WATER CORPORATION

Assets Planning and Delivery Group
Engineering

PIPELINE SELECTION GUIDELINES

Selection Criteria for Pipe, Pipe Fittings and Interconnection with New and Legacy Corporation Pipelines

VERSION 1
REVISION 1

MAY 2024

FOREWORD

The intent of Design Standards and associated Guidelines is to specify requirements, related guidance and information 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 and Guidelines are 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 and Guidelines 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 the Western Australia's Work Health and Safety (General) Regulations 2022 to the delivery of Corporation assets. Information on these statutory requirements may be viewed at the following web site location:

Overview of Western Australia’s Work Health and Safety (General) Regulations 2022 (dmirs.wa.gov.au)

Enquiries and informed feedback relating to the technical content of the Guidelines should be directed to the Senior Principal Engineer, Wastewater Conveyance, Engineering.

Head of Engineering

DISCLAIMER

This Guidelines are intended solely for application to the acquisition of water infrastructure in Western Australian Operating Areas where the Water Corporation has been licensed to provide water services subject to the terms and conditions of its Operating License.

The Guidelines are provided for application by suitably qualified engineering professionals who apply the engineering skill, knowledge and experience necessary to understand the risks involved and undertake all infrastructure, selection design and installation specification preparation work.

Any interpretation of anything in the Guidelines that deviates from the particular requirements specified in an asset project design brief drawing, construction specification or in design process requirements should be resolved by reference to and determination by the accountable project engineering professional.

The Corporation accepts no liability for any loss or damage that arises from anything in the Guidelines including loss or damage that may arise due to the errors and omissions of any person.

REVISION STATUS

The revision status of these Guidelines is shown section by section below:

REVISION STATUS						
SECT	**VER./ REV.**	**DATE**	**PAGES REVISED**	**REVISION DESCRIPTION (Section, Clause, Sub-Clause)**	**RVWD.**	**APRV.**
ALL	**1/1**	**30.06.2024**		**General and conformity text aligned for consistency and references to heavy duty PVC pipe fittings added and aligned throughout. Obsolete PE 80B references removed throughout.**	**KR**	**KP**
1	1/0	20.04. 17	All	New Version/Revision	KR	KP
2	1/0	20.04. 17	All	New Version/Revision	KR	KP
2	**1/1**	**16.05.2024**	**2.1/2.2/2.3**	**Lists of relevant industry standards and product specifications updated**	**KR**	**KP**
3	1/0	20.04. 17	All	New Version/Revision	KR	KP
4	1/0	20.04. 17	All	New Version/Revision	KR	KP
4	**1/1**	**16.05.2024**	**Tables 4.1.1/4.1.2/ Table 4.2**	**PE pipeline material requirements for water applications updated in Note 28. Added Table 4.2 Note 10 to provide DWV PVC pipe stiffness comparison with that of PVC-O pressure pipe**	**KR**	**KP**
APPENDICES						
A to F	1/0	20.04. 17	All	New Version/Revision	KR	KP
C	**1/1**	**16.05.2024**	**C5/C7**	**Legacy RC, PE & GRP pipe information discovered and added**	**KR**	**KP**
D	**1/1**	**16.05.2024**	**Tables D1/D2**	**Major overhaul of steel pipe information to eliminate duplication and correct typos**	**KR**	**KP**

PIPELINE SELECTION GUIDELINES
Selection Criteria for Pipe, Pipe Fittings and Interconnection with New and Legacy Corporation Pipelines

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1 Purpose and Scope

1.1 Purpose

The purpose of these Guidelines is to provide guidance to designers and specifiers of pipeline infrastructure systems to be owned, operated and maintained by the Corporation or pipeline systems to be taken over by the Corporation in accordance with agreed business processes and commercial arrangements.

1.2 Scope

The Guidelines are intended to provide information and guidance on conveyance pipeline system characteristics, selection criteria, usage constraints and limitations in one place. This is aimed at selecting pipeline system components that are best for Corporation business, having due regard to:

- Material, size, engineering performance and in-service performance;
- Market availability in the desired sizes and quantities, compatibility with new and legacy pipelines and ready availability of pipeline spares and repair components for all pipeline applications;
- Optimal whole of asset and service life value for money.
- Constructability, operability, maintainability and longevity performance in Western Australia;
- Timely establishment of the pipeline requirements baseline to be delivered throughout pipeline project planning, design, installation, commissioning and hand over to operators.

The Guidelines include references to recognised design, material, product and related installation standards and specifications that are acceptable to the Corporation, as asset owner and operator. Its coverage references physical, longevity and installability performance characteristics for many pipe materials - including some that are neither preferred nor authorised for general use at present. These include, for example, ABS and DI pipes. The guidance provided is intended to enable comparison of performance characteristics across a broad range of preferred and non-preferred pipe materials covered by current Australian pipe manufacturing standards. The Guidelines reference the Strategic Products Register where commonly used pipe and pipe fitting brands have been listed as authorised for use, on the basis of conformity with Corporation business requirements.

Any perceived conflict between information or guidance herein and requirements mandated in published Design Standards should be referred to the appropriate project Design Manager for clarification.

2 Referenced Documents

The Corporation has documented engineering and operational performance requirements for its strategic infrastructure in a suite of engineering standards and product specifications, based on over a century of service experience in the water industry. These are subject to periodic review and change - including the addition of new standards and specifications - from time to time in accordance with best for business priorities.

Corporation project planners, designers and specifiers should make application for access to the published standards and product specifications that are referenced in project documents as being relevant to project scope. Formal access should be on the basis of legitimate involvement in Corporation capital, operational and land development infrastructure projects. Applicants should liaise with project design managers to ensure that applications for access to particular standards/specifications are appropriate to the particular project to be delivered.

2.1 Corporation Design Standards

No	Electrical
DS 23	Pipeline AC Interference and Substation Earthing
No	**Mechanical**
DS 31-01	Pipework - Mechanical
DS 38-02	Flanged Connections
No	**Water, Wastewater & Drainage Conveyance**
DS 50	Design and Construction Requirements for Gravity Sewers DN 150 to DN 600

DS 51	Design & Construction of Wastewater Pumping Stations & Pressure Mains 4 to 90 LPS Capacity
DS 53	Vacuum Sewerage Standard
DS 60	Water Supply Distribution Standard - Pipelines Other Than Reticulation
DS 63	Water Reticulation Pipelines DN 250 and Smaller
DS 65	Pipe Fittings Standard Drawings
DS 66	Urban Main Drainage Standard
No	**Safety**
S151	Prevention of Falls
DS 100	Suspended Flooring (Grid Mesh and Chequer Plate)
SPN 1	Strategic Practice Note - Reinforced Concrete Practice
No	**Drafting**
DS 80	WCX CAD Standard
No	**Welding & Corrosion Prevention**
WS-1	Metal Arc Welding
WS-2	Welding Joining Specification Thermoplastics
DS 91	Selection, Design and Monitoring of Cathodic Protection (CP) Systems
DS 95	Standard for the selection, preparation, application, inspection and testing of Protective Coatings on Water Corporation Assets
Sub-ref.	**Description of Surface Preparation & Protective Coating Specifications** (DS 95 Table 5)
A1	Surface Preparation for the Application of Protective Coatings on Steel or Cast Iron
A2	Surface Preparation for the Application of Protective Coatings on Stainless Steel
A3	Surface Preparation for the Application of Protective Coatings on Galvanised Steel
A4	Surface Preparation for the Application of Protective Coatings on Aluminium
A5	Surface Preparation for the Application of Protective Coating on Concrete
A6	Surface Preparation for the Application of Protective Coating on Plastics
A7	Surface Preparation for the Application of Protective Coating on Fusion Bonded Polyethylene Sintakote®
B1	Inorganic Zinc Silicate Coating on Steel or Cast Iron
C1	Zinc Rich Epoxy primer Coating on Steel or Cast Iron
C2	Zinc Rich Epoxy primer Epoxy Mastic Coat, Polyurethane top Coat on Steel or Cast Iron
C3	Zinc Rich Epoxy primer Epoxy Mastic Coat, on Steel or Cast Iron
C4	Zinc Rich Epoxy primer , Polyurethane top Coat on Steel or Cast Iron
D1	High Build Epoxy Coating on Steel or Cast Iron
D2	High Build Epoxy Coating on Butterfly Valves
D3	High Build Epoxy Coating on New and Old Concrete
D4	Ultra High Build Epoxy Coating on Steel or Cast Iron
E1	Epoxy Mastic Coating on Steel or Cast Iron
E2	Epoxy Mastic Polyurethane Coating on Control Valves
E3	Epoxy Mastic Polyurethane top Coat on Steel or Cast Iron
E4	Epoxy Mastic Polyurethane top Coat on Galvanised Steel
E5	Epoxy Mastic Polyurethane top Coat on Fusion Bonded Polyethylene Sintakote
F1	Glass Flake Epoxy Mastic Coating
F2	High Build Epoxy Coating on Control Valves
F3	High Build Ceramic Filled Epoxy Coating on Pumps
G1	Thermostatically Applied Polyester Powder Coating
G2	Thermal Bonded Polymeric Coating on Valves and Fittings for Water Industry Purposes
H1	Repair ater Galvanisng
H2	Hot Dip Galvanising of Steel Structures
H3	Repair of Inorganic Zinc Silicate (IZS) Coated Structures
I1	Elastomeric Polyurethane Protective Coating on Concrete
J1	Anti-Graffiti Coating on New and Old Steel Structures
J2	Anti-Graffiti Coating on New and Old Concrete Structures
K1	Aesthetic Finish Coating on above Ground PVC Pipes and Fittings
L1	Tape Wrapping Requirements
L2	Heat Shrink Sleeve Requirements
L3	Visco-elastic tape wrapping requirements for above ground application
M1	Coating Procedure for Pipe Transition Below to Above Ground
M2	Coating Procedure for Above Ground Sintakote Pipe and Steel Pipe Joints
M3	Coating Procedure for Clean Skin Pipe Permanently Exposed to Atmosphere

M4	Coating Procedure for Coupling Jointed Pipes
M5	Coating Procedure for Above Ground Steel Pipe at new Concrete Interfaces
M6	Coating Procedure for Steel Pipe at the Concrete Interface & Sintakote Pipe Joint
M8	Cement Mortar Lining Repairs in New MSCL Pipes
M9	Grouting Convex Band in Pipelines

2.2 Industry Standards and Guidelines

No	Plastics Industry Pipe Association (PIPA) Guidelines
POP001	Electrofusion Jointing of PE Pipe and Fittings for Pressure Applications
POP002	Polyethylene (PE) Pipes and Fittings for Compressed Air
POP003	Butt Fusion Jointing of PE Pipes and Fittings - Recommended Parameters and Practices
POP004	Polyethylene Pipe and Fittings Compounds
POP004A	Supplementary List - Materials Specific to Electrofusion and Moulded Fittings
POP005	Packaging, Handling and Storage of Polyethylene Pipes and Fittings
POP006	PE Fabricated Fittings for Pressure Applications Derating Requirements
POP007	Flanged Joints for Polyethylene (PE) Pipe
POP010A	Part 1: Polyethylene Pressure Pipes Design for Dynamic Stresses
POP010B	Part 2: Fusion Fittings for use With Polyethylene Pressure Pipes Design for Dynamic Stresses
POP013	Temperature Rerating of PE Pipes
POP014	Assessment of Polyethylene Welds
POP016	High Stress Crack Resistant & Raised Crack Resistant PE100 Materials
POP017	Material Requirements for White PE Jacket Compounds Suitable for Long Term UV Exposure
POP018	Polyethylene Drinking Water Pipes in Contact with Chlorine and Chloramine Disinfectants
POP020	Principles of polyethylene (PE) electrofusion welding and assessment
POP101	PVC Pressure Pipes Design for Dynamic Stresses
POP102	Solvent Cement Jointing of PVC Pipe
POP103	Depth of Engagement for PVC Pipes
POP104	PVC Pipe Equivalence
POP105	PVC Pipes In Bore Casings
POP106	Verification Guidelines for Best Environmental Practice PVC Pipe and Fittings
POP107	Measuring the PVC content in PVC pipes and fittings
POP201	Resistance of Plastics Pipes and Fittings to Water and Wastewater Chemicals
POP202	PVC and PE Pressure Pipe Installation on Curved Alignments
POP203	Identification of Buried Pipe Systems
POP204	Expected Service Life of Elastomeric Pipe Seals
POP205	Water Jet Cleaning of Plastics Pipes
POP206	Thermal Insulation of Hot Water Pipes for Plumbing Applications
POP207	Installation of Potable Watermains In Contaminated Ground
POP208	Specification and testing guidelines for recycled materials suitable for non-pressure plastic pipe applications
No	**Technical Information**
TC4130	AS/NZS 4130 Polyethylene Pipes (PE) for Pressure Applications
No	**Technical Manuals**
TM001	PE Pipe System Maintenance Guide
TM002	PVC Pressure Pipe System Maintenance Guide
No	**Technical Note**
TN001	Electrofusion Jointing of Polyethylene (PE) Pipe and Fittings for Pressure Applications
TN002	Weathering of PE Pipes
TN003	Temperature Derating of PVC Pipes for Pressure Applications
TN004	Polyethylene - The Optimum Gas Material?
TN005	Notes on Hydrostatic Field Pressure Testing of PE Pipes
TN006	Weathering of PVC Pipes and Fittings
TN007	PVC and Polyethylene Pipe Systems for Food Transport Applications
TN008	Chlorine Dioxide Disinfectant for Drinking Water – Effect on Pipe and Seal Materials
TN009	Field Butt Welding of Rural Or Thin Wall Poly Pipe
TN010	Explanation of Material / SDR Relationship
TN011	Polyethylene Compressed Air Pipe Guidance Note
TN012	PVC Pipes At Low Operating Temperatures
TN013	Life Expectancy for Plastics Pipes

