0	1.0

Notes:

a) Multiply the temperature de-rating factor t by the PN number of the pipe to determine the reduction in the pipe's pressure rating due to thermal effects.

b) The figures for GRP are based on polyester pipe resin material. For continuous operation at or above 35°C vinylester resins are required. Temperature de-rating shall not apply for GRP pipes manufactured from vinylester resins where temperatures do not exceed 50°C.

c) PE Fittings shall be de-rated in accordance with PIPA industry guideline POP 006.

2.4.5.4 Oxidation

PE is known to degrade over time when in the presence of oxidative species such as chlorine. Where used in chlorinated applications or other situations with elevated oxidation-reduction potentials, PE components shall be derated by a factor of 0.45. This shall be applied cumulatively with any other thermal derating factor.

2.4.5.5 Long Term PVC Degeneration De-rating

Historic performance of Water Corporation PVC pipelines indicates that premature failure can occasionally occur in medium-long term service. To account for this, PVC pipe must be one class higher than would otherwise be required. This applies only to the pipe and does not apply to other non-PVC components nor the Test Pressure.

2.4.6 Installation Method De-rating

Trenchless installation methods can cause damage to the exterior of the pipe. It is also very difficult to identify when such damage occurs as the pipe is concealed from view. To account for this damage, pipe must be one pressure class higher than would otherwise be required.

2.4.7 Examples of Pipeline Pressure Determination

EXAMPLE 1:

Pipe = mPVC.

Required minimum MAOP = 1,150kPa

Temperature = 30°C

Cyclic Loading = 100,000 cycles/100 years; pressure range 300kPa

Install = open trench

Temperature derating:

30°C corresponds to derating factor of 0.87

1,150kPa / 0.87 = 1,322 kPa.

Next higher PN rating = PN16

Fatigue check:

Lookup PIPA POP101. Fatigue cycle factor = 0.67.

MCPR = PN16 / 10 x 0.67 = 1,072 kPa.

As 1,072kPa is larger than the 300kPa cyclic pressure range, PN16 is suitable

Oxidation adjustment:

not necessary for PVC

Install method adjustment:

no adjustment necessary (as it is open trench)

Long Term PVC Degeneration adjustment:

Pipe is PVC, therefore need to allow for Long term Degeneration (Refer Clause 2.4.5.5). Thus select pipe PN rating one PN higher than otherwise required. Without this consideration PN16 would be required. Therefore PVC pipe shall be minimum **PN20**.

Determine Pipe Fittings Rated Pressure:

Required MAOP is 1,150kPa and min fitting PN is PN16 (refer Clause 2.4.2).
Pipe fittings to be PN 16 (larger of required MAOP and minimum of PN16)

Determine System Test Pressure:

System Test Pressure = lowest PN of system components = lowest of PN16 (pipe) and PN16 (fittings) = PN16. (to be written on the drawings)

Determine Anchorage Design Pressure:

Anchorage designed for System Test Pressure = 1,600kPa.

Determine System MAOP:

System MAOP (to be written on drawings) is the lowest MAOP of the various components.

Thus System MAOP = 1600kPa * 0.87 = 1,390kPa.

EXAMPLE 2:

Pipe = PE100 (Disinfectant Resistant and HSCR grade).

Fluid = chlorinated water

Required minimum MAOP = 750kPa

Temperature = 30°C

Cyclic Loading = 1,000,000 cycles/100 years, pressure range 600kPa

Install = Horizontal Directional Drilling

Temperature derating:

30°C corresponds to design factor of 1.1

850kPa x 1.1 = 825kPa

Fatigue check:

Check against PIPA POP010A. 1,000,000 cycles yields 0.88 fatigue load factor.

Pressure range / Fatigue load factor = 600kPa / 0.88 = 682kPa

Oxidation adjustment:

Pipe is PE, so must consider oxidative derating. Use the greater of temperature and fatigue pressure requirements and divide by 0.45.

825 / 0.45 = 1,834 kPa

Long Term PVC Degeneration adjustment:

As Pipe is PE this is not required.

Based on the 4 considerations above: Select pipe with next highest PN = PN20

Install method adjustment:

HDD install, so must increase PE pipe pressure class to one class higher than otherwise required. Therefore pipe must be min PN25.

Pipe is considered PN20 (although pipe installed is actually PN25, scratches from installation method can effectively reduce wall thickness).

Determine Pipe Fittings Rated Pressure:

Required MAOP is 750kPa and min fitting PN is PN16 (refer Clause 2.4.2).
Pipe fittings to be PN 16 (larger of required MAOP and minimum of PN16)

Determine System Test Pressure:

System Test Pressure = lowest PN of system components = lower of PN20 (pipe) and PN16 (fittings) = 1,600kPa. (To be written on drawings)

Determine Anchorage Design Pressure:

Anchorage design pressure = System Test Pressure = 1,600kPa

Determine System MAOP:

Pipe is PN25. Install method (HDD) can result in scratches/damage that reduce wall thickness. Therefore must treat pipe as one PN class lower = PN20. Then apply oxidation and temperature adjustment factors

= PN20 x 0.45 / 1.1 = 818kPa.

Then check pipe fatigue --> PN20 x 0.88 = 1,760kPa.

Select lower pressure = lower of 818kPa and 1,760kPa = 818kPa

Check fitting PN = PN16

System MAOP (to be written on the drawings) is lowest of system components = lowest of 818kPa (pipe), 1,600kPa (fittings) and anchorage (1,600kPa) --> therefore System MAOP is 818kPa.

2.5 Design for Transient Pressures

Systems containing pumps or actuated control valves shall have a transient analysis undertaken using a dedicated transient surge analysis software system such as Watham, Wanda or an equivalent program.

The analysis shall consider short and long term system conditions and shall determine the protection devices and or valve operating times required to prevent the system MAOP being exceeded and to prevent air entry into the pipeline. The results of the analysis shall be contained in the design report.

The allowable methods of surge control include:

a) Surge vessels

b) Controlled pump start up and stopping times,

c) Controlled valve closing times.

d) For non-drinking water and negative surge, a bank of multiple and redundant air valves.

Note the mechanical design standards contain design requirements for these types of assets.

One way surge tanks have historically been used for negative surge. However, due to the unreliable operation of the seldom used non return valve and the potential to draw very old water into the main, new systems should not use one way surge tanks.

Where air valves are permitted for negative surge control, the installed number of air valves must be at least double the number of valves needed for surge control. This will allow up to 50% to be removed for maintenance at any time. Signage is required to inform operators that the bank of valves is required for water hammer protection and at least 50% shall be operational at all times.

In special cases, for drinking water and with project specific approval, where the allowable methods of negative surge control are impractical, the use of an air chamber located above the pipeline may be considered. The chamber is connected so that under normal operation chlorinated water flushes through the chamber and is large enough to contain 1.5 times the air volume that is predicted to be required during a negative surge. Multiple and redundant air valves and signage is required. As the air valve is required to always allow air entry, there can be no isolation valves between the air valve and the chamber.

The proposed transient protection shall be agreed with the Corporation prior to commencing detailed design.

2.6 Transitions Between Restrained and Unrestrained Pipeline Components

Where a pipeline transitions between restrained (e.g. fully welded) and unrestrained (e.g. elastomeric seal) joints, the design must account for axial movement of pipeline due to thermal effects and shortening due to pressurization (Poisson's ratio effect), such as incorporating appropriate pipeline restraints or anchorage into the design.

2.7 Polyvinylchloride (PVC)

2.7.1 Acceptable PVC Pipe

The PVC pipe listed in Table 2.3 is acceptable to the Corporation.

Table 2.3: PVC Pipe Types

Materials	Nominal Diameter (DN)	Nominal Pressure (PN)	Maximum Allowable Operating Pressure (m)	Acceptable use
MPVC to SPS116 and AS/NZS 4765 Series 2	Up to and including DN250[d]	16, 20	120, 160	Below ground use only. Not to be used in chemically contaminated ground (esters, ketones, ethers and aromatic or chlorinated hydrocarbons). Not to be used where exposed to UV radiation. Generally not used for pipelines subject to cyclic or high surges.

Notes:

a) Normal pipe lengths are 6m.

b) For pipes DN 250 and smaller refer to DS63.

c) Use of PN classes greater than PN20 or OPVC or diameters greater than DN250 PVC pipes shall be subject to acceptance of the Corporation.

d) PVC pipes DN300 and DN375 are not generally accepted and require project specific approval. Consideration shall be giving to installation of alternative pipe materials based on installation costs and the potential for and consequences of sudden and large bursts from the PVC pipe.

2.7.2 Fittings

Pipe fittings for use with PVC pipe shall be socketed Ductile Iron fittings to SPS106 and AS/NZS 2280. Spigoted Ductile Iron fittings shall not be permissible. All Ductile Iron fittings shall be thermal-bond polymerically coated and lined to AS/NZS 4158.

2.7.3 Pipeline Joints

PVC pipes shall be in accordance with AS/NZS 4765, Series 2 with elastomeric seal joints. Joint elastomeric seals shall be EPDM or NBR in accordance with AS 1646 and shall be supplied by the pipe manufacturer.

The use of bolted (e.g. Gibault or Straub type) pipe couplings in new pipeline work shall not be generally permissible in lieu of factory made pipe jointing systems. Where permitted, axially bolted (gibault style) couplings shall comply with AS/NZS 4998 long series couplings and the use of circumferentially bolted (Straub style) couplings shall be limited to straight (as distinct from deflected) pipeline joints in order to take due account of the relatively shorter length of this coupling style. The use of pipe couplings that provide axial restraint shall require submission of a justified design and installation methodology proposal to the Corporation for determination of acceptability in each case.

Note that the common gibault style couplings (e.g. Varigib) provide no axial joint restraint. E-lip Seal style couplings (e.g. Straub, Teekay or Norma) have a double lip sealing gasket and are available with or without axial restraint but can be subject to long delivery lead times.

2.7.4 De-rating

The maximum allowable operating pressure for PVC is not the same as the PN rating of the pipe.

The use of PVC pipe in any application where pressure cycling resistance may shorten its effective life expectancy to less than 50 years shall not be permissible.

2.7.5 Ground Conditions

PVC pipe shall not be used in ground contaminated by organic chemicals.

2.7.6 UV Exposure

PVC pipes shall be permissible only if less than 12 months old and less than 6 months exposed to direct sunlight. Exceptions will be determined by the Corporation on a project-by-project basis, subject to the quality of supporting documentary evidence provided in support of the circumstances of the pipe storage and protection from UV radiation.

2.7.7 Considerations in PVC Application

a) Resistant to corrosive soils

b) Resistant to aggressive raw water

c) Unaffected by galvanic or electrolytic corrosion

d) May flex to accommodate minor ground movement

e) Can be easily cut to length on site

f) Same outside diameter as DI pipe. Permits connection to existing DI, CI and AC pipeline systems without adaptors

g) Wide availability of DI fittings up to PN16 and DN300

h) Sensitive to impact damage

i) Significantly degraded by UV radiation

j) Should not be installed when more than 12 months since manufacturing has elapsed.

k) Suitable only for buried service unless shielded.

l) A failure mechanism seen more often in PVC pipe than in other pipe types are barrel failures. Barrel failures result in a sudden and large releases of water exceeding what is commonly seen in other types if failure (Joint leaks, pinholes). The volume and pressure of water released increases with pipe diameter. Barrel Splits can result in a very large amount of damage to the surroundings resulting in costly repairs. Where the pipe surroundings are developed, the potential for consequential and reputational damage shall be considered prior to using PVC.

m) Attacked by some solvents

n) Strength deteriorates at elevated temperatures

o) Cannot be welded therefore thrust blocks are required for fittings.

p) Incompatibility of different manufacturer's joints

q) Buried pipes not readily located without tracer tapes or wires

r) Not suitable for excessive cyclic loading or high surges

s) Nonconductive pipeline.

t) PVC Pipe systems typically uses joints that can accommodate movement

2.8 Polyethylene (PE)

2.8.1 Acceptability

To address premature failures of ordinary PE100 and the limited experience with new PE100 resins, PE100 is not to be used where there is a viable alternative pipe material. PE100 pipe may be accepted where PE100 is the only viable option, the minimum requirements listed below must be met. Note that meeting the minimum requirements does not imply acceptance.

PE100 pipes must:

a) Not to be used for chlorinated water capable of reaching 25°C or higher;

b) Be de-rated for pressure by an oxidation factor of 0.45 applied separately to any temperature and fatigue deratings applied, when it is used in a chlorinated water application;

c) Be manufactured from a resin approved for use by Water Corporation in chlorinated applications. Such approval is only demonstrated by being listed on the Strategic Product Register;

d) Not to be used for water with elevated chlorine or very low pH water;

e) Have repair fittings readily available (which is problematic in larger diameters); and

f) Meet the diameters listed within the Strategic Products Register

All polyethylene (PE100) pipes and stub-flanges used in chlorinated water applications must be entirely fabricated from resins that are both:

1. Classed as HSCR (as per PIPA document POP016); and
2. Considered Disinfection Resistant in accordance with SPS125 and listed as such in the Strategic Product Register.

Pipes and stub flanges must be indelibly marked with the resin manufacturer and resin name.

Compliant resins are identified in the Water Corporation’s Strategic Product Register. The use of any other resins is not permitted

2.8.2 Fittings

PE100 shall not be used for fittings, with the exception of stub flanges. Unless the ground conditions are unsuitably corrosive, DI bends and tees should be used for sizes up to the range of availability. MSCL bends and tees should be used for larger diameters. PE stub flanges shall:

a) Be butt-fusion-welded type;

b) De-rated by the same factor as applied to the adjoining PE pipe in addition to any other applicable derating; and

c) Be fabricated from the same resin as the adjoining PE pipe

2.8.3 Joints

The jointing of pipes shall be in accordance with WS-2.

Unless stated otherwise elsewhere in Water Corporation requirements, PE stub flanges and backing rings shall comply with PIPA Guideline POP007.

PE shall be anchored wherever it joins into non-axially restrained pipe or fittings.

2.8.4 De-Rating

The maximum allowable operating pressure for PE is not the same as the PN rating of the pipe.

2.8.5 Ground Conditions

PE pipe and fittings shall not be permissible in ground contaminated by organic chemicals.

2.9 Steel (S or MSCL)

2.9.1 Application of Steel Pipes

Steel pipes are generally used for most pipelines DN 400 and larger, and sometimes for sizes smaller than DN 400. Steel pipes are suitable for above or below ground use. Note that for extremely corrosive environments, large diameter GRP or plastic pipe has been used.

2.9.2 Manufacture

Pipes shall be manufactured in accordance with SPS 100. These pipes are externally coated with fusion-bonded medium density polyethylene and internally lined with cement mortar.

“Sintalined” pipes, which are externally and internally coated with fusion-bonded medium density polyethylene have yet to be commercially viable for acceptance by the Water Corporation for water supply pipelines. (Steel pipe OD’s are not compatible with PVC, PE or DI). Sintalined pipes may be accepted on a project specific basis where approval has been obtained from the Corporation.

2.9.3 External Coating – Buried and Above Ground Pipework

External coating of pipework buried in soil and above ground shall be coated in accordance with Section 13.0 of Water Corporation Design Standard DS95.

2.9.4 External Coating – Miscellaneous Pipework Configuration

External coating of miscellaneous pipework configuration such as below ground to above ground transitions, joints with couplings and concrete interface shall be coated in accordance with Section 13.0 of Water Corporation Design Standard DS95.

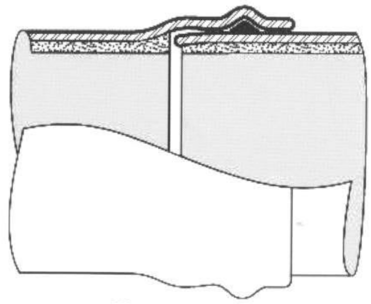
2.9.5 Joint Types and Allowable Joint Deflection

RING SEAL JOINTED

RRJ, Even though rubber rings have been replaced with EPDM seals, the abbreviation RRJ has become entrenched as the short name for ring sealed pipes. The abbreviation RRJ is the preferred terminology for ring seal jointed pipes in preference to the sometimes used ESJ (elastomeric seal joint).

According to steel pipe manufacturer’s design manuals, RRJ allows an angular deflection of up to approximately 3° depending on the pipe diameter; however, for all Water Corporation’s projects, the design angular deflection at any RRJ shall be limited to 2/3 of the allowable angular deflection specified by the manufacturer.

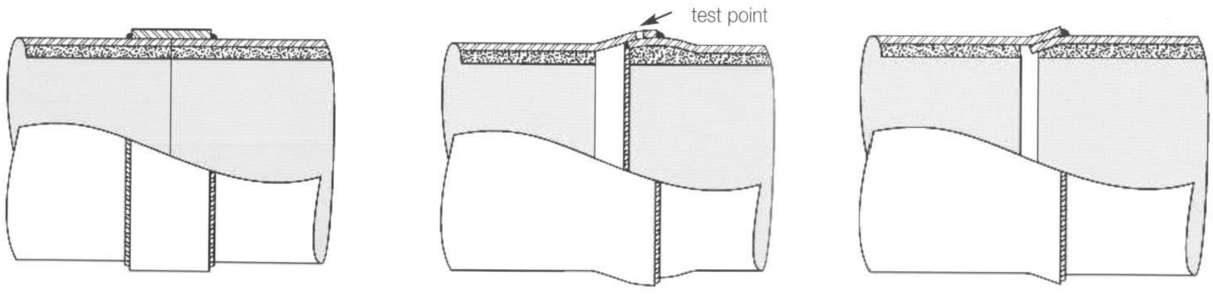
Figure 2.1: Example of RRJ Ring Jointed pipe



WELDED JOINT

WJ, Welded Joint. WJ is the preferred abbreviation for welded joint pipe. Non preferred abbreviations that have been sometimes used include Banded Joint Welding, SSJ (Spherical Slip in Joint), E&C (expanded and collapsed) or SIJ (Slip in jointed).

Figure 2.2: Examples of Typical Manufacturer WJ Welded Joint Pipe.



WJ – PE is the preferred notation for Welded Joint Pipe with Plain Ends.

WJ – SSJ is the preferred notation for Welded Joint Pipe with Slip in Joints (or expanded and collapsed or spherical slip in joints). The allowable angular deflection specified by steel pipe manufacturers is as shown in Table 2.4 below.

Table 2.4: Maximum Allowable Angular Deflection for WJ-SSJ (Joints)

Pipe DN	Angular deflection in degrees
100	2.4
150 – 1200	3.0
1400	2.8

The maximum allowable angular deflection for a banded joint in accordance with DS65 is as shown in Table 2.5 below. Refer to the Corporation's Pipe Fittings Standard Drawing AY58-19-1 for a banded joint detail.

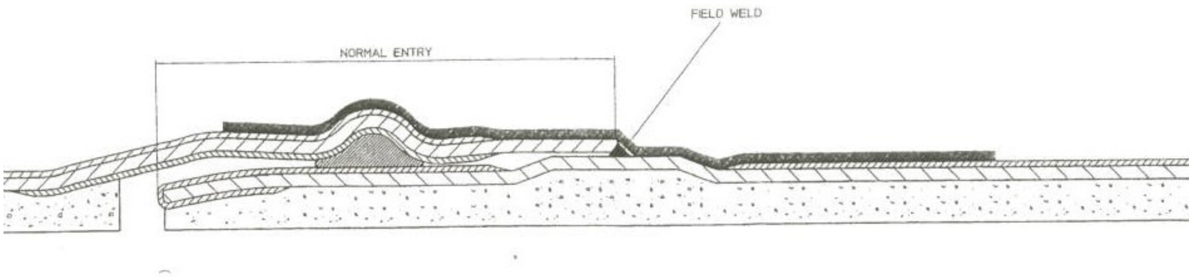
Table 2.5: Maximum Allowable Angular Deflection for Banded Joints

Pipe DN	Angular Deflection angle in degrees	Banded Joint Pressure Rating
100 – 800	10 Degree	350m
900	6 Degree	350m
1000 to 1600	6 Degree	250m

RING SEAL JOINTED WITH WELDED RESTRAINT

RRJ-WR is the preferred abbreviation for joints that are Ring jointed and also have welded restraint. Sintalock® (owned by Tyco/Tubemakers/Steelmain) is a brand of RRJ-WR pipe.

Figure 2.3: Sintalock® Ring seal joint with Welded Restraint, RRJ-WR



Allowable angular deflection of RRJ-WR needs to be confirmed with the MSCL Pipe Supplier's recommendations. In general the allowable deflection is 1.1°.

As RRJ-WR has only a single external weld, it does not have the same MAOP as either RRJ or WJ pipe. Hence the use of RRJ-WR Sintalock 1 pipe is to be limited as shown in Table 2.6.

Table 2.6: Pressure and Diameter range for use of Sintalock® RRJ-WR pipe

Sintalock ® RRJ-WR pipe	PN 16 Application	PN 21 Application
Minimum Diameter	324	324
Maximum Diameter	1422	1219

Joints for steel pipes of size DN 100 to DN 250 are normally only available as WJ-PE pipe.

Note that the diameter range given in Table 2.6 is the manufacturing range for RRJ-WR pipe. Product availability, particularly at sizes smaller than DN500, should be checked prior to design.

2.9.6 Joint Selection

RRJ-WR pipe would normally be specified in preference to WJ pipe as RRJ-WR joints have no internal surface that is unprotected against corrosion. This has the advantage that there is no need for constructors to enter the pipe to repair the internal lining, with obvious safety and speed of construction benefits. Also there is no need to externally overband and grout the joint, as is required for small diameter WJ pipe with no internal access.

For buried steel pipelines DN 300 and larger (if not using RRJ-WR pipelines), rubber ring joints (RRJ, Sintajoint) should normally be used. Ring seal joint with welded restraint, RRJ-WR, slip-in (expanded and collapsed) welded joints or welding band joints are only used where:

a) ground conditions are unsuitable for RRJ pipe

b) welded joints are required for thrust anchorage

c) there are other specific requirements for welded joints

Note: RRJ-WR may have a lower rated pressure than RRJ or WJ pipe. Check with the manufacturer prior to use.

Where conditions are suitable, to achieve capital cost savings the use of welded joints in a pipeline should be minimized.

Rubber ring jointed pipelines shall be installed in accordance with the Sintakote Handling and Installation Manual.

Where internal access for cement lining reinstatement is not available, RRJ-WR pipes shall be used or where slip-in (expanded and collapsed) welded joints are used, a convex band shall be welded over each joint as shown on the Corporation's Pipe Fittings Standard Drawing AY58-19-1.

Welded joints shall be in accordance with AS 4041 pipework Class 2P, the Water Corporation's Welding Specification WS-1 and the Standard Drawings.

Welded field joints for DN 900 and larger shall also be welded internally and shall be pneumatically pressure tested.

2.9.7 Ring Deflection

To ensure the integrity of joint, the maximum ring deflection for RRJ and welded pipelines shall be as per manufacturer's specifications.

2.9.8 Fittings

The structural capacity of fabricated fittings shall be checked and where required, tee and Y fittings shall be reinforced with collars, wrapper plates or crotch plates. Design of branch connections and openings including fitting reinforcement shall be in accordance with AS 4041.

Fittings for steel pipelines shall be fabricated or pressed mild steel in accordance with AS 1579, AS 4041 (Class 2P) and the Corporation's Pipe Fittings Standard Drawings – DS 65. Joints shall be as per drawing AY58-19-1. For angular deflection that cannot be achieved through the welded joints mentioned in the previous section, fabricated two to four segment bends with angular deflection angle of up to 90^0 shall be used. Flanges shall be to AS/NZS 4087 and drawing AY58-15-1. For applications outside the limits specified in AS/NZS 4087, the appropriate flange details may be determined from AS2129 and AS/NZS 4331.

'Straub' or 'Teekay' couplings are preferred for use over specially fabricated dismantling joints. The material shall be 316L stainless steel. Hot-dip galvanised fittings may only be used if it is proven that the stainless steel fittings are not available.

Following the unacceptable number of failures of flexible couplings due to the relative movement of the pipe on each side of the coupling, **all 'Straub' or 'Teekay' fittings shall be restrained using tie bolts between gussets, or flanges on the pipe either side of the flexible coupling.**

(Previously, unrestrained dismantling joints have failed at the Wanneroo WTP, Harris transfer main and Samson Dam outlet works. All of these failures were due to movement of the pipe in excess of the coupling capacity and would have been prevented by using the tie bolt restraint).

Where a dismantling joint coupling is used at a welded steel pipe, the external spiral weld shall be ground flush with the steel surface to achieve sealing by the coupling at the joint. The exposed steel surface of the pipe shall be protected with a two-part epoxy coating and the installed coupling protected with a wrapping system to the appropriate Corporation Standards.

Unrestrained joints shall not be used within the welded pipeline length required for anchorage.

Fabricated steel pipe fittings, such as lobster back bends, shall be cement mortar lined in accordance with the Water Corporation's specification M8 – Cement Mortar Lining Requirement and coated externally as detailed in clauses 2.9.3 and 2.9.4.

The use of Sintakote as external coating and as internal lining for fittings is also acceptable.

Prior to application of the protective lining and coating, surfaces shall be cleaned as recommended by the coating supplier but as a minimum, the steel substrate shall be de-greased and mechanically wire brushed. Mill scale shall be removed by grit blasting.

Where MSCL pipes with fusion bonded polyethylene coating are used to fabricate pipe fittings, the coating shall be stripped back a minimum 50 mm away from the actual weld. The stripped areas shall be wrapped after cleaning the welded areas. The wrapping shall overlay the polyethylene coating a minimum of 100 mm.

2.9.9 Jointing and Plate Thickness

Steel pipe jointing and plate thickness shall be considered on a job by job basis. The pipes shall be selected from Table 2.7: Elements of Steel Water Pipes, as supplied by the Corporation's period supply contract.

AS 1579 uses the 'rated pressure = maximum internal hydrostatic pressure, at which the pipe is suitable for sustained operation' based on limiting the pipe hoop stress to 0.72 of yield (specified minimum yield stress).

AS 1579 allows higher pressures for emergency conditions. The Water Corporation does not consider transient pressures generated through normal operation (including power failure), to be emergency conditions. Hence the rated pressure to AS 1579 is equivalent to the MAOP as defined in AS/NZS 4087 (the maximum internal pressure which may be applied as a continuous or transient peak pressure (ie. the max pressure to which a pipe or fitting may be subjected to under surge conditions)).

Table 2.7 yield stress are based on the Steel Mains supply at July 2021 of 250 MPa for thickness >8mm and 300 MPa for thickness =< 8mm.

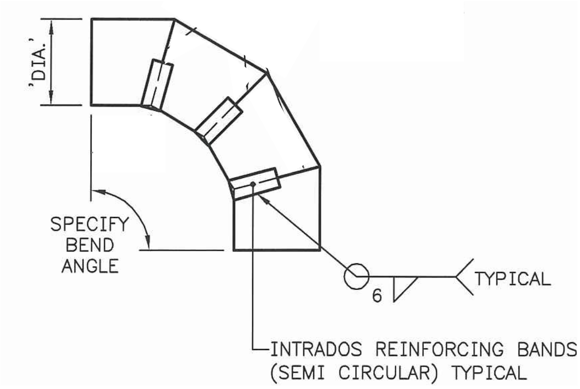
Occasionally, pipe will be required at a higher MAOP than the standard range. In these cases it may be possible to negotiate the supply of a higher yield material; a cheaper option when compared to increasing the pipe thickness. The use of DN1400 (1422/11/1360) grade 300 steel pipeline has been approved by the Water Corporation. To differentiate the DN1400 grade 250 and 300 steel pipelines, the grade 300 pipeline shall be marked with a continuous white stripe along its full length, which is in addition to the normal pipe numbering/lettering.

2.9.10 Design Criteria for Finite Element Analysis (FEA), for Intrados Banded Fabricated Bends

Non-reinforced mitre bend have a design pressure significantly lower than the design pressure of an equivalent straight pipe, up to 38% of a straight pipe design pressure. Finite Element Analysis (FEA) has verified that the addition of intrados reinforcements (semicircular bands) to a mitre bend as shown in Figure 2.4 allows a more efficient usage of the bends' material and found a noticeable increase in the mitre bends design pressures (from 73% up to 89% of an equivalent straight pipe design pressure).

Reinforced mitre bends may be used when bends are fabricated using standard MSCL pipes as an alternative to fabrication of fittings without reinforcement using commercial plates and with required thickness calculated in accordance with requirements of AS4041. For reinforced mitre bends detail refer to the Corporation's Pipe Fittings Standard Drawings – DS 65.

Figure 2.4: Four Segment Bend with Reinforcing Bands



Where FEA is required to be carried out to assess the maximum internal positive design pressure of pipe mitre bends reinforced at the intrados other than those specified in the Corporation's Pipe Fittings Standard drawings – DS 65, it shall be performed using the following basis of design and the acceptability criteria:

a) A proven computer program is to be used to construct Finite Element models of the reinforced pipe bends. All components are to be modelled as shell elements placed as close as possible to the centreline on the plate walls and keeping, as much as possible, a rectangular shape.

b) The following boundary conditions shall be applied to all models:

c) All pipes are to be rigidly constrained at one end. The ends are to be modeled at least 10 (ten) diameters away from the bend to ensure that the rigid constraints would have negligible effect on the stresses at the bends.

d) All free ends are to be assigned dummy end plates to apply the internal pressure thrust load to the pipes and the fittings.

e) AS1210 shall be used as a guideline for the FEA.

f) The maximum shear stress theory of failure (Tresca) is to be used as design criterion. The stress categories and stress limits shall be evaluated in accordance with AS1210.

g) As minimum, the thickness under-tolerance in accordance with AS/NZS1365, and weld joint factor, e = 0.85 must be considered as a base case

Table 2.7: Elements of Steel Water Pipes

STANDARD DIAMETERS USED BY THE WATER CORPORATION																		
DIMENSIONS								MASS						STEEL ONLY		Min. yield strength	MAOP (including surge, based on 72% yield to AS 1579) (See Note 3)
DN	O.D.	Plate Thk	I.D. (Lined)	Cement Mortar Lining	P.E. Coating Thk	Water Area	Steel Area	Steel	Cement Mortar	Coating	Total Empty	Water	Total Full	I	Z		
mm	mm	mm	mm	Mm	mm	m^2	mm^2	kg per metre						$x10^6mm^4$	$x10^3mm^3$	MPa	m
100	114	5 (4.8)	86	9(±3)	1.6	0.0058	1712	13.4	6	0.5	20	5.8	26	3	52.6	300	>350
150	168	5	140	9(±3)	1.6	0.0154	2560	20.1	10	0.8	31	15.4	46	9	107.1	300	>350
200	219	5	191	9(±3)	1.6	0.0287	3362	26.4	14	1.0	41	28.7	70	19	173.5	300	>350
250	273	5	245	9(±3)	1.6	0.0471	4210	33.0	17	1.3	52	47.1	99	38	276.9	300	>350
300	324	5	290	12(±4)	1.8	0.0661	5011	39.3	27	1.7	68	66.1	135	63.8	393.8	300	>350
400	406	5	372	12(±4)	1.8	0.1087	6299	49.4	35	2.1	86	108.7	195	126.6	623.6	300	>350
500	508	5	474	12(±4)	1.8	0.1765	7901	62.0	44	2.7	109	176.5	285	249.9	983.9	300	>350
600	610	6	574	12(±4)	2.0	0.2588	11385	89.4	53	3.5	146	258.8	405	519.2	1702.3	300	>350
700	711	6	675	12(±4)	2.0	0.3578	13289	104.3	62	4.1	171	357.8	528	825.7	2322.6	300	>350
800	813	7	767	16(±4)	2.3	0.4620	17725	139.1	95	5.4	239	462	701	1439.4	3541.1	300	>350
900	914	7	868	16(±4)	2.3	0.5917	19946	156.6	107	6.1	269	591.7	861	2051.2	4488.4	300	337
1000	1016	8	968	16(±4)	2.3	0.7359	25334	198.9	119	6.8	324	735.9	1060	3217.8	6334.3	300	347
1200	1219	9	1169	16(±4)	2.3	1.0733	34212	268.6	143	8.1	420	1073.3	1493	6261.6	10273.3	250	271
1400	1422	11	1360	19(±4)	2.3	1.4569	48761	382.8	198	9.5	590	1456.9	2047	12135.6	17068.4	250	284
1400	1422	11	1360	19(±4)	2.3	1.4569	48761	382.8	198	9.5	590	1456.9	2047	12135.6	17068.4	300	340

Notes:

1. Steady state pressures must be less than (the maximum allowable operating pressure – applicable surge)
2. Other loadings on pipes may require thicker plate than shown above
3. Information presented in the table is not applicable to Sintalock pipe

PIPE LENGTHS: 9m Nominal or 12m Nominal

ASSUMPTIONS:
Density of Steel: 7850 kg/m^3
Density of Concrete: 2400 kg/m^3
Mass of Coating: 925 kg/m^3

STANDARDS:
AS 1579 – Arc Welded Steel Pipes
AS 1281 – Cement Mortar Lining of Steel Pipes
AS 4321 – Fusion Bonded Medium Density PE Coating

2.9.11 Considerations in MSCL Application

a) Withstands higher external loading and pressures than PVC and PE.

b) Joints can be welded to make a long continuous pipeline that can withstand ground subsidence and movement.

c) Polyethylene external coating makes it resistant to aggressive soils and is more reliable than sleeving used with DI pipe.

d) Impermeable to gas and organic contaminants.

e) Easily traced leakage detection and location is straightforward.

f) Suitable for above ground with IZS coating.

g) Less change in length with temperature variations compared with PE and PVC.

h) Steel pipelines are proven, stable, long-life pipelines.

i) Mechanical lifting is required.

j) Fittings are not usually available ex-stock and require fabrication.

k) May require cathodic protection against corrosion. Cathodic protection requires regular monitoring and maintenance.

l) Welded joints require skilled installers and special equipment.

m) Longer lead times are required for ordering and manufacture.

n) Cement mortar lining may be eroded by aggressive raw water.

o) Voltage mitigation investigation required.