TN014	PVC Tops Pipe Joints Performance Test
TN015	Modified PVC Pressure Pipes
TN016	Non Destructive Examination of PE Welds - Emerging Techniques
TN017	Recommendations for Electrofusion Welding Specifications
TN018	Cross Linked Polyethylene (PE-X) Pipe in Hot Water Applications – Guidance for Determining Conformance with AS/NZS 3500
TN019	Sandwich Construction PVC-U Non-Pressure Pipe
TN020	Plastic Pipes and Microbial Growth
TN021	Squeezing-off Polyethylene Pipes
No	**Technical Papers**
TP001	PVC Technical Information (*Resistance of elastomeric seal pipe joints to tree root penetration*)
TP002	Pipeline Replacement Using Relining
TP004	Plastics Pipe In Water and Waste Water infrastructure
TP005	Flexible Pipe Design
TP006	Long Term Performance of PVC Pressure Pipe
No	**Test Method**
SM001	Method for Assessing The Resin Dispersion In PVC Pipes
No	**Other Information**
N/A	Polyethylene for Horizontal Directional Drilling Published by The Plastics Pipe Institute (*USA*)
N/A	History of Plastics Pipe Systems In Australia

No	WSAA Water Industry Standards
WSA 115	Post-Formed Variable Bend PVC Fittings for Non-Pressure Pipelines (Refer **DS 50**)
WSA 137	Uplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and Polyethylene (PE) maintenance shafts, maintenance chambers and maintenance holes for sewerage
No	**WSAA Technical Notes**
WSA-TN1	PE squeeze-off
WSA-TN2	Guidelines for the use of non-metallic pipes with ductile iron elastomeric joint fittings and spreadsheet calculation
WSA-TN3	Ring bending stiffness and allowable deflection of ductile iron pipe and steel pipe
WSA-TN6	Guidelines for the use of cement mortar linings in sewerage applications
WSA-TN7	Guidelines for Pressure Pipeline Data Cleansing
	WSAA Terminology Reference
	Pipeline Acronyms and Classifications Guideline

2.3 Product Specifications

Corporation Strategic Product Specifications (SPS) detail the minimum product engineering, supply, quality assurance and conformity performance characteristics required to deliver Corporation water infrastructure at least whole-of-life cost and least risk to service standards and safety.

Product specifications provide documented performance specifications for:

- Procurement of manufactured products and materials for water supply and sewerage networks;
- Reference in project installation and construction specifications and tender documents;
- Evaluating/auditing strategic branded products for conformance with Corporation performance requirements; and
- Authorisation and listing in the Strategic Products Register of conforming products.

Currently published Strategic Product Specifications are listed below for easy reference.

Corporation Strategic Product Specifications (WC SPS)

No	Description and Alignment with Industry Specification
100	Steel Pipe for Waterworks Purposes
106	Ductile Iron Pipe Fittings for Pressure Applications
115	Unplasticised Polyvinylchloride PVC-U Pipe for Pressure Applications
116	Modified Polyvinylchloride PVC-M Pipe for Pressure Applications
117	Oriented Polyvinylchloride PVC-O Pipe for Pressure Applications

125	Polyethylene and Polypropylene Pipe and Pipe Fittings
130	Glass Reinforced Plastics Pipe and Pipe Fittings
151	Bolted Mechanical Pipe Couplings and Dismantling Joints for Waterworks Purposes
152	Stainless Steel Repair Clamps for Waterworks Pipes
155	Metered Standpipes
200	Air Valves for Water Supply
201	Air Valves for Sewerage
214	Double Check Valves
215	Reduced Pressure Zone Devices
220	Metallic Non Return Valves
223	Ductile Iron Swing Check Non Return Valves
226	Dual Plate Non Return Valves
230	Rapid Response Non Return Valves
240	Hydraulically Operated Automatic Control Valves – Cast Iron Body
241	Inline (Axial) Control Valves
245	Vacuum Interface Valves
249	Bladder Surge Vessels
250	GRP Filter Vessels
251	Mains Tapping Ball Valves
252	Metallic Ball Valves for General Purposes
254	Meter Ball Valves
255	Copper Alloy Gate Valves
259	Knife Gate Valves
260	Butterfly Valves for General Purposes
261	Butterfly Valves for Waterworks Purposes
262	High Performance Butterfly Valves
263	Butterfly Guard Valves
271	Gate Valves for Waterworks Purposes Metal Seated
272	Gate Valves for Waterworks Purposes Resilient Seated
292	Screw Down Fire Hydrants
295	Penstocks for Waterworks Purposes
300	Water Meters - DN20
700	Precast RC Access Chambers
702	Precast Concrete Wastewater Pumping Stations
801	Access Covers for General Purposes
802	Prototype Assisted-Lift Access Covers

Relevant current Strategic Product Specifications (SPS), Design Standards (DS), The Strategic Products Register and Product Supplier Submission Requirements may be viewed and accessed at https://www.watercorporation.com.au/About-us/Suppliers-and-contractors/Resources/Design-standards.

2.4 Strategic Products Register

The Strategic Products Register lists proprietary (branded) pipeline products of a strategic nature that have been authorised on the basis of conformity with nominated product standards and performance requirements. The Register is typically reviewed and updated at publication intervals between one and two years. Accordingly, the **primary** evidence of product authorisation should be the formal Corporation letter of authorisation.

Selection and use of a potentially strategic product that has not yet been submitted for Corporation authorisation should be strictly subject to an evaluation of:

- conformity with the engineering, longevity, sustainability and service safety performance requirements nominated for the application under consideration;
- compatibility with best business value over the nominated service lifetime;

Formal submission of a product or product range for general use in Corporation infrastructure should comply with the "Product Supplier Submission Requirements.

Designers and specifiers should assure the selection of pipeline components by validating their authorisation credentials, prior to selecting and representing those products in pipeline designs or drawings. The objectives should be to:

- verify pipeline component authorisation status and identify service/usage limitations;
- record/validate demonstrable field performance characteristics for (as yet) unauthorised pipeline components in good time, prior to selection;
- assure pipeline component availability in the required sizes, pressure ratings, stiffness ratings and quantities on a project-by-project basis, by timely reference to the marketplace;
- inform pipeline project stakeholders of all significant constraints on pipeline component authorisation status or availability in the required sizes and quantities in good time prior to tendering and construction.

3 Legacy Pipeline Characteristics

Appendix C contains information on the material, configuration, vintage and history of Corporation (and predecessor organisation) pipeline networks installed over the last century in significant detail. The information provided is intended to form an essential reference resource for selecting and designing best-for-business new, replacement and extended pipelines.

4 Application by Designers

A high level outline of the required pipeline project deliverables and locations (e.g. a planning report), having due regard to site heritage and environmental constraints, will usually be provided as the starting point for establishing the initial (approved) project requirements baseline or ARB. Designers should select pipeline components that match ARB requirements on the basis of best-for-business and whole of pipeline installation and operating life economics. Designers should apply the guidance information provided to identify and evaluate the comparative feasibility, service longevity and life cost effectiveness of potential pipeline component options. Key guidance information and data have been tabulated in:

- **Clause 4.1** Pipeline Selection Considerations - including tabulated selection filters:
  - **Table 4.1.1** Pipeline Material and Application Criteria;
  - **Table 4.1.2** Trenchless Application Risk Criteria;
- **Tables 4.2/4.3/4.4** Indicative Characteristics of Plastics, MSCL and DICL Pipe;
- **Table 4.5** Pressure Re-rating Design Factors for Plastics & Metallic Pipes;
- **Tables 4.6, 4.7** Pressure and Non-pressure Pipeline System Inter-connectibility;
- **Table A1** Pipeline Material, Engineering and Jointing Characteristics;
- **Table A2** Pipeline Longevity, Installation and Testing Characteristics;
- The Notes and other guidance associated with these Tables;

Designers should also establish the market availability of pipeline components and lead time constraints for the pipe sizes and quantities to be supplied to match project timelines, prior to component selection.

Designers should ensure that new pipeline project design documents clearly identify and nominate the key design basis parameters and assumptions including those necessary for its safe construction and commissioning. These are pre-requisite to pipeline tender preparation, construction and operation by ‘downstream’ project delivery and operational stakeholders and should include:

- Safety and risk considerations pre-requisite to construction, installation and operations activities;
- The pipeline material strength, load, pressure and stiffness classes selected;
- The pipeline embedment material, grading, density and compaction parameters selected and the known (investigated) geotechnical environment of pipelines to be buried;
- The pipeline system design pressure, maximum allowable pipeline system pressure (MAOP) and recommended baseline (at 20ºC) field test pressure values (ASTP) nominated;
- The embedment design parameters that underlie thrust block dimensions and the bearing capacity of surround materials to resist thrusts due to pipeline operating, test and surge pressures.

4.1 Pipeline Selection Considerations

References to "Carrier Pipe" mean the primary – usually fluid bearing – pressure or non-pressure pipe. References to "Sleeve" mean a secondary conduit or encasement pipe, larger than the carrier pipe, that contains or encases the carrier pipe and enables carrier pipe installation, operation and repair without disrupting or disturbing the soil or structures below, above or through which the encasing sleeve has been installed.

4.1.1 Material and Application Comparison

Table 4.1.1 outlines default material criteria for comparing and selecting pipe, pipe fitting and associated jointing system materials, that are commonly available in WA, for particular pipeline project applications. Table 4.1.1 should be read in conjunction with the supplementary guidance in "Notes for Table 4.1.1".

Table 4.1.1 Pipeline Material and Application Criteria

Pipeline Component/Material	Drinking Water[44]	Non-drinking Water[2]	Wastewater	Drainage	Pipeline Size Constraints[5]	Typical Allowable Burial Cover Depth[11, 12] (m)	Deflection as % of Mean Pipe Diameter[18]	Above Ground and in Bridge Crossings as Carrier Pipe Only (No Sleeve)[24,25, 29]	Below Watercourses & Structures – as Carrier Pipe Only (No Sleeve)[24, 25, 27, 29]	Below Watercourses and Structures as Carrier Pipe in a Sleeve[24, 25, 27, 29]	As Sleeve Only [24, 25, 27, 29]	In Urban Centres and Below Roads[24, 25, 30]	Pipeline Embedment Constructability Rating[37]	Market Availability[43]	Strategic Products Register Listing
	Conveyance Application Fit				**Performance and Usage Constraints & Limitations**										
ABS	Yes	Yes	Yes	Yes	NP[5]	< 5[13]	< 3%	Maybe[21]	Maybe	Maybe	Unlikely	Maybe[31]	> 8[38]	Non-Preferred[5]	No
DICL	Yes	Yes	Maybe[3]	Maybe[3]	NP/conditional[5]	< 5[13]	< 1%	Maybe[21]	Yes[26]	Unlikely	Unlikely	Yes[31, 32]	> 5[39]	Non-Preferred[5]	No
DI Fittings	Yes	Yes	Maybe[3]	Maybe[3]	Note 5	< 5[13]	As pipe	Maybe[21]	Yes[26]	Maybe	Unlikely	Yes[31, 32]	> 5[39]	DN100/150 stocked WA; Limited DN200/300 stocks; Otherwise 8wks min order	Yes
CU	Yes	Yes	No	No	≤ DN 200[5]	< 2[14] services	N/A[18]	No	No	No	No	No	> 6	3 wks for min. order	Yes
GRP (Pressure)	Yes	Yes	Yes	Yes	> DN 375/400	< 6[13, 15] (SN 10)	< 3%	Maybe[21]	Yes	Maybe	No	Yes[31, 33, 34]	> 3[40]	7wks for min. order	Yes
GRP Pressure Fittings	Yes	Yes	Yes	Yes	As GRP pipe	As GRP pipe	As GRP pipe	Maybe[21]	Yes	Maybe	No	Yes[31, 33, 34]	> 3[40]	8 wks special order	No
GRP (Non-pressure)	Yes	Yes	Yes	Yes	> DN 375/400	< 8[13, 15] (SN 10)	< 3%	Maybe[21]	Yes	Maybe	Yes	Yes	> 3[40]	7wks for min. order	Yes
GRP Non- pressure Fittings	Yes	Yes	Yes	Yes	As GRP pipe	As GRP pipe	As GRP pipe	Maybe[21]	Yes	Maybe	Yes	Yes[33]	> 3[40]	8 wks special order	No
PE 100[28]	Yes	Yes	Yes	Yes	≤ DN 630[6]	< 5[13, 16, 28]	< 3%	Unlikely[22]	Yes	Yes	Unlikely	Maybe[28, 35]	> 5[38, 41]	DN125/180 @ PN12.5 stocked; 4 wks for larger DN/PN minimum order	Yes
Compression Fittings (PP)	Yes	Yes	No	No	≤ DN 63[7]	< 2[14]	N/A[19]	No[23]	No	No[23]	No	No[14]	> 5[38, 41]	Stocked locally; 2 wks	Yes
Fabricated Fittings (PE)	Yes	Yes	Yes	Yes	As PE pipe	< 5[13, 16]	< 3%	Unlikely[22]	Unlikely	Yes	Unlikely	Maybe[28, 35]	> 5[38, 41]	4-12 wks special order	No
PP (Non-pressure)	No	No	Yes	Yes	> DN 300	< 8[13, 16] (SN 10)	< 3%	No	Unlikely	Maybe	Maybe	Maybe[41]	> 9[38, 41]	4 wks for min. order	Yes
Fabricated Fittings for PP	No	No	Yes	Yes	As PP pipe	As PP pipe	As PP pipe	No	Unlikely	Maybe	Maybe	Maybe[41]	> 9[38, 41]	4-6wks for min. order	No
PVC-M	Yes	Yes	Maybe[4]	Yes	≤ DN 375[8]	< 5[13, 16]	< 3%	Unlikely[22]	Yes	Maybe	Maybe	Yes[31, 34]	> 6[38]	DN ≤ 250; PN < 20 stock. DN > 250 4wks min. order	Yes
PVC-O	Yes	Yes	Yes	Yes	≤ DN 375/400[8]	< 5[13, 16]	< 3%	Unlikely[22]	Yes	Maybe	No	Yes[31, 34]	> 7[38]	No local stock. PN 12/16 - 4-6 wks for min. order	Yes
PVC-U	Yes	Yes	Maybe[4]	Yes	≤ DN 375[8]	< 5[13, 16]	< 3%	Unlikely[22]	Yes	Maybe	Maybe	Yes[31, 34]	> 6[38]	Non preferred; special order	Yes
PVC-U (Non-pressure)	No	No	Yes	Yes	≤ DN 375[8]	< 6.5[13, 16] (SN 8)	< 3%	Unlikely[22]	Yes	Maybe	Maybe	Yes	> 6[38]	DN ≤300: stock. DN375 @ 3m lengths. Otherwise 4 wks	Yes
RC (Non-pressure)	No	No	Yes	Yes	> DN 600[5]	AS/NZS 3725[9]	N/A[19]	Unlikely[22]	Yes	Unlikely	Yes	Yes	> 4[42]	4 wks for min. order	Yes
RA (Non-pressure)	No	No	Yes	Yes	> DN 700[5]	Note 9	N/A[19]	No	Yes	No	Yes	Yes	> 4[42]	18 wks min. special order	Yes
MSCL[25]	Yes	Yes	Maybe[3]	Maybe[3]	> DN 1400[10]	< 5[13]	< 1.5 (1% ESJ)[18]	Yes[20]	Yes[26]	Yes	Yes	Yes[31, 34, 36]	> 5[39]	min. order 4 wks ≤ DN 450; 10-18 wks larger sizes	Yes
MSCL Fittings	Yes	Yes	Maybe[3]	Maybe[3]	> DN 1400[10]	As MSCL pipe	As MSCL pipe	Yes[20]	Yes[26]	Yes	Yes	Yes[31, 34, 36]	> 5[39]	4-8 wks special order	No
SS 316[17, 25]	Yes	Yes	Yes	Yes	> DN 600[10]	Note 17	Note 17	Yes[20]	Yes[26]	Yes	Yes	Yes[31, 34, 36]	> 4[39]	min. order 10-16 wks pipe; 14-20 wks fittings (specials)	No
VC (Non-pressure)	No	No	Yes	Yes	> DN 375/400	Note[9]	N/A[19]	Unlikely[22]	Yes	Unlikely	Yes	Yes	> 4[42]	6-12 wks for min order	No

Notes for Table 4.1.1

1	The following are essential considerations in a pipeline selection process intended to shortlist pipeline component options that are likely to be appropriate and feasible in terms of: • Mutual assurance by the suppliers of different pipeline components that the integrity of a planned pipeline system will not be compromised by the poor or non-compliant performance of any individual component; • Compatibility of component material, engineering and jointing characteristics with installability, operability and service longevity requirements; • Impacts of elevated temperature, frequent cyclic pressure fluctuations and creep (loss of strength/stiffness over time) on pipe material (e.g. plastics) and, hence, pipe sensitivity to poor quality/uncontrolled pipeline embedment; • Inter-connectibility of pressure and non-pressure pipeline components under consideration with adjoining new and legacy conveyance pipeline system components; • Added whole of Corporation pipeline system ownership, operational and maintenance business value, over the designated pipeline life; • Market availability of pipeline components in the project specific sizes and quantities and within the planned project materials supply lead times; • Specific provision for component operational, repair and maintenance spares aimed at minimizing service disruptions and outages in the context of Operating Licence services flow, pressure and continuity requirements;
2	Non-drinking water means any water other than drinking water - including wastewater, storm-water, bore water, ground water, lake or river water - which has been treated to meet a qualitative standard defined by the appropriate Regulator and which complies with the requirements for its intended end use.
3	General Portland cement lined pipes and pipe fittings should not be used for non-pressure wastewater applications. Their use in pressure wastewater applications - including consideration of AS 4321 or AS/NZS 4158 compliant MDPE or FBE lining or AS/NZS 2280 compliant calcium aluminate cement mortar lining - should be supported by an evaluation that assures lining longevity and maintainability wherever exposed to pipeline borne fluids and gases. An assurance of (absolute) minimum steady state positive head values > 7.5 kPa within a pressure pipeline system throughout its operational life may be a significant element of assuring the required longevity performance.
4	The superior fatigue performance of PVC-O as a pressure pipe material, coupled with limited market availability of PVC-M or PVC-U pipe of an appropriately high pressure rating, is likely to render the selection of PVC-M and PVC-U pressure pipe commercially unviable for applications that routinely involve frequent pressure cycling (e.g. wastewater pumping applications) and elevated temperatures, having due regard to Table 4.5 data.
5	General consideration of pipeline sizes other than those shown in the Table should be supported by acceptable evidence of their prior satisfactory use on agreed trial projects in accordance with a control process that evaluates and documents the quality of all elements of pipeline system design, manufacture, supply, delivery, installation and serviceability performance. In some cases, non-preferred pipe materials and sizes (e.g. ABS and DI pipe of any size and CU pipe for other than property service applications) should **not** be considered for selection for new pipeline projects, in the absence of prior technical, business and risk justification that is acceptable to and authorised by the Corporation for general infrastructure use.
6	Refer **Table A1** for background to the service constraint and operating licence risks associated with the selection of PE pipe sizes larger than DN 630 for Corporation services.
7	Compression fittings are available for PE pipe larger than DN 63 but have been associated with incomplete joint sealing where formal installer training is not a documented requirement and where the execution of installation practices that are poorly controlled/supervised or not subjected to ongoing performance conformity auditing of substance.
8	Some product standards designate DN 375 Series 2 PVC pressure pipe as DN 400, albeit the same <u>nominal</u> size. Where DN 450 non-pressure (AS/NZS 1260) PVC pipe is not commonly manufactured, DN 450 PVC pressure pipe may be considered subject, as always, to market availability (from eastern states), agreed minimum purchase quantities and appropriate management/control of long distance handling and transportation logistics and risks.
9	Design of RC, RA and VC pipeline systems including loadings, cover depth and bedding factors for alternative embedment arrangements should be in accordance with the requirements and guidance respectively set out in AS/NZS 3725:2007 “Design for installation of buried concrete pipes” and AS 4060-1992 “Loads on buried vitrified clay pipes” and associated Supplements AS/NZS 3725 Supp 1:2007 “Design for installation of buried concrete pipes – Commentary” and AS 4060 Supp 1-1992 “Loads on buried vitrified clay pipes – Commentary”, respectively
10	**Table 4.2** sets out indicative mechanical characteristics for steel pipes < DN 1400. Consideration of larger sizes is noted elsewhere in **Table 4.1.1 Notes**.
11	The indicative pipeline cover depth values shown are for comparison purposes. Designers should determine maximum burial cover depth values for individual applications by calculating the capacity of pipeline material, dimensions, pressure/stiffness classes and allowable pipe hoop stress/strain values to resist, subject to appropriate design (or safety) factors: • deflection or diametral deformation in excess of the values shown within 30 days of installation and burial, notwithstanding the values shown in AS/NZS 2566.2 Table 5.6 for an assumed high quality embedment installation and compaction. The application of additional design (safety) factors may be required to address inferior and unsupervised embedment work expectations; • buckling, having due regard to the potential for occurrence of positive or negative internal pressure extremes and external soil and hydrostatic loads, simultaneously or not; • imposed embankment (as distinct from trench) condition loads.
12	Structurally unprotected pipe burial cover depth should generally exceed 0.75 - where unpaved - or 0.6m - where paved to an acceptable paving and paving support structural specification - as an absolute minimum. Shallower cover depths may be considered by exception where engineering and risk analyses of pipeline/embedment design clearly assure safe structural, operational and service feasibility. Deeper burial cover depths may apply where a buried pipeline is to be exposed to: • unavoidable conflict with other buried services or service alignments; • vehicular and other imposed surface loads - including construction equipment loads - during pipeline installation work; • change of direction involving constructed thrust block supports; • horizontal or vertical proximity to other existing or proposed structural or built assets whose integrity or stability may be compromised by pipeline installation and - particularly in the case of viscoelastic (e.g. PE/PP) pressure pipe - its expansion and contraction in service and during pipeline field pressure testing operations. The use of concrete bulkhead/trench stop thrust restraints or cement stabilised embedment in accordance with the provisions of AS/NZS 2566.2 may be considered to provide structural stability where fill strength is poor, where cover depths are shallow and where pipeline gradients are steep.
13	Where any pipe selection is under consideration for depths exceeding the typical cover depth values shown, designers should verify the design basis and safety margin against failure due to excessive deflection (ring bending) or buckling where subject to trench and embankment loading conditions as applicable, by calculation and by reference to the pipe manufacturer as necessary. Higher cover depths may be considered where supported by (**i**) embedment and structural design calculations using appropriate design/safety factors and (**ii**) by an acceptable specification for pipeline installation including appropriate (embedment/compaction) quality inspection and testing controls.

Notes for Table 4.1.1 (continued)

14	Small bore PE and copper pipelines with compression and silver brazed joints respectively are intended for use at shallow depths away from paved roads e.g. property services. The use of PE pipeline compression fittings in buried applications should be limited to shallow off-road verge applications where the impacts of poor embedment quality are lower risk.
15	Where GRP pipe is under consideration, designers should, in particular, consider the comparatively limited ring bending strain capacity of GRP pipe.
16	The typical burial cover depths values shown for PE pressure and PP/PVC non-pressure pipe may be increased in conveyance applications where pipeline structure, stiffness, embedment and pipe deflection design calculations together with appropriate installation performance control specifications are provided to the Corporation and are shown to safely support the higher values.
17	Consideration of SS pipeline systems for conveyance applications should be determined on a project by project basis, subject to project justification including specific material (e.g. 316L or super duplex SS) need, the corrosive characteristics of pipeline borne fluids & gases, the extent of external exposure to corrosive environments, structural longevity performance and pipeline system life economics.
18	The typical allowable vertical pipe deflection values shown are lower than the 30 day values shown in AS/NZS 2566.2 Table 5.6 to address the risk of inferior, untested or unproven embedment work except where appropriate high quality installation, inspection and testing performance verification practices are demonstrably assured. Where steel pipeline joints are to be elastomerically sealed, allowable deflection values are generally lower (< 1%) than (< 1.5%) where pipeline joints are welded in accordance with WS-1.
19	No vertical deflection criteria are nominated, given other application constraints on the location of Cu pipe and compression fittings for PE pipe and the need to constrain RC, RA and unreinforced VC (rigid) pipe loads and crack development by virtue of a well-designed and tested pipeline/embedment in accordance with an assured embedment performance specification.
20	"Yes" indicates materials that should be prime candidates for above ground and bridge crossing applications, given appropriate design of pipeline structure, coating & protection systems, expansion/contraction potential and associated thrust restraint systems.
21	"Maybe" indicates materials that may be potential candidates for above ground and bridge crossing applications, provided that the mechanical/structural feasibility and economic viability of pipeline structure, protection systems and thrust restraint systems are supported by acceptable design basis assumptions including design factor selection that safely assures the required longevity performance.
22	"Unlikely" indicates pipeline materials that, except where specifically justified by considered project needs and risk analyses, are unlikely to provide the required service duration and least risk performance in above ground and bridge crossing applications. Risk considerations include thermal and creep characteristics, material/coating/lining susceptibility to heat and UV damage and in-service performance of pipe structure and jointing (thrust restrained or not) systems.
23	The use of compression jointed fittings under watercourses, significant structures or buried/concealed hard-to-access locations would present significant risk in the event of failures.
24	An engineering design basis, of an acceptable rigour, should be documented to support the: • Selection, engineering evaluation and design of carrier and sleeve encasement/containment pipelines in terms of structural viability, buckling resistance and joint integrity over designated pipeline service life; • Design and specification of embedment performance parameters for open cut/trenched applications **and** system control and installation methodology for trenchless applications (Refer Table 4.1.2 and Table 4.1.2 Notes).
25	The designer is accountable for evaluating the extent, if any, exposure of metallic pipeline to high voltage (> 11kV) transmission lines and cables where continuously welded and for designing the pipeline to mitigate the associated risk of corrosion, in accordance with the guidance in DS 91 and requirements of DS 23 as appropriate.
26	Where DI or steel pipe may be under consideration as part of a carrier pipeline or sleeve (encasement) under watercourses or significant structures, its selection/design should provide for corrosion prevention measures including tested coating and wrapping systems (in accordance with DS 95) to assure the required longevity performance and address pipeline exposure to external atmospheric and subterranean electrolytes over its designated service life.
27	The acceptability of pipe materials and pipe jointing systems for sleeve and carrier applications (i.e. for stand-alone carrier pipe, carrier pipe inside a sleeve or structural sleeve for a carrier pipe), using open cut/fill or trenchless techniques beneath a significant watercourse, structure or obstacle, should be specifically demonstrated in terms of: • Whole of sleeve/carrier longevity, engineering, installability, in-service risks and value for money (**Table 4.1.2** provides guidance on the selection of and risk rating criteria for pipeline materials in trenchless applications); • Pipeline and soil embedment structural stability, safety, security and durability during installation and during subsequent sleeve/carrier operations and maintenance over the designated service life, given the community impacts of premature sleeve/carrier pipe failure or instability and the logistics of pipeline repair and replacement operations; • Durability, stability and security of un-grouted carrier pressure pipe within a **non-corrodible** permanent sleeve pipe - typically by means of **non-corrodible** sleeve/casing spacers, spiders or supports of an acceptable design - where located beneath designated (existing and future) freeways, highways, railways and environmentally sensitive areas, given the impracticability - and unacceptability to asset owners - of open cut/fill installation techniques and the unacceptable impacts of premature carrier pipe failure (e.g. traffic disruption, carrier pipe repair/replacement logistics and service outages; • The need to structurally grout sleeve/carrier pipeline annulus (**A**) where located beneath designated freeways, highways, railways and environmentally sensitive areas or otherwise, (**B**) where a selected sleeve pipe material is corrodible (e.g. carbon steel) or may be incapable of safely bearing imposed loads or outlasting its inner carrier pipe and (**C**) where a selected carrier pipe material and may be structurally unstable (e.g. PE pipe). • The complexity (high cost and high failure risk) of future repair or replacement, where a carrier pipe with protruding, cast, moulded, fabricated or socketed (e.g. fusion) fittings is being considered for installation in a sleeve; • The improbability of RC as a viable carrier pipe material, where considered for installation in a sleeve pipe of RC or another material; • The improbability of flexibly (elastomeric seal) jointed pipe (e.g. DI, PVC, GRP) as a viable/acceptable carrier pipeline beneath significant watercourses, structures or obstacles, given pipeline inherent lack of structural, hydraulic continuity or (unanchored) axial restraint capability and given the impracticability of pipeline joint installation, pressure testing and repair or replacement in place.