2.10 Ductile Iron (DI)

2.10.1 Acceptability

Uncoated and sleeved DI pipe is not an accepted pipe system for Water Corporation applications.

Zinc coated DI may be accepted with project specific approval.

The minimum requirements for possible acceptance include:

a) Geotechnical investigation has proven the soil conditions.

b) Soil to have corrosion characteristics: pH > 5, Resistivity > 2,000 Ω.cm and Redox > +100mV.

c) The water pressure requires the pressure capacity of DI.

d) The use of other pipe materials, including PVC and MSCL, is demonstrated not to be feasible.

e) Pipe to have a minimum of 400g/m2 of zinc and aluminum and a pore sealer for corrosion protection.

f) Pipes to have WSSA approval.

g) DI pipes coated with zinc/aluminum must not be encased in concrete.

3 PIPELINE DESIGN

3.1 Design Considerations

3.1.1 Operational Life

The satisfactory long term operational life of the pipeline depends upon:

a) the establishment of the conditions and environment under which the pipeline will be operating;

b) the pipe selection;

c) the design of the pipeline and appurtenances, and

d) the construction procedures.

3.1.2 Determination of Pipe Diameters

The Water Corporation's Asset Planning Group usually determines the size of pipelines.

3.1.3 Design Flow Velocity and Head Loss

Generally, flow velocities used are between 1 and 3 metres/second and head losses 2 to 7 metres/1000 metres.

At high flow velocities there is a risk of cavitation occurring at discontinuities in the pipeline, such as bends, joints and tees.

For cement mortar lined pipes, continuous operation at velocities up to 4 m/s, with occasional velocity up to 6 m/s is acceptable. Failure of cement mortar in the lining is likely to occur at higher velocities, in these cases stainless steel pipework is acceptable.

3.1.4 Material Choice

The choice of material and the pressure rating for the pipeline may depend upon:

a) the diameter required

b) the location – above or below ground

c) the maximum operating or static pressure that will be encountered

d) fluctuations in the pressure

e) the frequency and effect of water hammer

f) the operating temperature

g) the laying conditions – farmlands, urban, central city etc

h) the external loading – traffic loads, construction loads etc

i) external corrosion

j) internal corrosion

k) the soil conditions/geology

l) the topography

m) the availability or lead time for delivery of the pipe

n) the economics – cost of pipe and laying costs

o) maintenance aspects, and

p) the type of pipework existing on a site

3.1.5 Voltage Mitigation

Pipeline voltage mitigation investigation, design and verification shall be undertaken for all metallic pipelines located in the vicinity of power lines, in accordance with the policy, process and technical requirements of Design Standard DS23 “Pipeline AC interference and Sub Station Earthing”

Such investigation, design and verification shall be undertaken by a specialist earthing design consultant approved by the Water Corporation.

Voltage mitigation measures shall be implemented in accordance with the voltage mitigation design of the consultant.

3.1.6 Other Considerations

Pipeline design shall consider the safety and welfare of operation and maintenance activities. In particular, the effects of induced currents, fault currents and lightning strikes shall be considered.

Wherever possible, metallic pipelines parallel to high voltage powerlines shall be avoided. If this is unavoidable, expensive voltage mitigation studies and voltage mitigation measures will be required.

Design shall also aim to eliminate the need for tasks (maintenance, inspection, etc.) to be performed at heights. Where this is not possible, the design requirements for working at heights shall comply with S151 - Prevention of Falls (POF) Standard.

The need for confined space entry for maintenance activities should be eliminated wherever practical. Where unavoidable, clause 3.14 gives design guidelines for valve pits.

3.2 Routes and Alignments

3.2.1 Routes

Factors affecting pipe route selection are:

a) length

b) profile

c) geology/terrain

d) environmental impact (refer to Water Corporation’s Environmental Handbook)

e) impact on other organisations and property owners

f) impact on other service providers

g) laying and restoration costs, and

h) minimizing potential consequential damage from a burst

3.2.2 Alignments

In street reserves, the alignments allocated to water mains by the Public Utility Services Committee are:

a) 2.1 m – generally used for reticulation mains, may be used for distribution mains etc, and

b) 4.5 m – this is the normal alignment for distribution mains

For further information, reference shall be made to the Utility Providers Code of Practice for Western Australia produced by the Utility Providers Services Committee. The use of other alignments such as in a central median strip, requires the approval of the Water Corporation, Local Authorities and other service providers.

Distribution mains shall be located in road reserves where possible. Where it is more practical to lay the main within cleared private property (for example, paddock fire breaks) and utilising the road reserve presents unacceptable environmental impacts or risks associated with maintaining the main, an alignment through private property may be considered if the landowner accepts:

- an easement over the pipeline,
- installation of marker posts, air and scour valves, and
- gates in fences with Water Corporation locks.

In addition, the designer must also consider:

- vee drains in the road reserve may prevent access to the pipeline,
- road safety at entry access roads to the gates (for example, slip lanes and clear sight distances),
- locating valves where access is possible in all situations (for example, all weather access, access during harvests, rain season etc)

Within pipe reserves and easements there are no fixed alignments. The pipeline should be positioned to facilitate construction and maintenance requirements, including the safe excavation of the pipeline for repair or the safe installation of a duplicate pipe.

Where the designer has a choice of possible pipe alignments, an alignment that avoids a high potential for consequential damage from a burst main should be selected. A typical high potential for consequential damage arises where the lost water will cause erosion of sloping ground and loss of support for any structure supported by the slope. Pipelines that are parallel to railway embankments, reservoir embankments, major road embankments or substantial retaining walls should be located such that the impact from a possible burst will not affect the embankment or wall. Note that pipelines crossing these structures have special protection provisions including sleeving or concrete encasement.

The width of reserves or easements depends upon the diameter and depth of the pipeline and the soil conditions, the minimum width is 5 metres. Large mains may require reserve or easement widths of up to 20 metres (and if unrestrained by social and environmental issues, a construction corridor of up to 30m).

All major roads should be crossed at an angle of approximately 90° to the road.

Pipelines shall be laid true to line and shall not deviate by more than 200 mm from the correct alignment without prior approval from the Water Corporation.

3.3 Depths/Cover

The cover to the pipe shall be designed to meet the requirements of the Corporation, Local Authority, Main Roads Western Australia (MRWA) and other utilities as appropriate to each project. The expected loads imposed on the pipe and the strength of the in-situ and fill materials shall be considered when selecting the cover depths.

Water mains shall have sufficient soil cover to:

a) transfer any vehicular loading in excess of the loading capability of the water main, to the adjacent soil strata;

b) accommodate the physical dimensions of fittings such as valves and hydrants where applicable;

c) meet the requirements of the road Owner (for water mains in road reserves); and

d) meet any special requirements nominated by the Water Corporation.

Pipelines shall be designed to facilitate future access. Pipeline cover shall not exceed 2000 mm unless specifically approved by the Corporation.

In wet ground conditions, cover requirements will also be influenced by the potential for flotation of the pipe.

The minimum depth or cover to top of pipe for buried distribution mains shall be measured from permanent finished surface level or in case of sealed roads invert of lowest kerb.

Standard minimum depths of cover for water mains shall be in accordance with Table 3.1.

Table 3.1: Minimum depths of pipe cover

Location	Minimum Cover
Road/ Street Reserves	
Verges	750 mm
Roadways	Greater of 750 mm or 75% of the outside diameter of the pipe.
Minor roads to be constructed	1000 mm
MRWA Roads	The Greater of MRWA requirements, 750mm or 75% of the outside diameter of the pipe.
Other locations	
Urban areas	750 mm
Other areas	600 mm

Cover shall be locally increased where necessary to accommodate stop/gate valves, hydrants and other appurtenances.

The minimum depth of cover may be required to be locally increased to accommodate the effective heights of the stop valves/gate valves plus the required clearances for the spindle caps below the finished surface level (FSL). This allows off-take connections, including stop valves, to be provided off the main without having to relay a section of the main to obtain the necessary valve effective depth.

The Water Corporation may also specify a different depth of cover for water mains in particular locations to suit an expected change in circumstances such as road construction or surface level adjustment.

The water main shall have the minimum cover as specified at the future FSL. Where a water main may be subject to abnormal loading during construction, temporary (or permanent) protection measures shall be taken to ensure that the water main is not overloaded e.g. increasing depth of cover. A structural analysis in accordance with AS/NZS 2566.1 shall be undertaken to ensure protection measures are adequate.

Minimum pipe cover shall only be reduced with the approval of the Water Corporation.

The maximum depth of cover is 2 m. Acceptance of the Corporation shall be obtained before exceeding 2 m.

The minimum and maximum depths of cover for each section of water main shall be shown on the Design Drawings.

3.4 Clearances

3.4.1 Horizontal Clearances

The minimum horizontal clearance required by the Water Corporation, between a pipeline and an adjacent parallel pipeline or other utility shall be:

a) 600 mm for DN300 pipelines; and

b) 1000 mm for DN400 and larger pipelines.

The minimum clear distance shall be subject to the following considerations and increased where necessary:

a) the required compaction and support of the side support material, particularly where a new pipeline is at a different depth to an existing pipeline;

b) sufficient clearance for installation of the new main and future maintenance of either main, including installation of shoring boxes, space to provide temporary support of existing thrust blocks, sufficient space for welding, adequate clearance for an excavator bucket;

c) additional clearance where one or both pipes contain bends, thrust blocks, tees, valves or other appurtenances;

d) consideration of the interference issues where one or both pipes have cathodic protection in place;

e) other utility owners may have greater clearance requirements.

3.4.2 Vertical Clearances

Where distribution mains cross other pipelines or utilities, the minimum vertical clearance required by the Water Corporation shall be:

a) 150 mm for pipelines up to DN300; and

b) 300 mm for pipelines larger than DN300.

Note that other utility owner may have greater clearance requirements.

For railway, freeway and highway crossings refer to clause 3.6 Trenchless Crossing.

3.5 Grade

Generally, DN500 or smaller pipelines shall be laid on a minimum grade of 1 in 500. This will achieve positive drainage of the pipe during emptying or scouring and will ensure that air valves are effectively placed and that they operate efficiently. Pipelines DN600 or greater shall be laid on a minimum grade of 1 in 1000.

In terrain with close undulations, the pipeline shall be designed to achieve an economical installation through a balanced consideration of an efficient pipeline depth, avoidance of rock excavation or deep excavations and/or dewatering requirement, minimizing the number of scours and air valves and their costly maintenance.

3.6 Trenchless Crossings

3.6.1 General

This section generally refers to pipelines installed using no dig techniques, it does not exclude the use of open trenched installation where appropriate.

A full geotechnical investigation is required in the design phase.

All road crossings, except minor country road crossings, should be at the normal 90 degrees.

Crossings shall be designed to facilitate the future replacement or relining. To facilitate future relining the pipeline should be dead straight in plan and profile. The straight pipe should extend past the crossing into land that is suitable for future entry and exit pits. The Corporation may require the initial pipe be slightly oversize to allow for future relining.

There are three options for trenchless installation applications in terms of encasement and grouting requirements:

a) No encasement pipe (carrier pipe only);

b) Encasement pipe with an un-grouted annulus;

c) Encasement pipe with a fully grouted annulus.

The design will determine:

a) Which encasement and grouting option is to be used;

b) The type, minimum class and cover for the pipes. However the installer may increase the pipe class or cover to suit the installation technique.

c) The installation techniques required, or excluded.

d) The minimum specification requirements for the installation.

The installer will produce a methodology plan and an installation plan. The installer may increase the designer's minimum requirements for the installation technique.

For Horizontal Directional Drilling, Table 3.2 provides the expectations of designers and tenderers.

Table 3.2: Horizontal Directional Drilling, Pre Award Expectations

HDD Characteristic	Expectations of Prelimary Designer	Expectations of Tenderer/ Contractor
Everyday work Simple Short Small Diameter Single pass	Geotech suitable for tenderer information and designers selection of appropriate trenchless technique.	Nominated experienced personnel. Proposed equipment and spares.

	Proof, by positive identification of services and other constraints, that the proposed entry and exits profiles are feasible. Undertake HDD specific constructability review, including pipe string locations. Design of pipes based on hydraulics, permanent loads, allowances for damage during installation and durability. Specification of the pipe and its minimum pipe class. State the allowable pull loading that is not to be exceeded. Proposed plan and profile. Predicted settlement and specification of maximum reamer size. Identify services, design pipe profile, including minimum and maximum cover and provide connection, air and scour details. Obtain all approvals. Prepare a specification specific for the project. Provide special conditions of tender to nominate the required information to be provided for tender evaluation.	Confirmation of proposed drill profile and specific reamer outside diameter. Proof of successful completion of prior projects, of similar size, length and conditions, that used the nominated personnel and proposed equipment. Including records of maximum pull loads, fluid pressures. Installation Plan. Contingency plan. Prove based on calculation or from construction records from previous jobs, that the installation loads will not exceed the designers stated allowable pipe pull loads. Upspec the pipe, as required for installation loads. Confirmation of • Maximum horizontal/vertical construction tolerances • Minimum achievable clearances to other services • Minimum drilling radius
Work including any of the following: Multistage reaming Mud recycling Longer than 150m Larger than DN 300 Reamer Significant infrastructure topside	As above plus: Geotech specifically for job specific drill fluid design by tenderers. Calculate expected pull loads. Predicted fluid pressures and frack out pressures. Design to consider suitable work areas: pipe stringing; minimise settlement and to allow for containment/repair	As above plus: Drill fluid program, including testing plan and onsite drilling fluid technician‘s role and responsibilities. Calculations of pull loads, drill rig anchorage, drill pressures, hydrofracture analysis and pipe stability. Proof of suitably matched equipment and capacity of equipment for pumps, drill, mud recycling for the expected conditions and installation rates.

	of fracking/collapse near the entry and exit. For complex work, engage the services of expert HDD consultants for design and tender evaluations.	Third party review of design and installation methodology.