Notes for Table 4.1.1 (continued)

28	The use of PE pipe and fittings for water conveyance applications, particularly where the water is chlorinated, is limited to pipe and fitting products manufactured from PE resins that have been duly assessed and authorised as conforming with High Stress Crack Resistant (HSCR), Disinfectant Resistant (DR) or Resistant to Cracks (RC) resin specifications, as defined in SPS 125 and as required by DS 60 and DS 63 for water conveyance applications. The use of PE pipe and fittings in chlorinated water conveyance applications where water temperature exceeds 25°C is non-preferred. Consideration of PE pipeline components for selection should provide for: • Market availability of or supply constraints on PE pipeline components and the specified (e.g. PE 100 HSCR, DR, RC) resins; • Pipeline thermal movements which can be considerable, particularly where directly exposed to significant outdoor temperature and internal pressure fluctuations: • Repairability constraints due to the impracticability of lengthy service shutdowns for repair (emptying, drying, fusion heating and cooling time) purposes and market availability of axially restrained mechanical coupling systems that require stainless steel stiffener inserts to secure PE pipeline mechanical joint integrity; • The constructability, cost inefficiencies and safety risks that are certain to arise where PE pipe is proposed for installation in an open cut trench traversed by multiple closely spaced utility services - due to the need to fusion joint PE pipe in many short lengths in confined trench conditions, as compared with its installation in long lengths (fusion jointed on the above ground surface) where conflicting utility service crossings are lesser in number and farther apart; • Need to select pipe wall thickness/pressure rating values that are higher than nominally required to withstand calculated internal pipeline design pressures to mitigate potential failure risks, including those arising from exposure to abrasion by sharp/angular soil particles (e.g. in trenchless applications) and those arising from exposure to high (> 25°C) temperature chlorinated water (e.g. disinfected water conveyance applications); • The logistical practicability (or not) of establishing and dis-establishing bulky pipe transportation, joint alignment, surface preparation and fusion equipment in remote regional locations, particularly for large PE pipelines; • The expansive swelling and uplift effects of large visco-elastic (e.g. PE) pipe where subjected to fluctuating test and service pressures below road and other significant built structures and where cover depths are shallow. Allowable PE pipeline pressures should be calculated by reference to this Table, Tables 4.2, 4.5, A1 and A2 and associated Table Notes. Accordingly, the "informative" service (design) coefficient values in AS/NZS 4130:2009 Table C1 are **not** applicable to water or wastewater conveyance applications in WA.
29	The selection of pipeline materials and jointing systems for trenchless applications should be on the basis of least risk or specified risk mitigation measures, in accordance with the guidance in Table 4.1.2 and associated Notes.
30	Selection of new pipeline components for use in buried urban centres, heavily trafficked roads, narrow road reserves, paved urban laneways and other areas with multiple utility services should include: • Conformity with requirements in the Utility Providers Code of Practice for service locations, depths and alignment corridors; • Planned mitigation measures to minimize the disturbance impacts and risks to existing Corporation and other utility services that rely on existing undisturbed soil to bear existing unbalanced pipeline thrusts; • Planned measures to address the site logistics of lengthy pipe 'strings' & sections of open trench, bulky (transportation & fusion) equipment space requirements as well as installation feasibility and economics.
31	The use of elastomeric seal jointed pressure pipe - particularly in larger (> DN 250) sizes - may require thrust blocks that are not physically nor economically constructible within prescribed service alignments and depths. In general, pipeline thrust restraint options – including designed thrust blocks - should be selected on the basis of structural stability, given the risk of de-stabilizing of other utility services that may adjoin them and the risk of poor/no quality control where others undertake sub-surface work and where there are multiple services and alignment constraints. The limited use (on agreed projects only) of non-preferred Series 1 solvent weld jointed plastics pipe should be considered only where justified on the basis of substantial (proven) life cost advantage in comparison with other pipe material and joint configuration options.
32	The use of (corrosion protected) flanged - in lieu of flexible socketed - jointing of DI pipeline components may be justifiable on the basis of life cost advantage when compared with other pipe material and joint configuration options, provided that the impracticability of field DI welding and induced electrical voltage potential are adequately evaluated and provided for in project cost/risk analyses.
33	The use of butt & strap - in lieu of flexible socketed - jointing of GRP pipeline components may, subject to Corporation acceptance, be justifiable on the basis of life cost advantage, compared with other pipe material and joint configuration options.
34	Straight flexibly socketed pipeline 'runs' may be supplemented with sections of flanged, welded (e.g. DI/MS) or 'butt & strapped' (e.g. GRP) components for a sufficient length on both 'sides' of pipeline direction changes to obviate the need for thrust blocks, where justified on the basis of life cost advantage, compared with other pipe material and joint configuration options.
35	Justification for the use of fusion jointed PE pipeline components should include consideration of the logistical impacts and the practicability of installing lengthy pipe 'strings' in open cut trenches where road/lane reserves are narrow and services congested, given the bulk and maneuverability requirements of fusion, re-rounding, positioning and preparation equipment as well as the need to efficiently and economically manage pipeline exposure to wet environments, work duration and logistics of fusion joint heating, cooling and proof testing equipment and operations.
36	Steel pipeline welding, welder competencies and conformity of weld and welder accreditation should be (and shown on project records to be) in accordance with WS-1 requirements.
37	Pipeline selection & design should provide justification for the constructability of pipeline materials and their relative sensitivity to inferior pipeline embedment design, installation and conformity test practices. Constructability is ranked to reflect the relative importance of good embedment quality design/specifications, embedment installation and its quality assurance by inspection and conformity testing. Embedment sensitivity to sub-standard, non-compliant and infrequent (or no) quality testing is ranked on a scale of 1 (insensitive) to 10 (very sensitive), to reflect the selection, design, installation and embedment conformity testing rigour required.
38	As plastics pipe materials are very sensitive to creep induced stiffness reduction, load and thermal induced deflection, ovality and scratch/notch induced damage, pipeline embedment should be designed and installed in conformity with a (nominated) high quality pipeline embedment specification that assures adequacy of surround material compaction to prevent deformity of lower stiffness pipeline in the later stages of its design life. As shown in Table 4.2, the short & long term stiffness of PVC-O pipe is much lower than for like PVC-M or PVC-U pipe. PVC pipe should be installed only by PVC pipe-layers who have been formally accredited by a Registered Training Organization in accordance with industry training modules that are nominated by the Corporation.
39	The flexibility of DI, MS & SS pipeline shell materials, although comparatively rigid, renders them moderately sensitive to poor embedment design, installation and conformity testing practices. More critically, poor embedment quality could potentially lead to excessive DI/MS pipe cement mortar lining strain and excessive pipe ovality which would, in turn, cause flexible joints to fail where joint (but not pipe barrel) deflection capacity is exceeded.
40	The low ring bending strain capacity of GRP pipe material renders it sensitive to deflection induced failure - particularly in embankment - as distinct from trench - conditions.
41	PP and PE pipeline components are exceptionally sensitive to inferior embedment design and installation practices, particularly in the absence of rigorous embedment conformity assurance and quality checking. They are particularly prone to failure where exposed to on-site handling and fusion welding practices undertaken by unqualified non-accredited (in accordance with WS-2) welding service providers.

42	The sensitivity of rigid (RC, RA and VC) pipelines to strain related cracking should be addressed by assuring good embedment design & installation (to AS/NZS 3725 and AS 4060 respectively) and conformity assurance practices.
43	The information on pipe component availability is indicative only and can vary significantly from time to time and from one supplier to another. It is likely to be very dependent on project quantum needs and timing. Availability for particular projects and applications should be evaluated by designers well in advance of a final selection for nomination on project drawings. Market enquiries should be particularly pro-active where potential project orders could involve larger (> DN 250) pipe sizes, short pipeline lengths (i.e. product volumes small relative to a commercial pipe production run) and correspondingly long supply lead times.
44	All pipeline components in contact with drinking water should comply with AS/NZS4020 for an acceptable minimum component surface to water volume ratio (or scaling factor).

4.1.2 Trenchless Application Comparison

Table 4.1.2 outlines risk rating criteria for pipeline materials in common trenchless applications. The Table should be read in conjunction with the supplementary guidance in "**Notes for Table 4.1.2**".

Table 4.1.2 Trenchless Application Risk Levels

Pipeline Material	HDD[1A]		MT[1A, 2]		PJ[1A, 2]	
	Trenchless Installation Method Risk Levels[1B, 3, 15]					
	Sleeve	Carrier Pipe	Sleeve	Carrier Pipe	Sleeve	Carrier Pipe
ABS[4]	N/A	N/A	M	M	M	M
DICL[5]	N/A	N/A	N/A	N/A	N/A	N/A
CU	N/A	N/A	N/A	N/A	N/A	N/A
GRP (Pressure)[6]	N/A	N/A	EL	VL	EL	VL
GRP (Non-pressure)[6]	N/A	N/A	EL	VL	EL	VL
PE 100[7]	EL	VL	N/A	N/A	N/A	N/A
PP (Non-pressure)	N/A	N/A	N/A	N/A	N/A	N/A
PVC-M	N/A	N/A	N/A	N/A	N/A	N/A
PVC-O	N/A	N/A	N/A	N/A	N/A	N/A
PVC-U[8]	N/A	N/A	M	N/A	M	N/A
PVC-U (Non-pressure)[8]	N/A	N/A	L	M	L	M
RC (Non-pressure)[9]	N/A	N/A	EL	VL	EL	VL
RA (Non-pressure)[9]	N/A	N/A	EL	VL	EL	VL
MSCL[10]	N/A	N/A	VL	L	VL	L
SS 316[11]	N/A	N/A	EL	VL	EL	VL
VC (Non-pressure)[12]	N/A	N/A	VL	N/A	VL	N/A

Notes for Table 4.1.2

	DEFINITIONS
1A	**<u>Trenchless Installation Methods</u>** **HDD - Horizontal Directional Drilling:** A remotely steered trenchless method of pre-boring and reaming a below ground pilot hole for a carrier pipe, using a surface-launched drilling machine. The carrier pipe is pulled behind the back reaming tool on a predetermined but wide-toleranced (low accuracy) alignment. **MT – Microtunneling:** A trenchless method for pre-boring a service conduit (sleeve) below ground, using a small (600-1200 mm) remotely - laser/CCTV - guided tunnelling drill. The carrier pipe is pushed through the conduit, using a jacking frame that follows the drilling head on an accurate predetermined alignment. **PJ - Pipe Jacking** (or Thrust Boring)**:** A trenchless method for hydraulically jacking/ramming a pipe along a below ground alignment, using laser guided pneumatic percussive jacking rams, a soil cutting shoe/band attached to the advancing driven pipe end and a shielded drill or excavator at the advancing head.
1B	**<u>Post Trenchless Installation Failure/Burst Risk Levels</u>** **N/A** (Not available/Not acceptable) – Pipe material or structure incompatible with available trenchless technology systems, installation expertise and installation economics in Western Australia. **M** (Major and Moderate) - Unacceptable risk of pipeline structure damage or impairment of service and longevity performance. **L** (Minor/Low) – Risk of structural damage or service and longevity performance impairment can be mitigated to an acceptable level by sustainable means, including additional pipe thickness, reinforcement or protective treatments and trenchless methodology. **VL** (Insignificant/Very Low) – Lower - than L - residual risk by virtue of alternative pipe material or mitigation treatment. **EL** (Insignificant/Extremely Low) – Negligible residual risk of structural damage or service and longevity performance impairment.
2	Each **MT** and **PJ** operation requires a launch pit (typically 8m x 3m) to accommodate tunnelling and jacking equipment and the pipe length to be launched/driven. Each also requires a reception pit for removal of the equipment and, in the case of long trenchless drives, intermediate pits for supplementary (or inter) jacking. A lubricant - typically bentonite slurry – is sometimes injected into the driven pipe interface with the surrounding soil to reduce interface friction and, hence, the thrust or jacking forces required.
3	Pipe of higher structural strength than required for conventional cut and fill open trench applications should be selected for trenchless installation in preference to reliance on an unrealistically 'ambitious' embedment performance specification whose enforcement, effectiveness and proof of implementation - from Corporation experience - are unlikely to be deliverable or delivered, in practice.
4	The inherent susceptibility of (thermoplastics) ABS pressure pipe – as a non-preferred pipe material at present - to distortion and abrasion damage, particularly at elevated temperatures, presents at least a moderate and often major (**M**) risk of failure in trenchless applications. The risks should be addressed in accordance with **Note 15** guidance.
5	DI pipe is a non-preferred pipe material for general use. It is available with integral (belled) joint sockets but not as a 'socket-less 'jacking' grade product. Hence, its (**N/A**) risk rating for trenchless installation applications.
6	The risk of trenchlessly installed GRP pipe failure is higher (**VL**) for carrier than (**EL**) for sleeve pipe applications. The risks should be addressed in accordance with **Note 15** guidance.
7	(**a**) For trenchless un-sleeved applications e.g. HDD, a PE carrier pipe of a higher wall thickness (lower SDR value), than that required for pipe hydraulic function, should be selected to mitigate potential thickness loss due to installation abrasion/scratching and to mitigate the risk of PE pipeline failure where un-protected by a separate structural sleeve, given the consequences of failure below significant assets.
	(**b**) A PE carrier pipe in a **non-corrodible** (e.g. stainless steel or plastics) permanent sleeve pipe - typically beneath designated freeways, highways, railways and environmentally sensitive areas – should be supported all round by non-corrodible skids, spacers, spiders or supports of an acceptable design, during installation and subsequent service. PE pipe SDR and annular sleeve support spacings should be designed to constrain (**i**) pipe movement within its designated (straight) alignment (without 'snaking') - and (**ii**) pipe expansion/contraction due to internal pressure fluctuations - including necking - within safe material (stress/strain) limitations.
	(**c**) The annulus between a PE carrier pipe and a **corrodible** (e.g. carbon steel) permanent sleeve pipe - typically in locations **other than** beneath designated freeways, highways, railways and environmentally sensitive areas - should be grouted, provided that the PE pipe is 'overwrapped' with a compressible elastomeric membrane of an acceptable design to temper the structural immobility of the concrete grout. Overwrap material thickness, compressibility and compression set should be selected to constrain pipe expansion and contraction due to internal pressure fluctuations - including necking at pipe entry to/exit from the annular grout - within safe material (stress/strain) limitations.
	(**d**) Carrier/sleeve pipe configuration and structural performance risks should be addressed in accordance with **Note 15** guidance.
8	The risk of trenchlessly installed PVC-U pipe failure is likely to vary according to project application and control as follows: • Moderate to major (**M**) for PVC-U **pressure pipe** in sleeve applications and for PVC-U **non-pressure pipe** in carrier applications – to reflect the limitations of the structural joint continuity and sealing system options available; • Low (**L**) for PVC-U **non-pressure pipe** in sleeve applications arising from the likely availability of purpose designed (e.g. jacking grade) PVC-U pipe product whose structural robustness, jointing integrity, installation safety and service longevity is assured; The risks should be addressed in accordance with **Note 15** guidance.
9	The risk of trenchlessly installed RC or RA pipe failure is ranked higher (**VL**) for carrier than (**EL**) for sleeve pipe applications to reflect the greater challenges of installing, maintaining in service and replacing an un-sleeved RC/RA carrier pipe. This risk should be addressed in accordance with **Note 15** guidance.
10	The risk of trenchlessly installed carbon (mild) steel pipe failure is ranked higher (**L**) for carrier than (**VL**) for sleeve pipe applications to reflect the greater challenges of installing, protecting, maintaining in service and replacing an un-sleeved MS carrier pipe. This and the risk level inherent in considering MS as a material option for sleeve pipe may typically be mitigated by: • Assuring un-sleeved steel carrier pipe protection from corrosion over nominated pipe design life by the specification of acceptable external surface treatment options (including cathodic protection in accordance with DS 91); • Specifying a structural grout filled sleeve/carrier pipe annulus for MS sleeve pipe applications; • Opting for non-corrodible (in lieu of carbon steel) material selections for sleeve pipe applications; The risks should be addressed in accordance with **Note 15** guidance.
11	The risk of trenchlessly installed stainless steel pipe failure is ranked higher (**VL**) for carrier than (**EL**) for sleeve pipe applications to reflect the greater challenges of installing, maintaining in service and replacing an un-sleeved carrier pipe failure. The risk, including the selection of an appropriate SS material grade (e.g. 316L and super duplex) for the required level of corrosion protection, should be addressed in accordance with **Note 15** guidance.
12	The nomination of VC pipe, as an unreinforced rigid pipe, presents at least a low (**L**) or significant risk of failure in trenchless applications. The risk should be addressed as recommended in **Note 15** guidance.

13	The annulus between an inner carrier pipe and outer sleeve should not be grouted where the (carrier) piped service is routed below significant structures (e.g. buildings, freeways, highways, railways) or areas of significant environmental, cultural or heritage value so as to enable future service repair or replacement without disrupting or (open) cutting the above ground facilities or areas.
14	The Strategic Products Register lists some jacking pipe products that have been authorised on the basis of conformity with acceptable design and installation standards (e.g. ISO 25780). Proposals to nominate other pipe systems for trenchless applications should be duly supported by an acceptable design and installation basis for materials, engineering, installation methodology and service durability/longevity performance
15	Trenchless application risk should be mitigated by prior submission of a justified feasibility, supply, installation and control methodology proposal that proves acceptable to the Corporation as prospective asset owner. The proposal should clearly identify all pipeline components proposed for selection and should establish the design, installation and service performance risks, including: • The scope of trenchless (as compared with open cut) installation components in terms of net added benefits and asset life value, mindful of the logistics and economics of trenchlessly installed pipeline repair or replacement in the future; • Pipe material and structural grade selection, duly justified by an original pipe manufacturer, by a third party structural designer, or both where an original pipe is modified to produce a final jacking pipe product; • Successful field installation trials for pipe of the nominated 'jacking grade', strength class and service performance, demonstrated eligibility for its authorisation on the Strategic Products Register together with its market availability and supply lead times; • Pipe coating and lining structural performance during application of jacking, driving and abrasion forces – particularly where lining (e.g. cement mortar) may become unevenly or eccentrically loaded beyond its safe limits - and pipeline longevity performance, subject to its level of exposure to corrosive installed environments over pipeline service life. • Structural integrity and continuity of pipe jointing system, fitness of trenchless drive attachments and directional precision of drive alignment control equipment and technology; • Pipe selection and trenchless installation feasibility and economics, duly informed in consultation with the owners of significant structures (e.g. buildings, freeways, highways, railways) or areas below which trenchless pipeline installation is proposed, with regulatory authorities and with experienced trenchless constructors/installers, as appropriate; • Summary of line, level, structural and longevity performance parameters for a trenchlessly installed pipeline, clearly defined and supported by a documented engineering basis of an appropriate rigour.

4.2 Flexible Pipe Characteristics

Tables 4.2, 4.3 and 4.4 below compare indicative material and hydrostatic (hoop) strength, stiffness, safety factor and service design coefficient characteristics and values for various plastics compounds, mild steel and ductile iron from which commonly available flexible pipes are manufactured. All values apply at a baseline pipe wall temperature of 20°C.

Table 4.2 - Indicative Characteristics of Plastics Pressure Pipes[4, 5, 6, 7]

Pressure Pipe Material (Product Standard)	Compound Material Classification	Minimum Required Material Strength	Service Design Coefficient/Safety Factor	Hydrostatic Design Stress	Short Term Ring Bending Modulus (E_b)[8]	Long Term Ring Bending Modulus (E_{bL})	Standard Dimension Ratio	Short Term Ring Bending Stiffness[8]	Long Term Ring Bending Stiffness	Standard Dimension Ratio	Short Term Ring Bending Stiffness	Long Term Ring Bending Stiffness	Standard Dimension Ratio	Short Term Ring Bending Stiffness	Long Term Ring Bending Stiffness
	APPLICABLE TO ALL PN RATINGS						**PN 12/12.5[2, 4]**			**PN 16/15[2, 4]**			**PN 20[2, 4]**		
		MRS		HDS	3min	50 yr	SDR	**SN**	**SN**	SDR	**SN**	**SN**	SDR	**SN**	**SN**
		MPa		MPa	MPa	MPa		3min	50 yr		3min	50 yr		3min	50 yr
ABS (AS/NZS 3518)[1]	120	12.0	1.60	7.5	2000	890	13.5	85.3	38.0	11.0	166.7	74	N/A	N/A	N/A
	140	14.0	1.60	8.8	2000	890	15.6	53.6	23.8	12.7	104.1	46	N/A	N/A	N/A
	160	16.0	1.60	10.0	2000	890	17.7	35.8	15.9	14.3	70.8	32	11.0	166.7	74
	180	18.0	1.60	11.3	2000	890	19.8	25.1	11.2	16.0	49.4	22	12.3	115.5	51
PE 100 (AS/NZS 4130)	100	10.0	1.25	8.0	950	260	13.6	39.6	10.8	11.0	79.2	22	9.0	154.6	42
PVC-O (AS/NZS 4441)	315[2]	31.5	1.60	19.7	3500	1600	32.0	9.8	4.5	25.9	18.9	9	21.0	36.5	17
	355	35.5	1.60	22.2	4000	1800	35.8	7.9	3.6	29.0	15.2	7	23.4	29.7	13
	400	40.0	1.60	25.0	4000	1800	40.6	5.4	2.4	32.0	11.2	5	25.9	21.6	10
	450	45.0	1.60	28.1	4000	1800	45.1	3.9	1.7	35.8	7.9	4	29.0	15.2	7
	500	50.0	1.60	31.3	4000	1800	50.7	2.7	1.2	40.6	5.4	2	32.0	11.2	5
PVC-M (AS/NZS 4765)	N/A	24.5	1.40	17.5	3000	1200	29.7	10.6	4.9	22.5	25.2	12	N/A	N/A	N/A
PVC-U (AS/NZS 1477)	≤ DN 150	23.6	2.15	11.0	3200	1400	19.3	43.5	19.0	14.7	103.7	45	11.9	206	90
	> DN 150	26.0	2.11	12.3	3200	1400	21.5	31.0	13.5	16.3	74.5	33	N/A	N/A	N/A