3.6.2 No Encasement Pipe Installations

The carrier pipe and joints shall be fully corrosion protected and fully axially restrained.

Polyethylene pipe installed in trenchless crossings shall be specified at least a class higher than would otherwise be required after all other design considerations to allow for hidden scratches.

The carrier pipeline and associated short and long term side support shall be designed to carry all imposed loads. Proof of compliance to AS2566.1 is required.

The pipeline shall be suitably anchored, particularly if joining onto Rubber Ring Jointed (RRJ) components. Refer to example drawings BD62-8-36 and LJ01-2-1.

Directionally drilled PE may be accepted on a project specific basis. A substantial redundant thickness of PE is required as an allowance for scratching during installation.

3.6.3 Encasement Pipe with an Un-grouted Annulus

A permanent encasement pipe is required. Non-permanent encasement pipes (ie steel pipes) will eventually corrode (particularly at the joints) and allow the surrounding soil to fill the annular gap between the encasement and the carrier pipe, resulting in possible sinkholes.

The encasement pipe and joints shall be non-corrosive. The life of the encasement pipe shall exceed that of the carrier pipe. Reinforced concrete or GRP encasement pipes have traditionally been used.

The encasement pipe shall be designed to carry all imposed loads. Proof of compliance to AS2566.1 is required. The carrier pipe and joints shall be fully corrosion protected and fully axially restrained.

The encasement pipe shall provide a minimum annulus dimension between the encasement and carrier pipes of 150 mm to make allowance for the deviation in the encasement pipe and the thickenings at the joints of the carrier pipe.

The carrier pipe shall be suitably anchored, particularly if joining onto RRJ components.

All the spacers between the carrier pipe and the encasement pipe shall be non-corrosive. Spacers must be entirely non-conductive if either the encasement or carrier pipe are metallic, irrespective of pipe coating.

Ends of un-grouted encasement pipes shall be capped by means of a non-shrink grout plug 300mm thick. The grout plug shall not have weeps holes in order to prevent entry of water into the encasement pipe.

Note:

a) Except in special circumstances, PE as an encasement pipe is not expected to be suitable to carry all imposed loads.

b) MSCL as an encasement pipe is not considered to have a life exceeding normal carrier pipes.

For longevity, any MSCL carrier pipe joints require two welds:

a) For large pipes with internal access, required to have internal and external welds;

b) For smaller pipes without internal access, a welded joint with an additional concave band.

Joints shall then be externally corrosion protected.

The carrier pipe joints shall be capable of transferring axial loads, i.e. pipe joints shall remain intact, enabling the pipeline to be installed or withdrawn.

3.6.4 Encasement Pipe with a Fully Grouted Annulus

Steel, GRP or reinforced concrete pipe are acceptable encasement pipes. PE encasement pipe may be acceptable.

a) The encasement pipe shall be designed to carry all imposed loads prior to grouting of the annulus. Proof of compliance to AS2566.1 is required.

b) The encasement pipe shall provide a minimum annulus dimension between the encasement and carrier pipes of 150 mm to make allowance for the deviation in the encasement pipe and the thickenings at the joints of the carrier pipe. It also shall provide sufficient space for grouting.

c) Grouting pressures are to be selected and controlled to avoid collapse of the carrier pipe.

d) Spacers are required to prevent flotation of the carrier during grouting.

e) For MSCL carrier pipes with CP, the effect of any steel encasement pipes on the CP shall be assessed. Spacers shall be non-conductive.

Where either the carrier or encasement is metallic, the spacers between the carrier pipe and the encasement pipe shall be non-conductive.

DCVG or other external pipe inspection techniques for the carrier pipe are not suitable.

3.6.5 Installation Requirements

The designer shall specify the minimum installation requirements. Table 3.3 provides guidelines for minimum requirements for trenchless installations.

Table 3.3: Guideline for trenchless installation

	Input Conditions (Select the furthest right of any input conditions.)					
Level of Risk:	Low consequence of settlement			High Consequence of settlement		
Surface Environment:	Landscaping or Trees	Under rivers or lakes where settlement is not a problem		Environmentally sensitive or difficult to access areas		
Road Hierarchy Classification:	Access roads (A)		Local Distributor (LD)	District Distributor B (DB) Regional Distributor (RD)	District Distributor A (DA)	Primary Distributor (PD)
Rail classification:						Railway
Encasement Pipe diameter:	up to and inc DN250	up to and inc DN630	up to and inc DN250	DN300 to 600	DN 600 or larger	DN600 or larger
Geotechnical Conditions:				Undetermined or unfavorable conditions including Dry running sand, variable rock/sand, high ground water table.		
	Minimum Requirements					
Allowable Trenchless Technique:	Earth Pressure Balance Machine Boring					
	Pipe Jacking					Not Allowed
	Horizontal Directional Drilling			Not Allowed (Except where depth is sufficient to eliminate settlement)		Not Allowed
Maximum Diameter of bore, cutter, or reamer:	1.2*Carrier OD	1.2*Carrier OD	1.1*Carrier OD	Encasement OD + 2 times 10mm	Encasement OD + 2 times 10mm	Encasement OD + 2 times 10mm
No encasement pipe	Allowed	Allowed	Allowed	Not Allowed	Not Allowed	Not Allowed
Quality Requirements:	Geotechnical Investigation					
	Topographical Survey					
	Existing Services and Utilities Survey					
	Risk Assessment					
	Safety Management Plan					
	Environmental Impact Assessment					
	Methodology plan					
	Design Calculation					
	Installation Plan and Records					
		Onsite Drilling Engineer Required				
		Settlement Planning and Monitoring				
		Measurement of Soil Removal				
						Emergency Response Plan
						Grouting outside of Encasement Pipe, for encasement pipes with internal access
						Infrastructure Pre- and Post-Construction Conditions Report

3.6.6 Major Road Crossings

To control subsidence of open trenched crossings, cement stabilised sand backfill is required to the underside of the road formation (refer AS 2566.2).

The road crossing pipe shall extend a minimum of 1.5 m clear of the road shoulder.

Installation with respect to other aspects such as fittings, testing etc shall be in accordance with this Design Standard.

For pipelines with greater than 2m cover, it is impractical to close major roads and open excavate for maintenance. A maintenance culvert may be required over the pipeline, to allow access to the pipeline for maintenance and replacement.

3.6.7 Railway Crossings

Rail crossing shall comply with AS 4799 and the rail owners requirements.

Cathodic protection system to control the stray-current corrosion caused by electrified railway systems shall be considered based on project specific basis.

3.6.8 Bridge Crossings

Where pipelines are to be carried on bridges, both pipe and support designs shall be submitted to the authority responsible for the structure.

3.6.9 Water Crossings

The design of any water crossing shall take into account the importance of the water main, the likely time to repair and impact on customers.

The main should survive and remain operational for a flood not less than

1. 1/2000 annual probability of exceedance for:
    a. Trunk Mains, and
    b. Mains that convey the sole source of water for a major community, that are unlikely to be able to be repaired in a reasonable time.
2. Or, 1/500 annual probability of exceedance for other mains.

Note, if carting of water is practical, then the main is not necessarily a sole source.

Where access onto a pipe is required, access, platform, walkway and security treatment shall be provided in accordance with S151 - POF Standard and DS62 - Standard Security Treatments.

Security barriers are required to prevent access onto the pipe crossing.

For below drain crossings, a concrete covering is required over the pipeline to prevent scouring of the drain over the pipe and also to prevent accidental impact by drain clearing equipment.

3.7 Below Ground Pipelines

3.7.1 Reasons for Laying Pipe below Ground

The majority of pipelines are now laid below ground for the following reasons:

a) water quality (avoids temperature rise of water)

b) environmental (aesthetics and fauna movement)

c) economics (generally cheaper in all but the hardest rock ground condition)

d) practicalities (no surface barriers created)

e) shielded from UV radiation and heat, therefore all pipe materials can be considered

f) less maintenance

3.7.2 Trench Excavation, Pipe Embedment and Backfill

Trench depths shall be sufficient to achieve the specified pipeline bedding, cover and grade.

Typical pipe embedment types and loading conditions are shown in drawings EG20-1-1 and EG20-1-2 where the allowable horizontal bearing pressure (AHBP) is 50 kPa or more. The material and compaction requirements for these shall be as detailed in these drawings and project drawings by the designer.

The designer shall specify special bedding to suit conditions where the trench floor has:

a) irregular outcrops of rock;

b) AHBP of <50 kPa; or

c) disturbed by groundwater or other activity.

The designer shall specify special bedding and embedment for inadequate and poor foundations (Refer to AS 2566.2)

The minimum embedment zone dimensions L_b, L_c and L_o shall comply with the dimensions provided on drawing EG20-1-1. Pipe trench width shall be nominally rounded up to accommodate the next larger standard backhoe bucket width.

Trench width shall be selected to allow effective placement and compaction of backfill in accordance with the specified requirements.

Wherever the natural soil along the pipeline route has an allowable horizontal bearing pressure (AHBP) of 50 kPa or more but does not strictly meet the embedment material requirements shown on drawing EG20-1-2 (eg Pindan sand), the designer shall consider:

a) an embedment design that accommodates use of natural material available along the pipeline route together with an appropriate pipe material and class selection for that natural material, and

b) a design using imported material and disposing of unsuitable material.

The designer shall then develop the most cost effective design that delivers a pipeline structural and service performance that is acceptable to the Corporation.

3.7.3 Trench stops

Trench stop shall be considered for pipelines where the grade exceeds 10% and the native soil is not free draining.

3.7.4 Steel Pipelines

3.7.4.1 Requirements for Restricted Access Steel Pipelines

New MSCL pipe that will be difficult to access, such as pipe located under major roads (for example, district and primary distributor roads), inside protective culverts or deeper than 3 m to invert, shall have at least two leakage barriers. That is, single RRJ and single weld joint pipes are to be overbanded.

For existing MSCL pipe, where modifications will result in the pipe being difficult to access, all joints that are not already double welded and internally corrosion protected, shall be overbanded.

3.7.4.2 Concrete Encased Pipework

MSCL Pipes, fittings or portions thereof which will be cast in or encased in concrete shall be Sintakote or bare steel coated with Caltex Rustproof Compound D2 or approved similar.

The coating used on the permanently exposed or buried section of the pipe shall extend 75 mm into the concrete.

3.7.4.3 Cement Mortar Lining

Field joint reinstatement is to be carried out using premixed materials as recommended by the pipe manufacturer. Nitobond EP is a concrete repair primer which has been previously used with Renderoc HB40. To address odour issues, Nitobond HAR is the specified primer to be used with Renderoc HB40 in reinstatement works. Repairs shall be carried out in accordance with MSCL Pipe supplier’s repair guidelines.

Cement mortar lining at welded pipe joints shall be made good for all DN 600 pipelines and larger, and wherever possible, for DN 500 and smaller. (Designers and constructors shall contact the Corporation regarding the limit of access into a pipeline).

3.7.4.4 Earthing Systems

Electrical earthing systems shall be incorporated in structures attached to below ground pipelines – refer to clause 3.14.12.

3.7.4.5 Cathodic Protection

Sintakote is the primary external corrosion protection for MSCL pipe. Cathodic Protection is a supplementary corrosion protection system which may be employed on welded joint steel pipelines immersed in water or buried in aggressive soil. Where Cathodic Protection is required and RRJ or RRJ-WR pipes are used, Cathodic Protection lugs prefabricated by the supplier are preferred.

The conditions that promote corrosion may include:

a) low resistivity soil,

b) high sulphides,

c) low pH,

d) fluctuating water table, and

e) adjacent pipelines with CP.

The selection, design, maintenance of CP systems for buried pipelines shall be in accordance with Water Corporation DS 91 - Standard for the Selection, Design and Monitoring of Cathodic Protection (CP) system.

3.7.4.6 Direct Current Voltage Gradient Survey (DCVG)

A direct current voltage gradient survey (DCVG) shall be carried out to detect and locate coating defects on new buried welded sections or bonded RRJ sections of steel pipelines.

The DCVG survey shall be carried out by the pipeline constructor using a qualified corrosion consultant approved by the Water Corporation.

3.8 Anchorage of Buried Pipelines

3.8.1 Thrust

Pressure pipelines develop thrust at changes of direction, changes of diameter, tees, valves and blank ends.

3.8.2 Thrust Restraint

a) Thrust Blocks

Thrust in smaller diameter RRJ pipe is usually resisted by the provision of thrust blocks. Standard blocks are detailed in the DS 63 - Water Reticulation Standard for pipe sizes up to DN250 and pressures up to 1200kPa. Thrust blocks for pipe diameters above DN250 require specific design for the appropriate soil conditions. For pipelines above DN600 the required block size can become excessively large and impractical to install without taking up more than a full road lane width or most of the verge width allocated to other service providers. In DN1400 pipe at 210m pressure, thrust blocks required would be the size of a small building and at several times the cost.

b) Welded Lengths

Thrust in large steel pipelines may be resisted by developing sufficient soil friction surrounding an adequate length of welded pipeline. The welded sections of the pipeline must bear against undisturbed soil or suitably compacted backfill.

c) Welded Length for Anchorage of Straight Pipe

1. The welded anchorage length is usually calculated using the American Waterworks Association M11 (1998 revision) formula. The total friction is based on the friction factor times the weight of soil acting above the pipe plus the friction factor times the weight of pipe and contents and soil that bears on the soil below the pipe. Unless modified for saturated soil conditions, this approach is unconservative for flooded backfill conditions as the effective weight of soil acting on the pipe and the effective weight of the pipe and contents are all reduced due to buoyancy.
2. A friction factor of 0.37 was measured in shear box testing using sand from Anketell Road, Kwinana, and Sintakote II. As this measurement is from a single source of sand, it is appropriate to reduce the factor to 0.32 for general sand (textbook value).

d) Welded Steel Pipe Length Required for Anchorage of Bends

Determining the component of the bend thrust resisted by tension in the pipe legs is not simple and should not be determined by empirical formulas. The unbalanced internal pressure force developed at a bend will be resisted by a combination of the pipe bearing against the soil at the bend and the tension along the pipe legs (refer to

Figure 3.1).

For example, should a pipe bend be located to bear against solid massive rock, the bend thrust will be countered entirely by bearing forces between the rock and the pipe.

However, should the same pipeline and bend be located in swampy condition with very low horizontal bearing resistance, the majority of the bend thrust will be balanced by axial tension in the pipe ‘legs’ which is in turn balanced by pipe/soil friction along long ‘leg’ lengths of the pipe.

The majority of pipeline bends are buried in conditions between the solid rock and swamp extremes. Hence the bend thrust will be resisted by a combination of both:

1) bearing forces between the pipe bend/soil, and

2) axial tension in the pipe 'legs' which is in turn balanced by pipe/soil friction along long 'leg' lengths of the pipe.

Small diameter pipelines, low MAOP and small angle bends will result in small thrust forces that may well be able to be predominantly or completely resisted by soil bearing capacity, refer to Figure 3.2.

However, the soil bearing capacity is limited and further increases in bend thrust must be resisted by increased leg tension. For very large bends (1.4m diameter, 90 degree) operating under high pressures (210m) the relative contribution of soil bearing resistance to the bend thrust is very minimal, refer to Figure 3.2.

To determine the relative contribution of the soil bearing and leg tension, the design requires:

1. a soil and pipe stress/stain deformation FEA model, or
2. a rational approach where the soil bearing resistance is conservatively calculated and the remaining net thrust (bend thrust– soil resistance) is resolved into tension along each bend leg.