Notes for Table 4.2

1	ABS is a non-preferred plastics pipe material that should not, at present, be considered for general selection on pipeline projects. Typical ABS pressure pipe material characteristics are shown to enable comparison with the characteristics of plastics pipe materials that are authorised and listed in the Strategic Products Register for general use in WA.
2	Characteristic pipe SDR and stiffness data are nominal, being based on minimum pipe diameters and wall thickness values given in the pipe manufacturing standards. In practice, SDR and stiffness data for manufactured pipe are likely to be higher, given that manufactured pipe wall thicknesses should approximate mean rather than minimum values. The effect of plastics material creep over time is evidenced by lower long (50 year) term theoretical stiffness values as compared with short (3 minute) term or initial values. (An SN 10 stiffness value equals a stiffness of 10,000 N/m per metre of pipe length).
3	Ring bending modulus values given for PVC-O pipe material class 315 are notional (shown in AS 4441 Int when published circa 2003) and have not been reviewed/confirmed because PVC-O pipe of that material class has not been manufactured since then. Where required, characteristic data for PVC-O Class 315 should be confirmed by reference to credible validated plastics pipe industry data.
4	The MAOP value of a plastics pressure pipe is the maximum operating pressure (including pressure excursions due to operational surge events) allowable during pipe service life. The effective MAOP value of a plastics pipe is, in effect, equivalent to its PN rating but decreases as mean pipe wall temperature rises above 20º C. For example, the MAOP value of a PN 16 rated pipe at 20º C is 1.6 MPa but is no more than 1.1 MPa where mean pipe wall temperature is 40º C. Pressure re-rating design factors for a range of pipeline materials subject to elevated temperatures and/or frequent internal pressure cycles are given in Table 4.5
5	The internal pressure applied to a plastics pipeline system to prove its leak-tightness "Allowable Site Test Pressure (ASTP)" should never exceed 125% of its MAOP value. The application of pressure excursions in excess of MAOP to a plastics pipe during its working life will reduce effective pipe service life, in proportion to the quantum and frequency of application.
6	Allowable operating and test pressures (e.g. MAOP, ASTP) reflect the safe characteristic capacity of plastics pipe to sustain internal pressures and are usually expressed in MPa. 1MPa is equivalent to 10 bar, 145 lbf/in^2 or 102 m of applied water head.
7	It may not be assumed that pressure pipes made from all plastics compound and diameter options nominated in product standards are available in the marketplace. The amounts of raw material and energy required to produce (larger sized) pipe from lower strength compounds are, in many cases, commercially unsustainable. This is evidenced by some high theoretical stiffness values in Table 4.2.
8	The short term ring bending modulus and stiffness values shown are the values at **3 minutes** i.e. at the time of manufacture. The **two year** ring bending modulus and stiffness values are typically applied for the purposes of project pipeline structural evaluation, given the known regression (creep/relaxation) characteristics of plastics pipe material from manufacture to actual installation on project sites. These two year values together with long term design basis checks should be applied to the selection and design of a structurally adequate pipeline, in accordance with AS/NZS 2566.1 requirements and guidance.
9	Characteristic values for Glass Reinforced Plastics (GRP) pipe strength/stress/strain are not given because GRP is a non-homogenous combination of thermosetting resin and glass reinforcement that is purpose designed and manufactured to provide specific pressure and stiffness ratings. Typical values for the circumferential flexural (ring bending) modulus of GRP pipe are between 10,000 and 15,000 MPa for cast GRP pipe and up to 30,000 MPa for filament wound GRP pipe. The long term stiffness of pressure and non-pressure GRP pipe can reduce to 50% and 40% respectively of its initial stiffness at the time of manufacture.
10	**Non-pressure** plastics pipe structural performance is defined in AS/NZS 1260 (PVC-U) and AS/NZS 5065 (PP & PE), solely in terms of stiffness (SN) value. For comparison purposes, non-pressure (DWV) PVC pipe SN 6, 8 and 16 stiffnesses are broadly equivalent to PVC-O pressure pipe 400 PN 12, 355 PN 12.5 and 355 PN 16 stiffnesses, respectively. PVC-O material strength classification numbers (355 and 400) are as defined in AS/NZS 4441.

Table 4.3 – Indicative Characteristics of MSCL Pipe

Pipe Nominal Diameter	Pipe Outside Diameter	Steel Pipe Shell Thickness	Cement Mortar Lining Thickness	Lined Pipe Inside Diameter	Steel Minimum Yield Strength (**MYS**)	Ring Strength at 90% MYS Allowable Site Test Pressure (**ASTP**)	Service Design Coefficient	Maximum Allowable Operating Pressure (**MAOP**) at 72% MYS	Lined Pipe Ring Bending Stiffness
DN	mm	mm	mm	mm	MPa	MPa[6]		MPa[6]	SN[3]
						(Max) **ASTP**[2, 5]		**MAOP**[2, 5]	
					MYS	**@ 90% MYS**		**@ 72% MYS**	
100	114	4.8	9	86.4	300	8.5[1]	1.25	6.8[1]	2470
150	168	5	9	140	300	8.5[1]	1.25	6.8[1]	823
200	219	5	9	191	300	8.5[1]	1.25	6.8[1]	364
250	273	5	9	245	300	8.5[1]	1.25	6.8[1]	185
300	324	5	12	290	300	8.3	1.25	6.7	128
400	406	5	12	372	300	6.7	1.25	5.3	64
500	508	5	12	474	300	5.3	1.25	4.3	32
600	610	6	12	574	300	5.3	1.25	4.2	29
700	711	6	12	675	300	4.6	1.25	3.6	19
800	813	7	16	767	300	4.6	1.25	3.7	21
900	914	7	16	868	300	4.1	1.25	3.3	15
1000	1016	8	16	968	300	4.3	1.25	3.4	15
1200	1220	9	16	1170	250	3.3	1.25	2.7	12
1400	1422	11	19	1362	300	4.2	1.25	3.3	13
1400	1422	11	19	1362	250[7]	3.5	1.25	2.8[7]	13

Notes for Table 4.3

1	The strength, pressure and stiffness values given for DN 100 to 250 steel pipe are nominal, being much lower than the actual values derived from pipe dimensions, in order to facilitate sustainable conformity pressure testing of finished steel pipe product, using test equipment, processes and parameters that are logistically achievable and economically viable.
2	The nominated MAOP and ASTP values apply to steel pipelines with manufacturer supplied elastomeric seal sockets and some steel that have fully WS-1 compliant welded joints (e.g. WJ-PE). The MAOP capacity of a weld-restrained elastomeric seal joint (RRJ-WR) is considerably lower e.g. < 2.1 MPa (< DN 600) and < 1.6 MPa (DN 700 -1000). Joint configurations are defined in DS 60.
3	Steel pipe stiffness values are as nominated by the pipe manufacturer and reflect composite cement lining/steel pipe stiffnesses. Bare (unlined) steel pipe shell stiffness generally tends to be between 52% and 63% of lined pipe stiffness pipe across the size range.
4	The MAOP value of steel pipe is the maximum operating pressure (including pressure excursions due to operational surge events) allowable during pipe service life. The PN rating of a pipe is, in effect, its MAOP value X 10 (e.g. MAOP of 2.8 MPa = PN 28
5	The pressure applied to prove steel pipeline system leak-tightness "Allowable Site Test Pressure" should not exceed the nominated pipe ASTP value, to avoid induction of any steel pipe wall stress higher than 90% of its MYS value.
6	Allowable operating and test pressures (e.g. MAOP, ASTP) reflect the safe capacity of steel pipe to sustain internal pressures and are usually expressed in MPa. 1MPa is equivalent to 10 bar, 145 lbf/in2 or 102 m of applied water head and 2.8 MPa is equivalent to 28 bar, 406 lbf/in^2 or 285.6 m of applied water head.
7	Steel pipe material of a higher yield strength (MAOP of 3.3 MPa) has, in the past, been selected for use on particular projects and may be considered for future steel pipeline projects, subject to demonstrated value for money and proven material strength test certification.

Table 4.4 – Indicative Characteristics of DICL Pipe

Nominal Diameter	Outside Diameter	Minimum DI Pipe Shell Thickness	Nominal Cement Lining Thickness	Lined Pipe Inside Diameter	DI Uniaxial Tensile Yield Strength	Ring/Hoop Strength at Yield	Design Safety Factor (**AOP/Hoop Strength**)	Allowable (Steady State) Pipe Operating Pressure (**AOP**)	Maximum Allowable Operating (Abnormal State) Pressure (**MAOP**)	Allowable Site Test Pressure (**ASTP**)	Lined Pipe Ring Bending Stiffness
DN	**mm**	**mm**	**mm**	**mm**	**MPa**	**MPa**		**MPa**	**MPa**	**MPa**	**SN**
								AOP	**MAOP**	**ASTP**	
Ductile Iron Pipe Rated PN 20											
100	122	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
150	177	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
200	232	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
250	286	3.0	5	270	300	6.3	3.1	2.0	2.4	2.5	51
300	345	3.0	5	329	300	5.2	2.6	2.0	2.4	2.5	28
400/375	426	3.1	5	410	300	4.4	2.2	2.0	2.4	2.5	16
450	507	3.6	5	490	300	4.3	2.1	2.0	2.4	2.5	13
500	560	4.0	5	542	300	4.3	2.1	2.0	2.4	2.5	12
600	667	4.8	5	647	300	4.3	2.2	2.0	2.4	2.5	11
750	826	5.9	6	802	300	4.3	2.1	2.0	2.4	2.5	10
Ductile Iron Pipe Rated PN 35											
100	122	3.5	5	105	300	17.2	4.9	3.5	4.2	4.4	695
150	177	3.5	5	160	300	11.9	3.4	3.5	4.2	4.4	220
200	232	3.5	5	215	300	9.1	2.6	3.5	4.2	4.4	96
250	286	3.6	5	269	300	7.6	2.2	3.5	4.2	4.4	75
300	345	4.3	5	326	300	7.5	2.1	3.5	4.2	4.4	63
400	426	5.3	5	405	300	7.5	2.1	3.5	4.2	4.4	55
450	507	6.3	5	484	300	7.5	2.1	3.5	4.2	4.4	49
500	560	7	5	536	300	7.5	2.1	3.5	4.2	4.4	48
600	667	8.3	5	640	300	7.5	2.1	3.5	4.2	4.4	44
750	826	10.2	6	794	300	7.4	2.1	3.5	4.2	4.4	40

Notes for Table 4.4

	The Table excludes strength, pressure and stiffness values for DN 100 to 200 ductile iron (DI) pipes rated PN 20 as these are not covered by the product standard AS/NZS 2280, given the ready market availability of (traditional) PN 35 pipe in those sizes.
	The ductile iron pipe stiffness values shown are as declared by the pipe manufacturer to reflect the composite stiffness of cement lined DI pipe. Bare DI pipe shell stiffness tends to be between 32% and 67% of lined DI pipe stiffness across the size range.
	The AOP value of a ductile iron pipe is the maximum operating pressure, excluding operational surge pressure excursions, that is allowable during DI pipe service life. The PN rating of a DI pipe is, in effect, 10 times its AOP value (e.g. AOP of 2.0 MPa = PN 20). The MAOP value of DI pipe is the maximum operating pressure (including operational pressure excursions due to surge events) that is allowable during pipe service life.
	The pressure applied to prove a DI pipeline system leak-tightness “Allowable Site Test Pressure” should not exceed nominated ASTP values, as higher pressures could induce unacceptably high tensile stresses (> 60% of yield strength) in the DI pipe wall.
	Allowable operating and test pressures (e.g. AOP, MAOP, ASTP) reflect the safe characteristic capacity of plastics pipe to sustain internal pressures and are usually expressed in MPa. 1MPa is equivalent to 10 bar, 145 lbf/in2 or 102 m of applied water head and 4.2 MPa is equivalent to 42 bar, 609.2 lbf/in^2 or 428.3 m of applied water head.

4.3 Asset Performance Requirements

Pipeline designers, having identified potential pipeline options by reference to Tables 4.1.1 and 4.1.2 default criteria, should match pipeline asset configuration and system characteristics, selected for each specific project, to optimal whole of asset and service performance life value. **The value for money and functional performance of the selected asset (i.e. mutually integrated pipeline components) over its service life should be validated by the pipeline designer. The basis for whole-of-asset performance acceptance should be supported by documented value for money and engineering design analyses of an acceptable rigour. A mutually consistent whole-of-asset performance warranty - across all pipeline component manufacturers – should be pre-requisite, including:**

4.3.1 Material and Engineering Properties

Typical characteristics outlined in Table 4.1.1 and associated Notes, including:

- Fitness for application e.g. chlorinated drinking water, non-chlorinated non-drinking water, wastewater or drainage;
- Size availability and supply lead time constraints for the pipeline sizes and quantities involved;
- Maximum burial cover depth within safe buckling and nominated deflection limits including the use of heavy duty wall thickness PVC pipe fittings as and where required by DS 50;
- Suitability for above ground or bridge crossing applications where relevant;
- Suitability for below watercourse or structure applications where relevant;
- Suitability for urban centres (e.g. congested services) and heavy road traffic load applications;
- Pipeline embedment constructability rating in terms of the quality of material and compaction specifications and of embedment work conformity, inspection and test records;
- Project risk level where (selected) pipeline components have not been subjected to prior product appraisal and performance testing (e.g. where not authorised or listed in the Strategic Products Register).