Figure 3.1: Derivation of Limit State Forces on a Pipe Bend

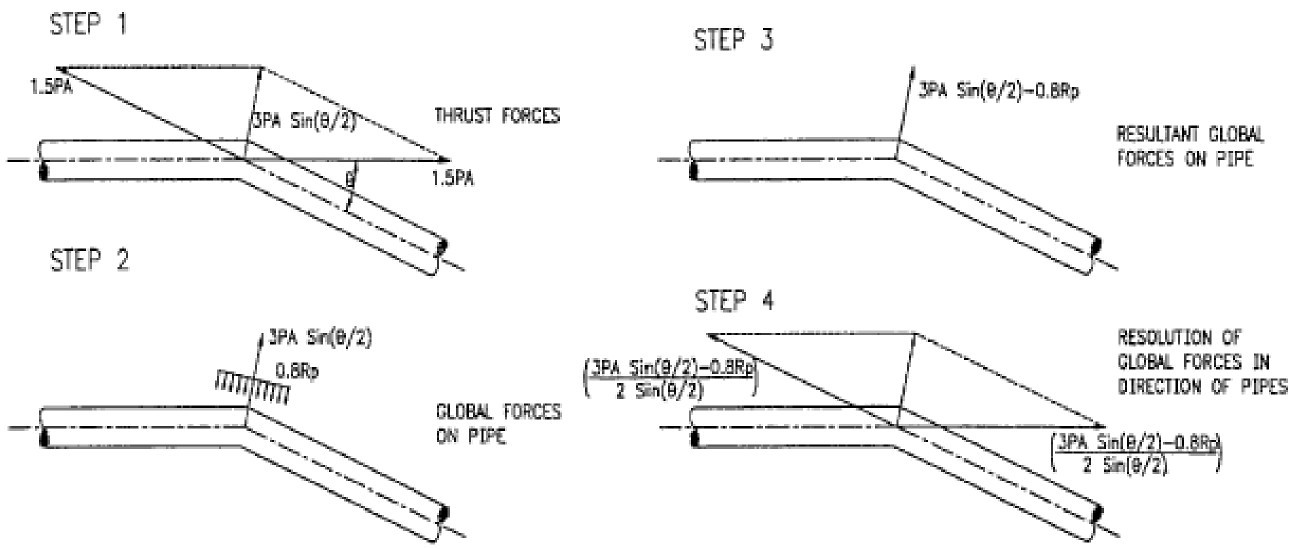
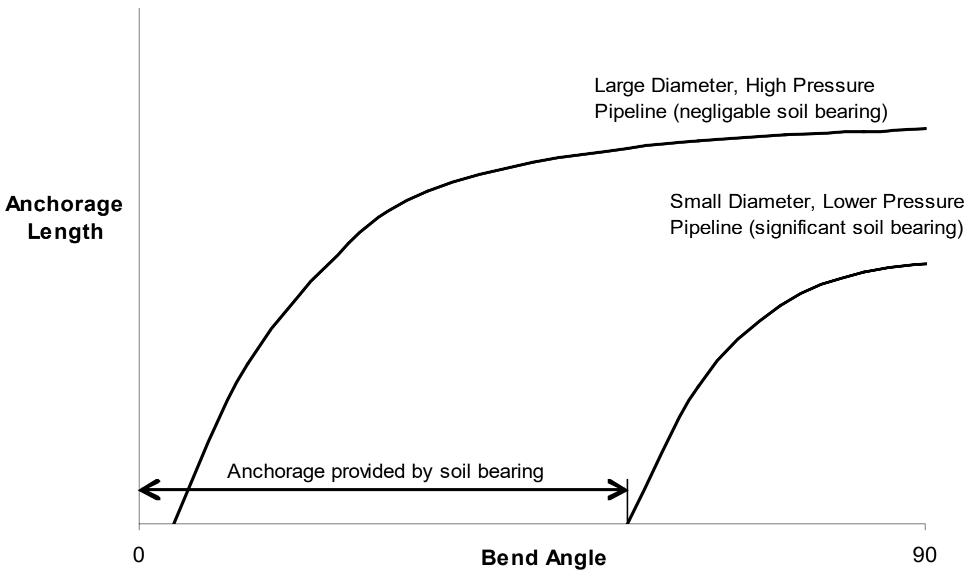


Figure 3.2: Comparison of Anchorage Lengths for Varying Conditions



The measured friction factor is provided for information only. Designers should be cautious in using this information for other backfill materials and locations

The use of anchor blocks to resist thrust in large diameter steel pipelines is not a preferred option of the Corporation, except where induced voltage may develop from nearby high tension power lines.

The length of welded joint pipe is to be minimised by design. The design should:

a) Minimise unnecessary large angle bends
b) Co-locate section valves where anchorage is already required for necessary bends
c) Use a series of small angle bends that do not incur significant anchorage costs
d) Use large radius pipe curves utilising the allowable angular deflection at pipe joints / banded joint

Anchorage may be incorporated in suitably designed valve pit walls.

3.8.3 Anchorage on Steep Slopes

Precautions shall be taken to prevent movement at the joints when buried pipelines are constructed on steep slopes.

Steel pipes laid on steep slopes shall have welded joints for the sloped distance extending to beyond the top end of the slope to meet anchorage and other requirements.

The bedding and backfill may be scoured out by water movement. Water movement within the trench can be controlled by clay stops at designated intervals. Concrete cut-off collars with subsoil drains have been used with success where the conditions were particularly adverse.

Surface erosion can be controlled by the use of cut-off drains combined with careful rehabilitation using natural topsoil, seeded final trench fill, geofabrics and rip rap.

3.9 Marker Posts and Gates

Standard marker posts shall be installed to indicate pipeline locations, pipeline alignments and valve locations where kerb marking is not possible. For safety reasons, standard marker posts shall be flexible posts type such as Dura-Post Reflex-Post (Refer to drawing planset KA76).

Post locations shall be shown on the design drawings, and should be located:

a) at fence lines,

b) to indicate the location of bends, manholes of other pipe fittings,

c) to allow the identification of the pipeline location when viewed from the adjacent road,

d) where practical, to allow visible sight between adjacent markers.

Gates will be required in all fences, where crossed.

3.10 Tracer Tape

Where it is practicable, Wavelay or equivalent detectable underground warning tracer tape shall be used to safeguard pipelines from being damaged by any operating excavation equipment. Tracer tape shall be located 300mm above the pipelines and indicated on the bedding and backfill design drawing.

3.11 Connections to Distribution and Reticulation Mains

Connections of new pipelines to commissioned pipelines shall be carried out by the pipeline contractor under the Water Corporation's supervision and at the Corporation's discretion.

Reticulation mains should be connected to distribution mains at road intersections. In urban or industrial subdivisions, the minimum size connection shall be DN200 mm. If more than 250 services are expected to be supplied from the connection, then a DN300 connection shall be installed. The size of the connection shall be submitted for acceptance by the Water Corporation.

Intersecting mains shall be connected by means of a bypass connection, not a "cross". This is detailed in the DS 63 - Water Reticulation Standard.

Where a disconnection from an existing distribution main becomes necessary, the offtake valve shall be removed and offtake pipework terminated or removed. For steel pipe, the distribution main shall be plated and the coating and lining reinstated.

3.12 Above Ground Pipelines

3.12.1 Reasons for laying pipe above ground

Pipelines are generally constructed above ground to:

a) avoid extremely corrosive ground conditions

b) avoid contaminated sites

c) avoid expensive trenching conditions, such as hard rock, swampy conditions. Note that for steel pipes greater than DN600, excavation of 'normal' fractured rock is generally less costly than providing above ground pipe

d) allow easy access for maintenance or inspection, particularly valve complexes within secure sites

e) cross a river or waterway when a buried pipeline is not a feasible option

Disadvantages of above ground pipelines are:

a) exposures to fire damage

b) exposures to vandalism and impact from falling trees

c) adverse effect on water quality due to the rise in water temperature

d) increased maintenance

e) permanent environmental and aesthetic impact

f) difficult to prevent determined people from gaining access to the pipeline

g) risk of liability claims should people fall from the pipe.

3.12.2 Pipe Type

For above ground steel pipes, including those installed through valve pits, welded joint, sintakoted, cement mortar lined steel pipe is the preferred pipe type. Other pipe types or joint types may be considered by the Water Corporation for specific applications.

3.12.3 Pipe Supports

The pipe shall be supported on cast in situ concrete saddles designed to provide adequate bearing area for the pipe and to suit the soil conditions.

The design of the pipe span shall take into account all of the stresses induced on the pipe.

Straps or over-the-pipe restraining saddles shall be provided at centres sufficient to hold the pipe in place (not to exceed 80m centres on straight pipelines).

Pipe supports should be a minimum 1 m clear distance from pipe joints.

3.12.3.1 Pipe Supports – Modifications to Existing Painted Pipe

The contact area between the saddle supports and pipe has traditionally been difficult to seal against moisture ingress and the development of corrosion.

A steel pad should be installed between the steel pipe and the neoprene pad, as shown in Figure 3.3. The benefits of this include:

a) Allows seal weld between pipe and saddle

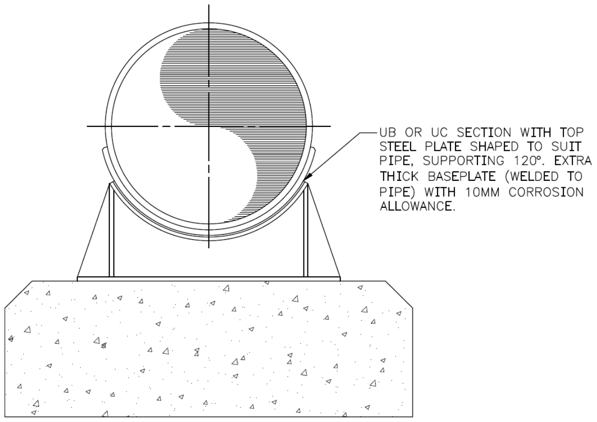
b) Allows for repainting of support/pipe as required

c) Extra thick baseplate has corrosion allowance

d) Eventual corrosion of baseplate does not compromise the pipe integrity.

NOTE:

- Figure 3.3 is diagrammatic only, actual dimensions to be determined by design.
- Pipe support to provide 120° of support to underside of pipe.
- Bolt edge distance, size, number of and embedment depth in concrete to be determined by engineer.



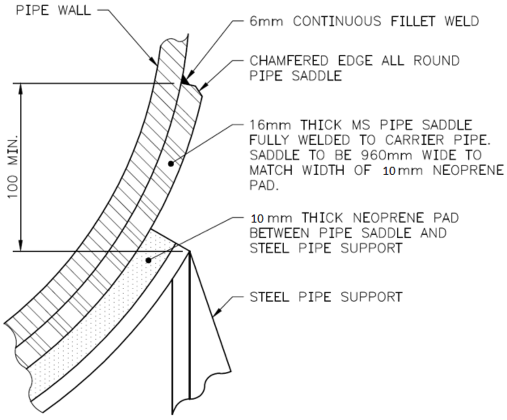


Figure 3.3 Acceptable Pipe Support Details (for modifications to existing painted pipe)

3.12.4 Deficient Pipe Supports

Historically, the concrete support to pipe interface has promoted interface corrosion and been very difficult to repair. Deficient designs are shown in Figure 3.4 and include:

a) Excessive encasement of the pipe by the support block resulting in support cracks due to the expansion of the pipe from thermal and/or internal pressure.

b) Concrete support shaped to profile of pipe leading to trapped moisture and corrosion that cannot be easily repaired.

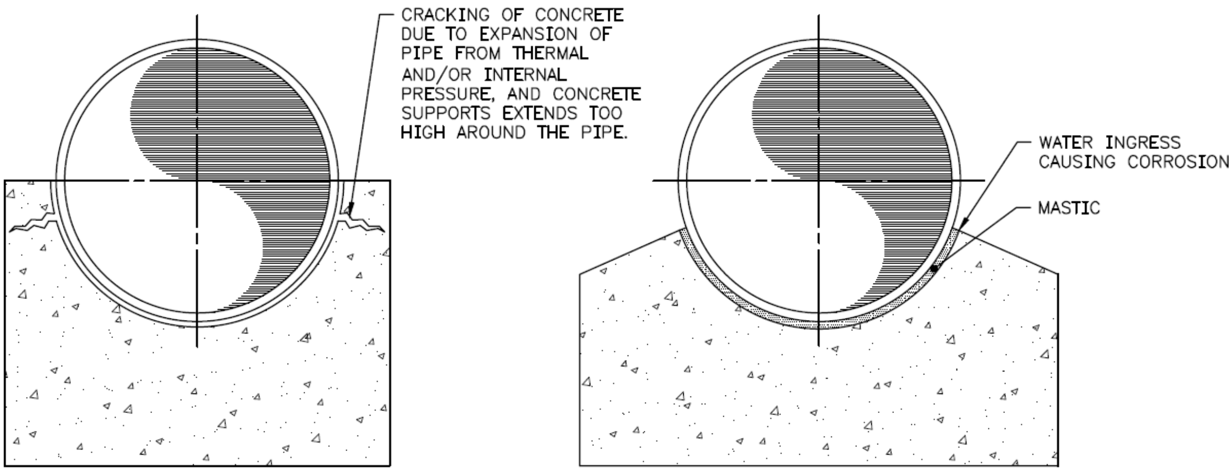


Figure 3.4 Deficient Concrete Supports for MSCL Pipelines

3.12.5 Pipe Anchorage

The stress and strain effects in welded joint pipelines due to temperature change shall be considered in the design of above ground pipelines. The design shall specify the appropriate 'link-in' temperature range to mitigate the temperature effects.

Above ground pipes shall be restrained at changes of vertical and horizontal direction, tees, changes of diameters, valves and blank-ends and where the pipeline is laid on steep slopes.

Restraint is usually achieved by the use of over-the-pipe reinforced concrete thrust blocks and anchor blocks. Other techniques, such as 'screw-in' piles may be considered by the Water Corporation for specific applications.

3.12.6 Other Requirements

Minimum grade, pipelaying qualifications, welding, earthing systems, preparation for flexible couplings etc are as required for buried pipelines.

3.13 Valves

3.13.1 Valve Types, Uses and Installation

For mechanical design standards, guidelines and preferred engineering practice for valves refer to corporation's Standard DS 31-02 - Valves and Appurtenances-Mechanical (DS 31-02).

3.13.1.1 Pressure Rating

Valves shall comply with one of the following pressure ratings as applicable:

a) PN 16

b) PN 21

c) PN 25 (ISO Standard)

d) PN 35

3.13.1.2 Valve Types

Valves that are commonly used in the Water Corporation's system are as follows:

a) Section Valves – used for isolating sections of pipelines during maintenance shutdowns etc. They shall be operated in either a fully open or fully closed position.

b) Isolating Valves – used for isolating pumps, storages, bores etc. They shall be operated in either a fully open or fully closed position.

c) Bypass Valves – the bypass enables the main valve to be operated under balanced pressure conditions and allows pipelines to be filled through the bypass at an acceptable rate.

d) Non-Return Valves – used to prevent reverse flow in pipelines.

e) Double Air Valves (DAV) – located at high points in pipelines to allow air to escape automatically or to allow air in or out during emptying or filling. An air valve may be required adjacent to section valves for the same reason.

f) Scour Valves – located at low points in pipelines to enable draining during pipeline maintenance.

g) Pressure Reducing Valves (PRV) – used to reduce high pressures in pipelines.

h) Pressure Sustaining Valve (PSV) – installed where the objective is to maintain a preset minimum head upstream of the valve.

i) Level Control Valve – installed where the objective is to maintain the water level in storage within desired limits.

j) Regulating Valves – used for regulating flow in pipelines.

3.13.1.3 Installation

On steel pipelines, valves are normally installed by using two flanged matching pieces which are bolted to the valve prior to making the closing welded joint to the pipe (usually of the banded type). Misalignment at the flange faces is eliminated by this method. For large valves DN 600 and above, the Water Corporation purchasing contract allows the purchase of factory pressure tested valve assembly including the flanged matching pieces and by-pass. This eliminates any dispute between the valve supplier and installation contractor should the valve flanges leak during onsite pressure test.

The designer shall also specify the appropriate use or absence of isolation joints, bonding studs and bonding straps and earthing as required to suit the valve operation, cathodic protection and voltage mitigation.

Unless otherwise contained in the mechanical standards, the designer shall specify the flange type, gasket type and bolting torques.

3.13.1.4 Valves Above Ground, Buried or in Pits.

Where the locality allows the installation of above ground pipework, such as a valve complex inside a secure compound in an undeveloped area, the use of above ground pipework and valves has the following advantages (for both the valving and associated equipment such as flowmeters etc).

a) Visual identification of valves and the flow they control.

b) Valve is accessible for external condition assessment.

c) Valve set to a suitable operating height.

d) Valve accessible for maintenance or replacement

Where the locality requires buried valves, such as public accessible areas, the use of direct buried valves is general preferable to installing valves in pits.

Buried valves should not be located under roadways. Valves should be located

a) away from major intersections,

b) to avoid the pavement of future road widening, turning lanes or roundabouts.

c) to avoid traffic hazards whilst being operated / maintained

d) to allow all weather access by HIAB type trucks

The use of valve pits may be considered for valves that require routine maintenance, such as non-return valves.

The use of valve pits, or enclosures, may be considered for valves that emit noise, such as PRV’s, and the noise needs to be attenuated. In some instances, some Regions may require section valves, non-return valves etc to be installed together with a dismantling joint. Some dismantling joints may not be suitable for burying in which case a valve pit would be required.

3.13.1.5 Valve Markers

Valve markers or signs shall be installed to enable easy location and identification of the valves. Refer to drawing set KA76 for standard marker posts.

3.13.2 Section and Isolating Valves

Assets should be designed to eliminate or minimise the need for person entry wherever possible.

Where personnel are required to undertake inspection or maintenance within a workspace that may be subjected to rapid inundation and limited means of egress, an Occupation Safety and Health (OSH) objective is to provide two points of effective isolation (control) between a live main and the workspace.

3.13.2.1 Types

Section and isolating valves may be butterfly valves or gate valves. However, butterfly valves are normally used for pipelines of DN 600 or larger diameter and sluice valves are normally used for valves of DN 400 or smaller. Resilient seated sluice valves are preferred for DN 400 and smaller.

3.13.2.2 Location

For distribution mains, section and isolating valves will be located approximately 2 km apart or at pipeline junctions.

For trunk/transfer mains (long pipelines), they will be located approximately 5 km apart or at pipeline junctions.

Closer spacing may be required at bridge crossings, freeway crossings, or for other operational and maintenance reasons etc.

For rural trunk mains, section valves shall be located to allow all weather access, ie close to roads with vehicle access to the valve location (and not accessed through farm paddocks).

On trunk mains, proposed or future town water supply off the trunk main should be taken from the bypass around the section valves. This will allow feed from either direction during shutdown of portions of the trunk main.

In situations where cross connections exist between treated and untreated water pipe systems, and also between operating schemes and non-operating scheme (stagnant or offline for a considerable amount of time) double section/isolation valves shall be used to separate the systems by incorporating an air gap between them as outlined in Criteria for Regulated Water Supply (August 2004). Scour valve shall be installed in between the double isolation valves and shall remain open during isolation.

3.13.2.3 Buried Valves

Valves suitable for buried service shall be used whenever possible.

DS 31-01 and 02 - Pipework and Valves and Appurtenances – Mechanical (DS 31), and relevant SPS's address the Corporation's requirements for sluice valves and butterfly valves, gearing, bypasses, unbalanced head operation except that all valves are to be double flanged.

3.13.2.4 Butterfly Valves

All butterfly valves shall be geared except for those used for air valve isolation (in which case, lever operated valves shall be used).

Valve pits are not required for butterfly valves rated for 'buried service'.

Butterfly valves of DN 250 or less, installed above ground, may be lever operated providing there are no detrimental effects (water hammer etc) caused by the rapid closing.

Butterfly valves that are subjected to continuous immersion shall have the valve gearboxes rated for continuous immersion to a depth of 5m above the base of the primary gearbox as outlined in DS 31-02.

3.13.2.5 Size

Section and isolating valve sizes should be as dictated by the hydraulic requirements and the capital cost.

Large diameter mains in particular will have a reduced capital cost by using two reducers and a smaller section valve. A size reduction of one or two standard diameters, but not less than two thirds of the pipeline diameter is normally acceptable unless there are specific reasons to use full size valves. In general terms, a reduced size valve is less expensive than full size valves and the reduced size flanges are less likely to have sealing problems.

Full size valves are used:

a) On small and medium diameter mains, where the cost of two reducers is greater than the saving in valve costs.

b) on the suction side of pump pipework within pumping stations to limit the loss in NPSH available, and

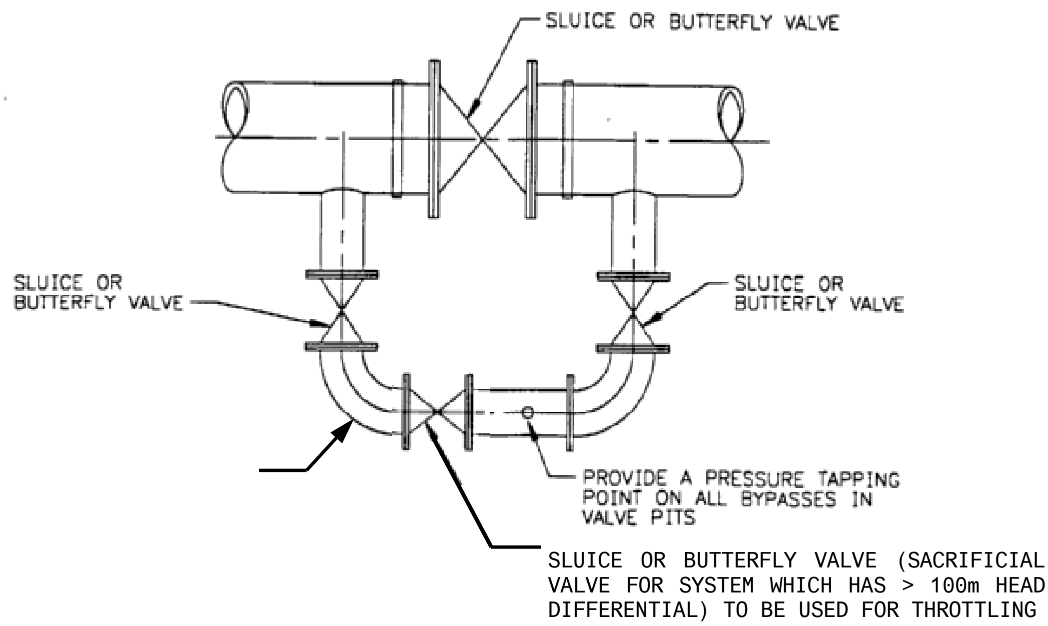
c) on surge vessels to enable fast flow of water in or out of the vessel, and

d) tank outlet pipework supplying pump stations

3.13.3 Bypass Arrangements

Refer to DS 31 and DS 65 - Pipe Fittings Standard Drawings

Figure 3.3: Two Valve Bypass Installation (Sluice valves are normal, Collars not shown)



3.13.4 Non-Return Valves

Refer to DS 31

3.13.4.1 Purpose

Typical applications of non-return valves are:

a) On the delivery pipe work of all pumps

b) On a bypass pipeline around a booster pump to allow flow to pass the pump when the pump is off and to prevent reverse flow into a pump suction system, and

c) On surge tanks and surge vessels.

It is important that non-return valves are readily accessible and easily isolated for maintenance.

Non-return valves generally should not be buried. For pit details refer to the Standard Drawings.

A section valve should normally be located in close proximity to a non-return valve. In strategic application, section valves should be installed close to and upstream and downstream of the non-return valve.

Pressure tapping points are required close by and on both sides of a non-return valve of DN 300 and larger.

3.13.5 Air Valves

3.13.5.1 Purpose

All air valve installations are required to perform two different functions:

a) to evacuate air which accumulates while the pipeline is operating normally under pressure, and

b) to exhaust or admit air while the pipeline is being charged or drained of water.

Evacuation of the air is essential. If it is not removed, it can:

a) dramatically affect the hydraulic performance of the pipeline,

b) affect the water quality (causes white water),

c) accelerate corrosion,

d) cause erosion of the pipe lining, and

e) cause secondary surges.

The ability to admit air into the pipeline is required when closed sections of pipelines are emptied for maintenance.

Air valves should be sized to:

a) prevent negative pressure induced pipe collapse, and

b) allow the pipeline to drain within the prescribed time limits.

3.13.5.2 Type

Double acting air valves shall be used in all circumstances.

The design principle shall be such that it ensures that the ball or float in the air valve is not caught up in the flow of high velocity air resulting in the valve closing prematurely. The large orifice of the valve remains shut during normal pipeline operation.

Air valves shall:

a) not have a built-in isolating valve,

b) have a suitable air flow capacity,

c) be of a suitable pressure rating,

d) have suitable corrosion protection for the intended operating environment,

e) have an acceptable operating noise level,

f) be physically compact.

3.13.5.3 Location

Each section of the pipeline (i.e. between section valves) shall be checked for appropriate air valve locations.

Air valves shall be located:

a) at all physical peaks in the pipeline profile,

b) at 1 km maximum intervals on long flat pipelines,

c) at the downstream side of all flow regulating valves, pressure reducing valves and pressure sustaining valves, and

d) at changes from a long, shallow downgrade to a steep downgrade.

These guidelines result in less air valves than 'textbook' or DS 31-02 requirements and have proven to be sufficient for typical distribution mains. The reduced number of valves results in significant ongoing operation and maintenance savings. Typical distribution mains have the following advantages in limiting air intake or retention of air in pipelines:

a) Typical distribution mains are gravity fed from a high level source, such as a tank, reservoir or dam and as a result are normally full of pressurised water, which limits the opportunity for air entry.

b) The flow rate generally changes according to daily demand. The profile of the hydraulic grade line changes accordingly, reducing the probability of small pockets of air being permanently trapped at relative peaks in the HGL vs pipeline long section.

Pipelines that operate with close to negative suction pressures due to pump stations, bores or water hammer will require additional air valves. For example, they may require locating additional air valves as required by DS 31-02 in the first portion of the pipeline.

Pipelines that drain and refill as part of normal operation will require additional special provisions for air removal and intake.

Note: There is a general requirement that pipelines be laid on a grade no flatter than 1 in 500, hence in long flat terrain the maximum spacing for air valves would be approximately 1 km or less.

In some circumstances, air valves may need to be considered for profile peaks with respect to the maximum hydraulic gradient (that is points of lowest operating water pressure in the pipeline), and for peaks in the maximum hydraulic gradient.

On public road reserves above ground air valves should be located outside the road clear zone (Guidance available in Austroad Guide to Road Design Part 6 and MRWA supplement to Austroads Guide to Road Design part 6). and if practical generally as close a practical to rural boundary fence. Located to minimize traffic management and traffic hazards. This can generally be achieved through the use of an offset air valve.

Marker posts should be used in preference to bollards and preferably located outside the road clear zone. Any marker post required to be within the road clear zone are to be the frangible type.

Bollards should be avoided or located outside the road clear zone.

Where possible, Air valves should be above ground type and should be located to avoid:

a) pits in roadways,

b) becoming submerged by high groundwater or ponded water. In flooded rural road reserves or paddocks, air valves are typically located above ground with suitable protection/location bollards,

c) in rural mains crossing farm lands, and where practical without significant additional trenching costs, air valves and scour valves should be preferentially located at roads, boundaries, fencelines or tracks (ie to avoid becoming isolated obstructions in paddocks).

3.13.5.4 Size

Air valves shall be sized such that for any section of pipeline:

a) it shall be possible to drain the pipeline in 8 hours, and

b) it shall be possible to fill the pipeline in 4 hours.

c) However, the size shown in Table 3.2 shall be the minimum size used.

Table 3.2: Sizing of Air Valves

Nominal main diameter (mm)	Air branch and valve size (mm)
<300	50
300	80
400	100
500	100
600	100
700	150
800	150
900	150
1000	150
1200	150
1400	150
1600	150

The air valve size shall not be less than 50 mm or larger than 150 mm.

If required, the DN 150 valve size on larger pipes shall either be positioned closer together or in a multiple configuration.

3.13.5.5 Installation

A separate isolating valve is required to allow the air valve to be removed (for maintenance) and replaced without interruption to the operation of the pipeline.

In the case of DN 50 DAVs fitted to mild steel pipes, a DN 100 flanged spigot is welded to the pipeline instead of welding on a tapping plate or button. The advantages are:

a) Bi-metallic corrosion is confined to a replaceable tapped deadplate

b) The air valve can be readily upgraded to a DN 100 installation if necessary

Installation details shall be as shown in the Corporation's Pipe Fittings Standard Drawings – DS65.

3.13.5.6 Ventilation

Air valves on buried pipelines in urban areas shall be installed in pits. In rural areas, air valves on buried pipelines may be mounted above ground on a branch pipe.

Where it is necessary for the pits to have covers, it is essential that ventilation be provided to allow the entry/exit of air.

Air valves are likely to be ineffective during draining of pipelines if the pit covers prevent air entry.

Ventilation may be critical in 'emergency' cases where the air valve is required to admit air to the pipeline during negative water-hammer surges.

3.13.6 Scour Valves

3.13.6.1 Purpose

In all typical circumstances, sluice valves are used as scour valves on pipelines.

Scour valves on pipelines are used to empty the pipeline, usually for maintenance operations. This normally occurs under low differential head conditions because the section valves will be closed and the head is created only by the elevation profile of the pipeline. Sluice valves are therefore adequate to control the rate of the emptying under these low head conditions.

Flushing points are addressed elsewhere.

3.13.6.2 Type

General

Discharges from scour valves shall be arranged to:

a) prevent backflow contamination of the pipeline

b) where possible, allow the discharge to be viewed during the scouring process

c) ensure adequate flow control

d) avoid damage to property and public inconvenience

Direct connection from the scour valve to a drainage pipe shall not be acceptable unless approval has been obtained from the Local Authority.

<u>Scour into Pit</u>

Design shall be prepared in accordance with Standard Drawing EG20-6-1. This arrangement is generally well accepted and has the following advantages:

- allows for simple inspection and changing of valves

- allows for a second valve to be bolted on
- allows more than one pump to be used to remove scour water if necessary.

Scour pits shall not be deeper than 3.5m.

Pitless Scour

Design shall be prepared in accordance with Standard Drawing EG20-6-8. This arrangement requires project approval, and has the following advantages:

- eliminates both prevention of falls and confined space entry requirements.
- removes the requirement to use a portable grid mesh cover over a pit.
- pipe can be drained by either connecting temporary hose to the camlock and directing drainage water; removing the camlock adaptor and allowing water to spill out of the riser; or pumping the water from the riser using either an open suction or submersible pump.
- reduced footprint lessening the extent of intrusion into other utility service corridors.

High Volume Scour

For high volume scour scenarios (of any size), 2 adjacent sluice valves (geared if required) are required. The valve closest to the main acts as the isolating valve, whilst the other is used for scouring (acts as the sacrificial valve).

The valve used for throttling is to be a metal seated valve, the sealing valve is to be a resilient seated valve.

Scours on High Pressure Pipelines

Any scours subject to high pressures should have two valves to allow throttling, similar to high volume scours.

Where this high pressure is generated from pipelines in steep or deep valleys, extra scours shall be provided at higher elevations along the length of the pipe. These can be opened first to lower the pressure progressively along the pipeline.

3.13.6.3 Location

Each section of the pipeline (i.e. between section valves) should be checked independently for appropriate scour valve locations.

Scour valves shall be located:

a) at all physical low points in the pipe profile, and

b) at 1 km maximum intervals on long flat pipelines (refer note below).

Scour valves shall not be located in roadways.

Scour valves shall be located at suitable locations to allow the pipe to be scoured at high rates, and where erosion or damage from chlorinated water can be managed or will not present problems. This may result in scour valves being located at points other than physical low points.

This requirement is particularly important for the commissioning of new mains or to remove water that has to be scoured as a result of a chlorination failure.

High rate scours are required in conjunction with the first flow control valve downstream of a chlorination plant. Designers shall design the size and location of high rate scours in to suit the Corporation's operating requirements and commissioning procedures.