Failure risk mitigation where pipelines are proposed for trenchless installation, mindful of the guidance in Table 4.1.2 and associated Notes, namely:

- Justification of trenchless (vs open cut) installation on basis of net value added over pipeline life;
- Selection for trenchless installation of pipe class, coating, lining and jointing systems that have been 'proven' - by engineering evaluation and calculation - for the structural and environmental longevity performance required for the trenchless applications and locations;
- Market availability of and supply lead times for (duly authorised) pipe of the required class/grade;
- Conformity of trenchless drive alignment and control systems with required directional precision;
- Justification of trenchless installation feasibility, economics and risk mitigation, duly documented in a formal installation/methodology proposal;

Typical characteristics outlined in Table A1 and associated Notes, including:

- Conformity of pipeline components with nominated reference specifications and their suitability for the project application, including component age since first manufactured;
- Diameter series compatibility/inter-connectibility with existing pipelines and selected size range availability;
- Adequacy of rated pressures and stiffnesses for the proposed MAOP, embedment specification and quality of embedment work inspection and testing records;
- Constraints on use of standard pipe lengths or long (e.g. welded) pipe 'strings' where installation space is limited and services are congested;
- Adequacy of pipeline jointing specification (unrestrained/restrained) for required system integrity;
- Adequacy of pipeline protection from UV and thermal radiation embrittlement

4.3.2 Location and Environment

Typical characteristics outlined in Table A2 and associated Notes, including:

- Adequacy of pipeline abrasion resistance for project applications and service longevity;
- Durability and long term resistance of pipeline materials, coatings & linings to external and fluid borne corrodants, sulphides, H_2S, acids and biogenic activity;

- Adequacy of metallic pipe insulation/isolation from unsafe levels of induced electrical voltage;
- Pipeline material and joint seal resistance to permeation by contaminants (e.g. hydrocarbons and solvents) by selecting non-permeable pipeline materials and more chemically resistant seal materials (e.g. NBR or SBR in lieu of EPDM) for contaminated, gaseous (e.g. wastewater conveyance) and undesirable taste/tainting environments, for example;
- Adequacy of pipeline installation and embedment design provisions and specifications for expansion/contraction arising from exposure to temperature variations;
- Verification of pipeline joint seal adequacy for exposure to 'full' vacuum applications;
- Adequacy of field/site acceptance test specifications for pipeline material selections;
- Pipeline hydraulic profile for given site topography and subsurface geotechnical characteristics;
- Environmental and heritage constraints in the vicinity of pipeline location;
- Alignment with Utility Providers Code of Practice for WA constraints and requirements;
- Adequacy of easement/reserve width for future pipeline access and replacement (5m to > 20m);
- Prevention of pipeline flotation due to its depth and seasonal ground water level movements;
- Practicability and cost of delivering pipeline embedment performance of the required quality where sub-surface conditions and instability risks are high and where services are congested;
- Adequacy of design provisions to protect built infrastructure above a proposed visco-elastic (e.g. PE) pipeline, given the extent of linear & radial pipeline movement during installation and testing.

4.3.3 System Pressure Constraints and Re-rating

Characteristic pressure attributes as outlined in Tables 4.2, 4.3 & 4.4:

- The different approaches in pipe product standards to defining pipeline system pressure capabilities - MAOP (maximum allowable **dynamic** – i.e. including operating **surge** - pressure) and ASTP (allowable site test pressure required - to prove system leak-tightness and general integrity), being:

MAOP

  - PN rating divided by 10 (MPa) for **plastics** pipelines at a baseline temperature of **20º C**;
  - Pressure that stress pipe wall by no more than 72% of its strength (MYS) for **steel** pipelines;
  - PN rating divided by 8.33 (MPa) for **ductile iron** pipelines. DI pipe allowable **steady state** operating pressure AOP is equivalent to its PN rating divided by 10 (MPa), and

ASTP

Site test pressure value selected so as to never exceed:

  - 125% of pipeline MAOP for **plastics** pipelines (duly re-rated for temperatures above **20º C)**;
  - Pressures that stress pipe wall by more than 90% of its strength (MYS) for **steel** pipelines;
  - 125% of pipeline AOP for **ductile iron** pipe (ductile iron pipe MAOP is 120% of its AOP).

- Need to assign a **system** MAOP lower than the MAOP of any single pipeline system component;
- Need to design pipeline thrust blocks to resist the highest lifetime pressure (e.g. ASTP), based on supporting soil bearing strength, overburden resistance to uplift & a realistic design safety margin;

Typical pressure re-rating values outlined in Table 4.5 and associated Notes:

- Decreased plastics pipe MAOP capability, as mean wall temperatures rise above 20º C;
- Decreased MAOP capability in line with cyclic pressure event frequency over pipe lifetime;
- Residual MAOP - lower than 'as new' MAOP - of existing (legacy) PVC pipelines arising from exposure to frequent cyclic pressure events over the years since installation.
- Residual MAOP – considerably lower than 'as new' MAOP - of existing (legacy) AC pipelines arising from deterioration of pipe cementitious material over the years since installation.
- Decreased effective pipe MAOP where to be installed by trenchless techniques, including:
  - Adequate design margin between pulling/jacking forces & permissible pipe stress/strain values;
  - Adequate design ratio of effective to actual pipe wall thicknesses (e.g. $\leq$ 90%) to cover risks due to potential damage by angular soil particles during installation by pipe pulling or driving.

4.3.4 Field Testing

Typical characteristics outlined in Tables A2, 4.5 and associated Notes, including:

- Selection and nomination on design drawings of appropriate (allowable) pipeline system pressures (e.g. MAOP and ASTP) for the purposes of field or site pressure proof (leak-tightness) testing;

- Nomination of an ASTP value based on the appropriate pipeline MAOP value at 20º C, calculated at the lowest elevation of a pipeline section to be tested, in accordance with the guidance in **4.3.3**;
- Adjustment or re-rating, by field testing operatives, of the nominated ASTP value (at 20º C) to safely provide for mean pipe wall temperatures exceeding 20ºC at the location and time of testing;
- Use of the General Pressure Test (Technical) defined in AS/NZS 2033 (the constant pressure test) as the required field/site pressure test for proving PE pipeline hydraulic integrity, in accordance with the requirements of WS-2 the Corporation standard for thermoplastics welding and joining;

It should be noted that the application of field/site test pressures (ASTP) will exceed pipeline MAOP (or AOP in the case of a DI pipeline) where a design pressure greater than 80% of pipeline MAOP is selected for a project. The inevitable consequence of a pressure event that exceed pipeline MAOP is a shortening or impairment of pipeline engineering life, however insignificant. Its significance is greater for plastics than for metallic pipelines but is mitigated by (field testing) event frequency which should generally be constrained to a **single** post-installation pre-commissioning occurrence.

4.3.5 Pipeline System Inter-connectibility

Typical characteristics outlined in Tables 4.6 & 4.7 and associated Notes, including:

- Predominance of CIOD (Cast Iron Outside Diameter) diameter compatibility in (non- steel/PE) Corporation pressure pipelines in preference to ISO (metric) diameters, as explained in Section 3;
- Selection of pipeline diameter size series (e.g. Series 2, CIOD) and joint disposition that most effectively align with existing pipeline network configurations and pipeline spares inventory;
- Selection of pipe manufacturer supplied jointing systems as an absolute preference over the use of third party supplied pipe couplings for new pipeline work except where justified for closure joints;
- Restrained joint design justification and installation methodology specification, with restrained and unrestrained sections of pipeline clearly differentiated on design and as constructed drawings. Joint axial restraint - e.g. by welding or mechanical 'grips' – should be of an acceptable design;
- Design provision for external steel pipe weld grinding (to a flush surface) and corrosion protection of exposed steel to assure adequate seal at the interface between pipe and joint couplings or fittings;
- Selection of standard backing ring sizes and PCDs for PE pipeline stub flanges so as to directly align and interconnect with other Corporation pipeline system flanges;
- Specification of appropriate anti-seize treatments (e.g. PTFE or molybdenum disulphide) on fastener threads to mitigate galling (micro welding) of – particularly SS – threaded joints.

4.3.6 System Accessibility, Safety, Operability and Maintainability

- Compatibility of component material, mechanical and dimensional performances with pipeline operability and maintainability needs over its nominated service life;
- Need to undertake planning, design and construction activities associated with projects that involve (legacy) AC pipelines in accordance with the Corporation Safety and Wellbeing "Asbestos Procedure";
- Need to evaluate the residual cyclic fatigue viability of existing (legacy) PVC-pipelines, where they are proposed for integration into new pipeline system projects
- Need for optimal owner access across the land area above pipelines for the purpose of safe pipeline operation, upkeep and replacement e.g. inspection access for venting, flushing and scouring operations and (right angle) crossing of urban road reserves;
- Conformity with the technical specifications and installation requirements for (pipeline) asset identification and pipeline warning signage defined in DS 101;
- Proximity to existing utility services and the risk of consequential disruption of or damage to those services due to ground erosion or loss of support to structures supported by eroded ground e.g. railway, reservoir or road embankment, bridge abutment, retaining wall or river crossings;
- Justification of trenchless installation methodology selection in terms of impaired owner access to trenchlessly installed pipelines for condition inspection, repair or replacement.
- Pipeline component repairability constraints including, typically, the maximum acceptable service outage duration and the ready availability of acceptable repair products (e.g. mechanical pipe

couplings, repair clamps, pipe spool pieces of an appropriate OD throughout) in Corporation stock holdings to facilitate rapid deployment for 'emergency' repair operations;
- Adequacy of operational and repair/maintenance spares to assure pipeline service continuity after takeover, duly reviewed on each project and provided for in project baseline requirements.
- Identification of all potential construction, operation and maintenance hazards and their elimination or mitigation by design measures wherever practicable;

4.4 Design Selection Justification

Pipeline designers should, by reference to the guidance in, including the foregoing "Performance Requirements" section:

- Apply an appropriate level of professional engineering skills, calculations and expertise to the evaluation of potential pipeline delivery options;
- Document the pipeline component selections made and the design basis for each selection, for the information of the pipeline owner, constructor and operator. Typically, design selection justification should be clearly documented in the relevant project engineering summary reports.

Table 4.5 - Pressure Re-rating Design Factors for Plastics & Metallic Pipes[9, 10, 11]

Table 4.5 outlines acceptable multiplier values (design re-rating factors) for application to nominal pressure ratings where mean pipes temperature over its lifetime deviates from a 20ºC baseline norm. Table 4.5 should be read in conjunction with the supplementary guidance in the "**Notes for Table 4.5**" that follow the Table.

Pipe Material	**(A) Re-rating factors for pipe temperatures[1] of:**							**(B) Re-rating factors for exposure to pressure cycle numbers[7]:**							
Plastics	20ºC	25ºC	30ºC	35ºC	40ºC	45ºC[6]	50ºC[6]	27k	100k	200k	500k	1M	2.5M	5M	10M
ABS[2]	1.00	0.90	0.82	0.73	0.64	0.54	0.50	1.00	1.00	1.00	> 0.98	> 0.95	> 0.94	> 0.93	> 0.90
GRP[3]	1.00	1.00	1.00	1.00	0.85	0.75	0.60	1.00	1.00	1.00	1.00	> 0.98	> 0.96	> 0.94	> 0.90
PE 100[4]	1.00	1.00	0.94	0.89	0.84	0.80	0.76	1.00	1.00	1.00	0.95	0.88	0.81	0.74	0.68
PVC-M[5]	1.00	0.94	0.87	0.78	0.70	0.64	0.58	1.00	0.67	0.54	0.41	0.33	0.25	0.25	0.25
PVC-O[5]	1.00	0.94	0.87	0.78	0.70	0.64	0.58	1.00	0.75	0.66	0.56	0.49	0.41	0.41	0.41
PVC-U[5]	1.00	0.94	0.87	0.78	0.70	0.64	0.58	1.00	1.00	0.81	0.62	0.50	0.38	0.38	0.38
Metals															
MSCL	1.00	1.00	1.00	1.00	1.00	1.00	N/A[6]	1.00	1.00	1.00	1.00	> 0.95[8]	> 0.95[8]	> 0.95[8]	> 0.95[8]
SS	1.00	1.00	1.00	1.00	1.00	1.00	N/A[6]	1.00	1.00	1.00	1.00	> 0.95[8]	> 0.95[8]	> 0.95[8]	> 0.95[8]
DI	1.00	1.00	1.00	1.00	1.00	1.00	N/A[6]	1.00	1.00	1.00	1.00	> 0.98[8]	> 0.98[8]	> 0.98[8]	> 0.98[8]
CU	1.00	1.00	1.00	1.00	1.00	1.00	N/A[6]	1.00	1.00	1.00	1.00	> 0.95[8]	> 0.95[8]	> 0.95[8]	> 0.95[8]

The re-rating factors for PE in this Table apply to PE pipe fittings that are generally injection-moulded in accordance with AS/NZS 4129 requirements. They exclude consideration of the fabrication geometry of non-injection-moulded PE pipe fittings which require (additional) de-rating/re-rating in accordance with the guidance in Note 4.