Note: There is a general requirement that pipelines be laid on a grade no flatter than 1 in 500, hence in long flat terrain, the maximum spacing for scour valves would be approximately 1 km or less.

3.13.6.4 Size

For normal installations the size of the scour branch and valves shall be in accordance with Table 3.5.

Table 3.5: Sizing of scour valves

Nominal main diameter (mm)	**Scour branch and valve size (mm)**
300	100
400	100
500	100
600	100
700	150
800	150
900	150
1000	150
1200	150
1400	150
1600	150

In most cases, the rate of scouring or draining of a pipeline is likely to be constrained by the ability to dispose of the volume of water (usually the pump out capacity). Hence it is considered that a more graduated or larger range of sizes is not necessary.

Scour sizes may be increased where disposal situations are suitable and provided that air valve capacities are checked.

Installations with special scour requirements such as high pressure dispersal or disposal of water with high debris loading will require an individual design.

The minimum size scour is DN 100.

Large mains often require twin scour valves in series, the closest to the main used for full open/full close isolation and the second valve used to throttle and control the scour rate. The second valve can wear out during throttling and can be replaced while the main is online with the isolation valve closed.

3.13.7 Pressure Reducing and Pressure Sustaining Valves

Refer also to DS 31.

3.13.7.1 Purpose

These valves are hydraulically-actuated control valves which are used in a variety of situations to control pressure, flow rate or water level. The same basic valve can be used to achieve each of these functions by changing the hydraulic servo-circuit on the valve.

The typical applications are:

a) a pressure reducing valve (PRV) where the objective is to maintain a constant head downstream of the valve and/or to limit the downstream pressure to a set maximum

b) a pressure sustaining valve (PSV) where the objective is to maintain a preset minimum head upstream of the valve

Less frequent applications are:

a) a rate of flow control valve. The objective of these valves is to achieve a constant flow rate or at least limit the maximum flow rate; and

b) combinations of two or more of the above applications can be configured in the one valve.

3.13.7.2 Type and Design Considerations

Diaphragm valves are the preferred type, however they are generally only available in sizes up to and including DN 600.

The piston type of valve is not preferred because the water in the actuating chamber is separated by hydraulic seals, which if not regularly serviced, are susceptible to leakage which leads to the failure of the valve.

Valves with flanged-end connections shall be used for all sizes DN 50 and above.

Screwed-end connections shall be used for all sizes less than DN 50.

Stainless steel trim is used in all valves to resist wear and damage from cavitation.

Valves shall be supplied with filters and pilot valves.

Other design considerations for hydraulically actuated control valves are:

a) the amount of head loss across the valve

b) the stability of the valve at low flow rates

c) the operating range and control characteristics

d) the level of noise that can be tolerated

e) the pressure rating

f) the likelihood of any cavitation problems

g) maintenance requirements

Valves shall comply with the Corporation’s valve specification, available from the Manager Procurement Services, Procurement Services Branch.

3.13.7.3 Installation Arrangement

As the hydraulic servo-circuit needs ready access, it is essential that hydraulically actuated control valves are installed in pits (for below-ground pipelines).

An isolating valve shall be placed immediately upstream and downstream of the control valve to allow dismantling for service without draining the pipeline and to minimise disruption during maintenance.

The design shall consider the need to mitigate the noise generated during operation of the valve.

A bypass is required around single PRV installations.

3.13.7.4 Size

Hydraulically actuated control valves need to be individually sized for their specific duty.

Two fundamental parameters must be checked when sizing the valves:

a) the head loss through the valve under maximum flow conditions must be acceptable to hydraulic and operating requirements

b) the valve must be able to efficiently control the flow of water under conditions of minimum flow rate and/or minimum pressure differentials

Two or more valves in series or parallel may be required to achieve the required differential and control stability.

Efficient control relates to the sensitivity of flow rate to small changes in the degree of valve opening. It is necessary to avoid "hunting" – where small changes in valve opening cause too large changes in flow rate or head and so the valve oscillates continually around its set point.

Low flow rates typically occur for a much larger proportion of a year than peak flow rates. Valve sizing in relation to these low flows is therefore of critical importance.

As a guide, the chosen valve size must be capable of operating in the 20-80% range of opening when controlling flows.

3.13.8 Flow Regulating Valves

Refer also to DS 31

3.13.8.1 Purpose

a) In-Line Regulating Valves

These valves are designed to regulate flows over a flow range within a pipeline system. (Sluice valves and standard butterfly valves are designed to be either fully open or fully closed during operation and shall not be used for regulating flows).

In-line regulating valves are mainly used at headworks installations (dams etc) where variable flow rates are required for system management purposes.

b) Discharge Regulating Valves

The primary application of these valves is on dams or pipelines where open discharge into streams etc is required over a fully adjustable flow range. The discharge configuration (generally cone shaped) is designed to reduce the velocity and dissipate the energy.

3.13.8.2 Design Considerations

Flow regulation valves are not frequently used and shall be individually designed for each application. General considerations are as follows:

a) Need to be easily accessible for maintenance, they are normally housed in buildings or pits, particularly in urban applications

b) Shall be designed to minimise the effects of cavitation

c) Use above ground installation wherever possible to avoid confined space entry

d) Provision for valve isolation. In pipeline applications this will generally utilise an upstream butterfly and a downstream sluice valve

e) Provision of a bypass

f) Noise potential

g) The provision of a dismantling joint

h) Pipe anchorage and valve support

i) Flanged valves required

3.14 Valve Pits

All valve pits shall comply with the requirements in S151 - Prevention of Falls (POF) Standard. Confined Space Entry (CSE) assessment shall be done for all pits in accordance with requirements of the Water Corporation and if necessary, pits shall be designed to enable CSE or exit and rescue operation to be carried out safely. The following subsections do not apply to scour and air valve pits which shall be in accordance with the Standard Drawings.

3.14.1 Purpose

The purpose of the valve pit is to provide an easy and safe access to below ground water works appurtenances so that normal operation, maintenance or repair can be carried out. The pit also provides shelter, protection and security. As pits may be classified as confined spaces and require a full rescue crew for each entry, pits should be avoided wherever practical.

Alternatives may include:

a) Locally bringing the pipe above ground

b) Locally bringing valves above ground and securing them in enclosed cabinets

c) Where cross-sloping ground allows, utilise a three sided 'pit' with walk in access from the low side

d) Using very shallow pits to expose the top of the pipe only

e) Eliminate the pit by using equipment rated for buried service

If pits are unavoidable, dependent on the frequency of access the order of priority of entry aids in accordance with S151 - POF Standard is sloping walkway, stairway, steps, step ladder, inclined rung ladder and vertical rung ladder.

3.14.2 Type

The types of pits commonly used are:

a) Precast reinforced concrete

b) Site-cast reinforced concrete

Reinforced concrete pits are generally preferred. For durability reasons, a minimum concrete grade of N32 is required.

3.14.3 Location

In road reserves the pit should be located in the road verge to allow:

a) safer personnel access, away from the traffic

b) minimum interruption to traffic

In other locations, including reservoir or tank sites, the pits should be located:

a) to allow for future expansion of the facilities

b) to allow for vehicle access to all facilities

3.14.4 Loading

Design cases to be considered include:

a) Soil Loading, to be determined by the designer

b) Vehicle Loading

Where the pit is located in the road way, wheel load shall be assessed by the designer with reference to Austroads Bridge Design Specification. Vehicle loading considerations are presented in Table 3.6.

Table 3.6 Pit Loading Conditions

Location of Pit	Loading Condition
Road Pavement	Fully trafficable Class D to AS 3996
Urban Road Verge	Fully trafficable Class D to AS 3996, where the maximum 'open' dimension is more than 1500 mm. Light duty trafficable (Class B to AS 3996) where the maximum 'open' dimension is less than 1200mm ie only one wheel supported by the cover. Refer drg EG20-6-3.
Other Locations	To be assessed by the designer as: a) Fully trafficable b) Light traffic only c) Open and typically protected by extending the pit walls 300mm above the ground, providing a guardrail all around and providing grating over the pit.

3.14.5 Anchoring Pipework

Under certain circumstances, when the pit wall is required to anchor the pipe, the hydraulic force and the temperature force shall be taken into account for pit design.

Where by design, the pipe is free to move through the pit wall, a groove and suitable sealant shall be provided to prevent the ingress of ground or storm water.

3.14.6 Buoyancy

Where the pit is to be built in wet conditions, flotation shall be mitigated by the design.

3.14.7 Valve Supports

Concrete or steel supports shall be provided for valves and other heavy components to avoid stress on pipework, valves, flanges, dismantling joints or other fittings.

Pipe supports shall be protected against corrosion. For steel supports, hot dip galvanising is considered a minimum corrosion protection requirement, using a minimum steel thickness of 5 mm.

3.14.8 Pit Access Clearances

The layout of pipework in the pit shall be individually designed such that there is sufficient clearance for operation, maintenance and repair of any particular installation.

Minimum general clearances between the pit and the nearest component are shown in Table 3.7.

Table 3.7: Minimum Pit Clearances

Distance from pit component to	Clearance
Floor	300 mm
Side wall without a ladder (non-working side)	600 mm
Side wall with ladder (working side)	1000 mm
End wall to near flange face	400 mm
End wall to nearest weld or dismantling joint. However where pipework or fitting removal is facilitated by cutting and banding the pipework, an additional 600 mm of straight pipe is required.	300 mm
Covered pits – head room under the beams	2000 mm

3.14.9 Pit Drainage

Pits shall be provided with drainage facilities.

a) For dry, free draining soils - Concrete floors shall be graded to a free draining sump. Alternatively a pit floor consisting of not less than 150 mm thickness of crushed rock of not more than 19 mm nominal size may be acceptable.

b) Where the pit will not freely drain, or groundwater rises to within 1m of the floor - A concrete floor graded to a cast in (i.e. watertight) sump with a removable flush covering grill shall be provided. The sump should be large enough to hold some debris and the suction of a portable pump. A 450 mm diameter by 600 mm deep sump is considered acceptable. The protection of opening shall comply with the requirements in S151 - POF Standard.

3.14.10 Ladders, Stairs and Platforms

Ladders, stairs and platforms shall comply with the requirements in S151 - POF Standard and shall be designed to allow for easy platform dismantling if required for valve removal.

Suspended flooring and grating shall be in accordance with DS100.

Ladders, stairs and platforms shall be hot dip galvanised after fabrication.

3.14.11 Pit Covers and Edge Protection

Valve pits in secure compounds, are generally not fitted with covers. Where this is the case, the pit walls shall extend 300 mm above the ground level and guardrail shall be fitted as a safety requirement. Guardrail system shall comply with the requirements in S151 - POF Standard.

Where pits are required to be covered, the covers shall be designed to perform the specific functions required including drainage and ventilation to avoid the build-up of a moist and corrosive environment. The cover type shall suit the requirements of the location. Openings greater than 200mm x 200mm (or 200mm diameter) requires a cover and grate as required by S151 - POF Standard.

3.14.12 Earthing Systems

Pipeline systems, including operational components such as valve pits, shall be designed to ensure personal safety from the effects of high voltage fault currents and the effects of lightning strikes on or near the pipeline.

Maintenance of equal potentials may be provided by electrically bonding all components including pipework, pit reinforcement, all metal items including decking, ladders and guardrails and connecting them to an external earth ring. However, corrosion by galvanic action shall be prevented.

To prevent galvanic-cell corrosion, reinforcing and all dissimilar metal components shall be built as electrically isolated components, with earth bonding points provided on each isolated item. Electrical connection shall only be permitted through the earth bonding points. Insulating joint protectors (IJPs) may be required under certain conditions.

Compatibility of earthing systems, cathodic protection, electrical isolation and lightning protection is essential and shall be a prime consideration in the design.

3.15 Flow Measurement

3.15.1 Purpose

To record water usage for distribution management purposes and for extraction rate monitoring of bore fields.

3.15.2 Types of Meters

There are three types of meters used on pipelines as permanent installations: electromagnetic flowmeters, inferential meters and ultrasonic flowmeters (pitometers are also used as temporary measurement devices – see Clause 3.15.4). Inferential and ultrasonic meters are not normally used in distribution systems.

The general requirements for the various types of meters are addressed in Section 3.3 of DS 25-01 - Field Instrumentation.

Note: Electrical, instrumentation, control and SCADA requirements are job specific and are not addressed in this Standard.

3.15.3 Electromagnetic Flowmeter Installation

a) Meters shall be installed in accordance with the manufacturer's recommendations.

b) Meters shall not be completely buried.

   Installation of meters shall be in one of the following configurations:

   1) Semi buried (Refer to standard drawing EG20-4-2)
   2) In a pit (to be designed for each specific project)
   3) Above ground

c) When determining the most appropriate installation configuration, consider:

   1) Safety during installation and maintenance
   2) Reliability of the meter in the selected configuration
   3) Whole of life cost of the installation including safety, reliability, land acquisition and pipe diversions.

d) The accuracy of Mag Flow meters can be affected by flow disturbances resulting from pipe fittings and valves upstream of the meter. To maintain accuracy, meters shall be installed with upstream and downstream straight pipe lengths in accordance with the manufacturer's recommendations. In the absence of the manufacturer's recommendations, 10 upstream and 5 downstream diameters shall be used, or 10 diameters on both sides for bidirectional meters.

e) The designers shall specify any isolation of the meter; earthing and or bonding to suit the manufacturers meter installation requirements and also any cathodic protection or voltage mitigation requirements.

f) The designer may also specify if a dismantling joint is required with the meter.

g) Mag Flow meters shall be protected from UV exposure.

3.15.4 Pitometers

Pitometers are simple portable flow measuring devices designed for investigation work on pipeline networks.

Pressures are measured on the upstream face and downstream face of a probe which is inserted into the pipeline at the time of measurement. From the information gained, the velocity and hence the flow rate can be calculated.

It is preferable, wherever practicable, to locate pitometer points in straight sections of a pipeline at a distance of at least twenty times the pipe diameter downstream, and ten times the pipe diameter upstream of any bends, fittings, valves and the likes which are likely to affect the pipe flow. Where this is impracticable, the minimum requirements are ten diameters downstream and five diameters upstream.

In general, a pitometer point is required at a location 20 pipe diameters downstream of any magflow meter. Refer to standard drawing EG20-9-1.

3.16 Sampling and Tapping Points

Sampling points are used for monitoring water quality at headworks installations and throughout the pipeline network.

Tapping points are any type of fitting on a main that allows a sample of water to be taken for the measurement of chemical or aesthetic parameters. They are also used for the measurement of water pressure in the system. A tapping point is not arranged for the taking of bacteriological samples.

Tapping points are to be fitted on the pipeline in the field during installation stage to ensure that the reinstatement of the external coating and internal lining of the pipeline can be done properly.

3.16.1 Functional Requirements for Water Sampling

Below are a series of notes for assisting in the design of fittings associated with the taking of water samples from water mains. The notes are intended to functionally describe the requirements for various water sampling methods.

3.16.2 Tapping points

A DN100 flanged spigot with DN100 sluice valve and threaded blank flange tapping button is required for all tapping points located directly onto a distribution main. This allows the tapping to be isolated from the main for repair.

Threaded tapping buttons welded directly to the pipe are only acceptable where the tapping can otherwise be isolated from the main, eg on a section valve bypass pipework or at an air valve that can be isolated.

3.16.3 Manual Sampling Point

A Manual Sampling Point is a fitting on a main that is specifically arranged to allow a sample of water to be taken from the water main for bacteriological analysis. The fittings associated with the main are to be such that a spear is inserted partially into the main so as to avoid the draw off of water from adjacent to the pipe wall. The fittings shall be as shown on Standard Drawing EG20-8-2. A standard stainless steel "gooseneck" fitting is to be supplied above ground adjacent to the fitting on the main to allow the point to be "flamed", i.e. externally heated to destroy contaminants.

The location of sampling points is to be determined in consultation with the Water Corporation. As a guideline, the location of the Tapping or Sampling points should be such that the water drawn from them would be typically representative of the water in the main. If a fitting is located adjacent to a "T", then adequately sized pipework and valving should be provided to allow any "dead" water to be flushed to waste should this situation be possible.

3.16.4 Analyser Sampling Point

An Analyser Sampling Point is a fitting that is arranged to allow a sample of water to be taken automatically from the water main for supply to an online water quality parameter analyser as well as for bacteriological analysis. The fittings associated with the main are to be such that a permanent spear is inserted partially into the main so as to avoid the draw off of water from adjacent to the pipe wall. In addition a standard manual sampling point fitting is to be supplied above ground adjacent to the automatic analyzer sampling point.

Should it be determined that that the manual sample point cannot be located at the same location as the analyser sample point (eg due to access issues), then it is acceptable that a separate Manual Sampling Point is installed nearby.

Provision shall be made at the analyser itself to allow a sample of water to be taken immediately prior to or subsequent to the analyser for the purpose of calibration.

All pipework and fittings sizing shall be sized such that the flow of water to the analyser is maintained when a manual sample is being taken.

3.17 Manhole Entry into Pipelines

3.17.1 Purpose

Manholes and inspection openings are used for gaining access to pipelines for welding, repairs and restoration of cement mortar lining, and for inspection.

3.17.2 Size

Manholes provided on pressure mains shall be a minimum of DN 600 as shown in the Corporation's Pipe Fittings Standard Drawings – DS65 and are therefore only installed on DN 600 or larger pipelines.

3.17.3 Location

Manholes are increasingly being used to access pipelines for remote inspections. Generally the inspection device works with the pipe full of water. Hence it is desirable to locate the manholes at local high points in the pipeline profile, preferably near an air valve.

Manholes are generally required to be installed close to connections and on either side of section/isolation or air valve installations where internal welding and cement mortar lining restoration is necessary.

The internal surfaces of pipelines become slippery with time. Large diameter pipelines, which may be inspected by entering the pipe, will require access holes at both the top and bottom of steep sections (slope greater than 1 in 10).

3.17.4 Installation

Manhole should be fabricated without the internal cement mortar lining. After welding of the manhole to the pipe, the internal surfaces of the manhole should be primed with Nitobond HAR and lined with Parchem "Renderoc HB40" premixed cement mortar in accordance with Water Corporation Specification M8- Cement Mortar Lining Requirement.

The thickness of the cement mortar lining should be in accordance of AS 1281. For the pipework, there should be a setback of 50 mm minimum from the weld to reduce damage to the pipe cement mortar lining during the installation of the manhole to the pipe.

3.18 Flanged Joints

Refer to DS 31 and DS38-02.

Insulated flanged joints shall be used for the electrical isolation of sections of pipelines where cathodic protection is to be employed and where isolation of Mag Flow meters is required. Insulation shall be achieved by the use of insulating kits and full face gaskets. O-rings are not suitable for use on insulated flanged joints.

3.19 Termination of Pipelines

Pipelines shall be terminated with a deadplate, blank-end, or a deadplated section valve.

Where future extension is a possibility, consideration should be given to using a suitable length of welded joint steel pipe or an alternative anchorage that will allow a straightforward connection to the extension.

4 PIPELINE DRAWINGS

4.1 Design Drawings

Design drawings produced for submission to the Corporation shall be in accordance with WCX CAD Standard DS 80 (refer to Figure 4.2 for an example of a design drawing). For the preparation of design drawings, external designers shall refer to DMS Procedure 8 and 11 in Section 10 of DS 80.

The drawings shall include a locality plan, route plans, longitudinal sections, details of variations to standard drawings and other details as required.

The test pressure and maximum allowable operating pressure (MAOP) shall be noted on the drawings.

4.2 Drafting Details for Design Drawings

4.2.1 Scales

Drawings shall be drawn to scales such that the drawing content is clear when printed in A3 size for tendering purposes.

The scales used will depend on the location of the pipeline (rural or urban), the number of other utilities involved and the level of detail necessary. For pipelines in urban areas, scales of 1:1000 horizontal and 1:100 vertical are generally satisfactory.

4.2.2 Notation

Line thickness drawn on A1 sheet size, line markings, symbols, and standard abbreviations shall be as follows:

a) Line thickness: Refer to WCX CAD Standard DS 80.

b) Line markings for existing services (e.g. water, drain, gas line, etc.) shall be in accordance with Section 4 of WCX CAD Standard DS 80.

c) Symbols: Refer to Figure 4.1

d) Standard Abbreviations: Refer to Table 4.1

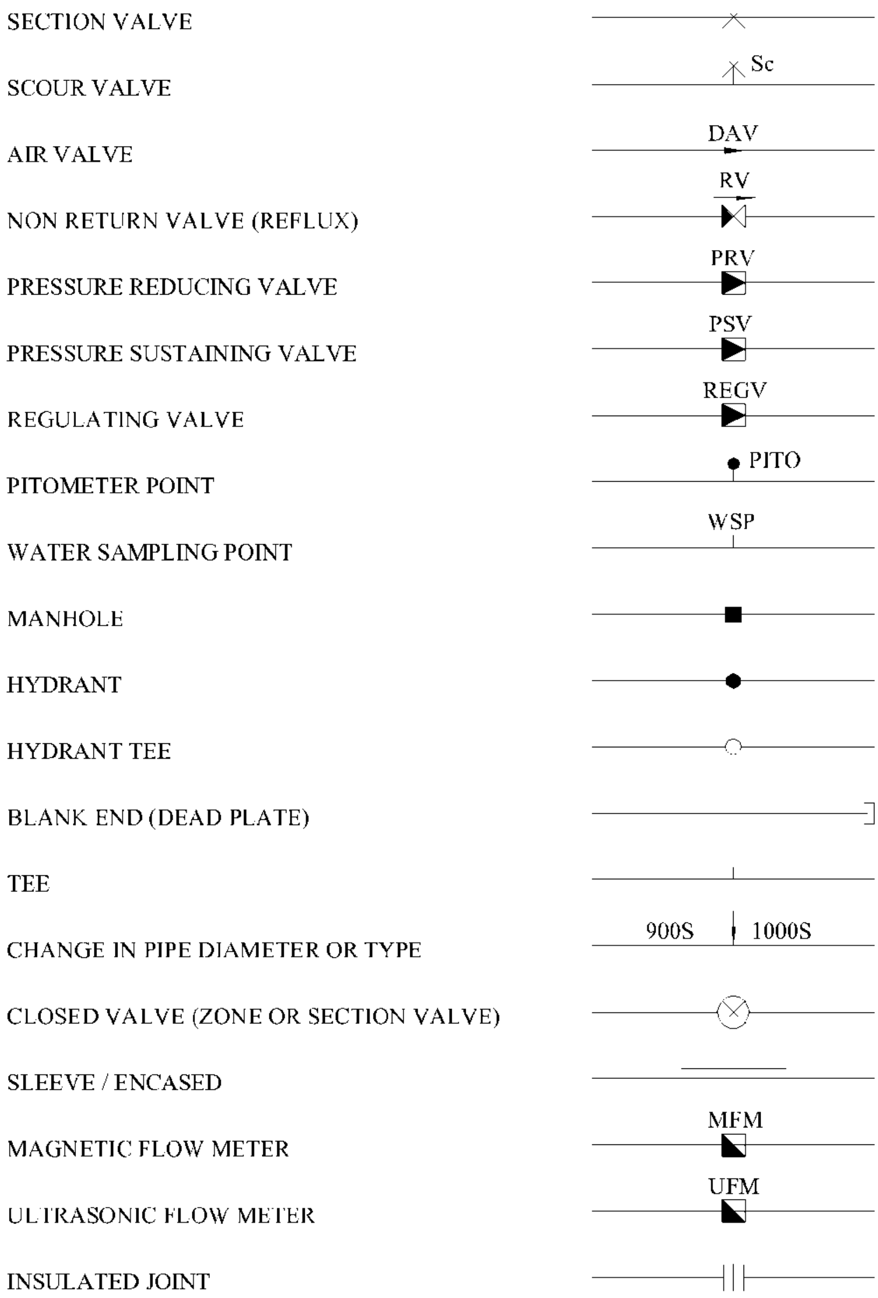


Figure 4.1: Pipeline Drawing Symbols

Table 4.1: Pipeline Drawings Standard Abbreviations

AC	Asbestos Cement	MGA94	Map Grid of Australia
AHD	Australian Height Datum	MFM	Magnetic Flow Meter
BL	Boundary Line (Property)		
B/END	Bland End (Deadplate)	MH	Man Hole
BV	Butterfly Valve		
CI	Cast Iron	OD	Outside Diameter
CP	Cathodic Protection	PE	Polyethylene
CU	Copper Pipe	PITO	Pitometer Point
DAV	Double Air Valve	P	PVC
		PN	Pressure Nominal
DI	Ductile Iron	PRV	Pressure Reducing Valve
DN	Diameter Nominal	PSV	Pressure Sustaining Valve
DRG	Drawing		
ENC	Encased	REGV	Flow Regulating Valve
EXIST	Existing	R	Resilient Seated Valve
		R80 etc.	DN 80 Service Duct
FP	Flushing Point	RC	Reinforced Concrete Pipe
FW	Bronze Gate Valve (Fullway)		
		RRJ	Rubber Ring Joint
HYD	Hydrant	RV	Non Return Valve (Reflux Valve)
ID	Internal Diameter	S	MSCL Pipe
IF	Insulated Flange	Sc	Scour
IL	Invert Level	SL	Sleeve
IZS	Inorganic Zinc Silicate	SV	Sluice Valve
		UFM	Ultrasonic Flow Meter
		WSP	Water Sampling Point

a) Some of the above abbreviations and symbols relate to drafting of distribution pipeline plans; however they have been included as a guide to information shown on the Corporation's base sheets. Refer to WCX CAD Standard DS 80 for further information.

4.3 Pipe Route Surveys

4.3.1 Basis of Survey

Surveys of features along the general pipe route, based on established cadastral boundaries, are often required in urban situations in order to determine the most suitable side of the street for the pipeline and to provide information on ground levels.

In headworks compound areas the survey may be based on an established base line.

In rural situations, surveyed MGA94 coordinates may be used to document the selected pipe route.

Vertical datum and coordinate system designations used shall be in accordance with Section 12 of WCX CAD Standard DS 80.

4.3.2 Presentation Standard

All survey information is to be provided in hard copy A1 size plans with a symbol legend and in digital form DWG format for AutoCAD 2012 (or later version).

4.3.3 Survey Pegs

A qualified Engineering Surveyor (eligible for corporate membership of SSSI) shall be employed for the setting out and As Constructed survey of the works.

All offset measurements shall be from cadastral survey pegs installed by a licensed surveyor. The pipeline contractor shall ensure that the survey pegs remain uncovered and undisturbed. Re-establishment of cadastral survey pegs shall only be carried out by the licensed surveyor.

4.4 Route Plans

Route plans shall show the proposed pipeline, location and alignment of other utilities, carriageways, roadways, street names, and lot boundaries and lot numbers. Contours at intervals such that they will not detract from other information, should also be shown.

The pipeline alignment shall, wherever possible, be indicated as offsets from street or cadastral boundaries.

Location of the pipeline by MGA94 co-ordinates should be used where specifically required or where offsets to cadastral information are not practical. The nominated coordinates shall be established by survey when the proposed pipe route has been pegged. MGA94 gridlines should be shown typically at 100 m intervals.

4.5 Longitudinal Sections

Longitudinal sections shall be included in the design documentation and shall show:

a) the proposed pipeline relative to existing surface levels;

b) the proposed pipeline with respect to other utilities;

c) proposed earthwork and road levels;

d) pipeline grades;

e) all appurtenances including air valves, scour valves, section valves and flow meters, and the co-ordinates of these appurtenances;

f) all vertical and horizontal bends;

g) the extent of river, wetland crossings;

h) the size and type of pipe;

i) locations where clearance to work (CTW) is required; and

j) where required, the relative locations of the ground profile and the hydraulic grade line.

Where rock or ground water conditions exist, the location of investigation holes or pits shall be shown on the longitudinal sections and reference made to the investigation report.

The longitudinal section format shall be as shown in the example in Figure 4.2.

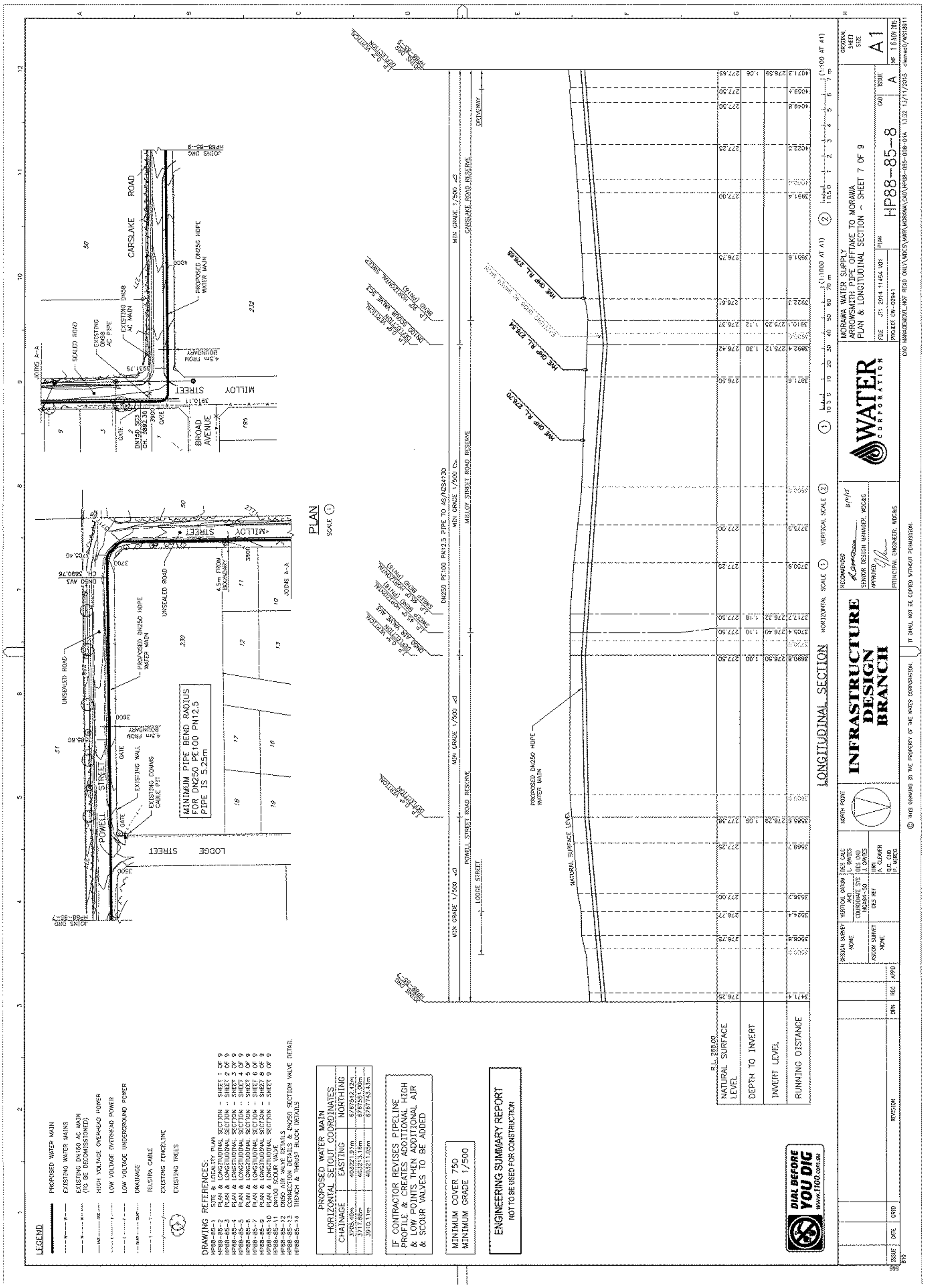


Figure 4.2: Example of Design Drawing

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