Notes for Table 4.5

1	The information in the Corporation's "Design Operating Temperature Estimation for Thermal De-rating of PVC Sewer Pressure Mains" may be adapted to estimate and derive sustained mean (design life) pipe wall temperature values across WA for application to PVC pressure pipelines generally.
2	Indicative re-rating design factors for ABS pipe are shown for comparison with those of other plastics pipe materials. The re-rating factors are only estimated, based on ABS pipe manufacturer literature, and subject to the emergence of verifiable cyclic fatigue performance data for ABS pipe from authoritative research/testing sources. ABS, as a non-preferred plastics pipe material, should not be considered for general selection on conveyance pipeline projects.
3	The re-rating design factors for GRP pipe are based on **filament-wound, polyester resin** based pipe and are subject to the emergence of verifiable temperature and cyclic fatigue performance data for **cast and vinylester** based GRP pipe from authoritative research/testing sources. Vinyl-ester is preferred to polyester as a GRP pipe resin where GRP pressure pipe may be exposed to sustained mean pipe wall temperatures > 35ºC during its nominated design life.
4	Refer to AS/NZS 2033 Sub-clause 3.7 for more information on PE pipe thermal characteristics. Supplementary information may be referenced in PIPA "Temperature Rerating of PE Pipes" (POP013), "Polyethylene Pressure Pipes Design for Dynamic Stresses" (POP010A) and "Fusion Fittings for use with Polyethylene Pressure Pipes Design for Dynamic Stresses" (POP10B). The nominal pressure rating of fabricated and heat formed PE pipe fittings (at a baseline temperature of 20ºC) should be subjected to de-rating by a fitting geometry de-rating factor and the de-rated pressure rating should be marked on the fabricated fitting bodies, in accordance with "Derating Requirements for (Polyethylene Pipe) Fittings" (POP006) which aligns with the international PE pipe fittings product standard ISO 4427.3. The service (design) coefficient values in AS/NZS 4130 Table C1 are **not** applicable to PE conveyance pipeline pressure re-rating (Refer Table 4.1.1 Note 28).
5	PVC pipe re-rating information may be referenced in PIPA "Temperature Derating of PVC Pipes for Pressure Applications" (TN003) and "PVC Pressure Pipes Design for Dynamic Stresses" (POP101).
6	The underlying pipeline longevity and operational risks from pipe material for exposure to sustained temperatures > 40ºC for plastics pipe and > 45ºC for metallic pipe should be evaluated and the final selection justified on a project by project basis, for acceptance or not by the Corporation.
7	Number (No.) of significant pressure excursion cycles over pipeline fatigue design life: k = 1,000 cycles; M = 1,000,000 cycles.
8	Re-rating design factors for metallic pipes where exposed to 1,000,000 (M) or more cyclic pressure events are estimated, subject to the emergence of verifiable cyclic fatigue performance data for metallic pipe materials from accredited test facilities.
9	The maximum allowable operating pressure (**MAOP as defined in sub-clause 4.3.3**) of a pipeline system is the maximum pressure that all pipeline components can safely withstand in service without failure. The adverse impacts of surge events due to **non-routine** power outages and planned system integrity pressure tests on pipeline MAOP value may be discounted, subject to consideration of the number and rarity of those pressure 'spikes' over pipeline design life.
10	Re-rating design factors are intended for application to pipe nominal pressure rating (PN) to derive a safe (maximum allowable) operating pressure (MAOP) value for plastics and metallic pipe in given thermal or cyclic pressure environments.
11	Only the lower re-rating design factor (A or B) value should be applied where pipe is re-rated for both elevated temperature and cyclic fatigue environments.

Table 4.6 - Pressure Pipeline System Inter-connectibility

Tables 4.6 and 4.7 provide guidance on the most common types of generic pipeline fittings for interconnecting pipes (and pipe fittings) of various materials. Pipe connection fittings have been designated as "**Pipe System**" – designed, manufactured and supplied by an original pipe manufacturer, "**Adaptors**" – most commonly designed, manufactured and supplied by a third party pipe fittings manufacturer and "**Connectors**" – usually involving a direct pipe to pipe connection or 'fusion' process that eliminates the need for a third party adaptor or other connection fitting. Both Tables should be read in conjunction with the supplementary guidance in the "**Notes for Tables 4.6 and 4.7**" that follows.

NEW PRESSURE PIPELINES																LEGACY PRESSURE PIPELINES					
Pipeline Material	**ABS**	**DI**	***DI Fittings***	**CU**	**GRP**	***GRP Fittings***	**PE 80B/100**	***PP Compression Fittings***	***Fabricated PE Fittings***	**PVC-M**	**PVC-O**	**PVC-U**	**MSCL**	***MSCL Fittings***	**SS 316**	**AC**	**AC (Sutton)**	**CS/GMS**	**CICL**	**RC**	**PE**
ABS	SYS															B[14]	N/A	Replace	B[14]	N/A	N/A
DI	A	SYS														B[14]	N/A	Replace	A	N/A	N/A
DI Fittings	A	A, C	SYS													B[14]	N/A	Replace	A	N/A	N/A
CU	N/A	N/A	N/A	SYS												N/A	N/A	Replace	N/A	N/A	N/A
GRP	B[14]	B[14]	B[14], C	N/A	SYS											B[14]	N/A	Replace	B[14], C	N/A	N/A
GRP Fittings	B[14]	B[14]	B[14], C	N/A	A, C	SYS										B[14]	N/A	Replace	B[14], C	N/A	N/A
Compression Fittings for PE	N/A	N/A	N/A	E	N/A	N/A	E	N/A								N/A	N/A	Replace	N/A	N/A	A
Fabricated PE Fittings	N/A	D	C	N/A	D	C	F,J	N/A	F,J							N/A	N/A	Replace	N/A	N/A	N/A
PVC-M	B[14]	B[14]	A	N/A	B[14]	B[14]	H[10,14]	N/A	N/A	SYS						B[14]	B[14]	Replace	B[14], C	B[14]	N/A
PVC-O	B[14]	B[14]	A	N/A	B[14]	B[14]	H[10,14]	N/A	N/A	A	SYS					B[14]	B[14]	Replace	B[14], C	B[14]	N/A
PVC-U	B[14]	B[14]	A	N/A	B[14]	B[14]	H[10,14]	N/A	N/A	A	A	SYS				B[14]	B[14]	Replace	B[14], C	B[14]	N/A
MSCL	N/A	C	C	N/A	C	N/A	N/A	N/A	N/A	B[14]	B[14]	B[14]	SYS			N/A	N/A	Replace	N/A	N/A	N/A
MSCL Fittings	A	C	C	N/A	A, C	A	N/A	N/A	C	B[14]	B[14]	B[14]	A, C	SYS		N/A	N/A	Replace	N/A	N/A	N/A
SS 316	N/A	N/A	N/A	N/A	B[14]	N/A	N/A	N/A	N/A	B[14]	B[14]	B[14]	N/A	N/A	SYS	N/A	N/A	Replace	N/A	N/A	N/A

Table 4.7 - Non-pressure Pipeline System Inter-connectibility

NEW NON-PRESSURE PIPELINES									LEGACY NON-PRESSURE PIPELINES	
Pipeline Material	**GRP**	***GRP Fittings***	**PP**	***Fittings for PP***	**PVC-U**	***PVC Fittings***	**RC**	***RC Bends***	**RC**	**VC**
GRP	SYS								M/H	M/H
GRP Fittings	A	SYS							M/H	M/H
PP-B	M/H	N/A	SYS						M/H	M/H
Fittings for PP	N/A	N/A	SYS	SYS					N/A	G
PVC-U	B[14]	B[14]	M/H	G	SYS				M/H	A, M/H
PVC-U Fittings	B[14]	B[14]	N/A	N/A	SYS	SYS			N/A	N/A
RC	M/H	M/H	M/H	M/H	M/H	M/H	SYS		M/H	M/H
RC Bends	N/A	N/A	N/A	N/A	N/A	N/A	SYS	SYS	N/A	N/A

Notes for Tables 4.6 and 4.7

No.	Acronym	Description	
1	SYS	**Pipe System**	Integral or (detached) collared double socketed ESJ or SWJ proprietary system that is designed and manufactured by the original pipe manufacturer to join pipe to pipe of like material, size and joint style. Where 'collared', each pipe should be supplied with an (original) compatible collar factory fitted in place on one pipe spigot. ABS, whilst referenced for comparison, is not intended for general selection on conveyance pipeline projects at present.
2	A	**Adaptor A**	Integral ESJ (or SWJ) socketed or detachable (double socketed) collar proprietary jointing system designed and manufactured for pipe to pipe of like materials, size and joint style by an original pipe fittings manufacturer but which may prove suitable for inter-connecting various pipes and pipe fittings of non-original manufacturing brands. Pipeline joint interconnections should preclude the insertion of a metallic pipe spigot into a plastics pipe socket.
3	B	**Adaptor B**	**Long series** AS/NZS 4998 compliant third party Series 2 (CIOD) '**multifit**' ESJ double socketed couplings or flange to socket adaptors manufactured by an original coupling/adaptor manufacturer- for spigot to spigot or spigot to flange jointing respectively of pipes of compatible diameter ranges - but supplied for inter-connecting pipes/pipe fittings of various non-original manufacturing brands.
4	C	**Adaptor C**	A pipe fitting that has two or more integral DS 38-02 compliant flanged ends or a combination of flanged and socketed ends that can, typically, be made from the same or different material as the pipes to be interconnected.
5	D	**Adaptor D**	An AS/NZS 4129 compliant PE stub flange adaptor assembly with a DS 38-02 compliant (or approved equivalent) steel backing flange, for fusion jointing of one adaptor end to an AS/NZS 4130 compliant PE pipeline and for mechanical bolting of the other adaptor end to a compatible mating flange. Steel backing flanges for PN 16/21 should be configured and drilled in accordance with AS 4087 Figures B7/B8 respectively.
6	E	**Adaptor E**	An AS/NZS 4129 compliant PP compression adaptor fitting with one or more socketed ends for direct jointing to PE pipe ends or with a combination of socketed and threaded ends for direct jointing to PE pipe ends and (AS 3688 compliant) copper alloy fitting ends respectively to achieve leak-proof restrained mechanical joint sealing. The use of mechanical compression couplings should be generally limited to nominal pipe and pipe fitting diameters ≤ DN 63, except where expressly authorized in writing to address project specific requirements.
7	F	**Adaptor F**	An AS/NZS 4129 compatible socketed coupling or other fitting configuration that incorporates heating coils for the purpose of electro-fusion jointing of PE pipe spigots of like diameter and configuration.
8	G	**Adaptor G**	A non-pressure AS/NZS 5065 compliant socketed adaptor for joining PP (polypropylene) pipe to non-pressure pipes of the same or other materials
9	H	**Adaptor H**	A PE pipe spigot to spigot jointing assembly comprising a restrained Adaptor B style coupling and an associated (316 SS) bore stiffener insert that is designed for insertion into and is dimensionally compatible with the PE pipe SDR for the purposes of preventing pipe radial movement in service arising from a combination of PE material cold flow (creep) and an internal operational pressure fluctuation range between MAOP and zero.
10	–	–	Adaptors and associated insert stiffeners for PE jointing applications should be designed to restrain axial movement and diametral creep of interconnected pipeline joints to respectively assure no loss of joint grip or seal, where other means of joint constraint (e.g. flanged joints or strategic placement of concrete thrust blocks at pipeline changes of direction, take-off locations, pipeline size changes and interconnections with flexibly jointed i.e unrestrained pipelines) do not provide a proven level of pipeline joint integrity in service.
11	J	**Connector J**	WS-2 compliant connecting system for direct butt-fusion jointing of compatible AS/NZS 4129 compliant PE pipe spigot ends without the need for an additional adaptor fitting.
12	M/H	**Manhole**	Also known as access chamber or maintenance hole and used to incorporate, terminate or change the alignment of one or more non-pressure pipelines. Designers should evaluate and design for differential movements of inter-connected pipelines, structures (e,g, manholes, pits, pumping stations), pipeline embedment and surrounding soil by selecting appropriate pipeline components and complying with AS/NZS 2566.2 requirements, to prevent unacceptable pipeline strains/stresses and premature pipeline failures.
13	N/A	**Not applicable**	Not applicable except in special cases where a prior proposal that details connecting component configuration, installation methodology and a convincing business justification is submitted and proves to be acceptable.
14	–	–	**Multifit** (or wide tolerance) pipeline couplings and adaptors for axial (gibault style) bolting should comply with AS/NZS 4998 for unrestrained - other than PE - pressure pipe applications. Multifit couplings and adaptors for restrained non-PE and PE pressure pipe applications, including axial and circumferential (e.g. Teekay/Straub style) bolting styles, should comply with EN 14525. The diameter tolerance range of circumferentially bolted couplings in the marketplace at present is generally narrower than that of true 'multifit' couplings. Mechanical compression and fusion jointing systems for PE pressure pipe applications should comply with AS/NZS 4129.
15	–	–	Typically, '**straight**' couplings/adaptors are designed to join pipes/pipe fittings of the same nominal diameter while some manufacturers design and supply '**stepped**' couplings/adaptors that interconnect pipes/pipe fittings of dissimilar nominal diameters. Where pipes or pipe fitting diameters to be connected are not connectible by means of coupling/adaptor size ranges available in the marketplace (e.g. legacy RC, AC, MS & CU across non-standard pipe diameter series and diameter divergences significantly greater than 24 mm), consideration should be given to special – typically 316L stainless steel – stepped adaptor pipe fittings.
16	–	–	Pipeline ESJ and SWJ jointing systems are dimensionally and mechanically incompatible and should not be inter-connected, notwithstanding nominal diameter sizes and diameter series (S1/ISO or S2/CIOD) in common.

APPENDIX A

Table A1 Pipeline Material, Engineering and Jointing Characteristics

Pipe Material[1]	Acronym	Reference Specification[3]	Diameter Series (S1-ISO/Metric or S2 - CIOD)[5]	Diameter Range (DN)[1]	Pressure Rating (PN)[10] or Non-pressure (NP)	Stiffness Rating[11]	Standard Pipe Length (m)	Pipe Coating Specification[45] (PE or FBE[22])	Pipe Lining Specification[45] (CL or FBE[23])	Pipe Jointing Specification[25, 28]	Unrestrained (UR) or Restrained (R)[44]
NEW PIPES											
Acronitrile Butadiene Styrene	**ABS**	AS/NZS 3518	S2	AS/NZS 3518 Table 3.4 (A & B) DN 100 to 750[6]	12, 15 & 20	Refer Table 4.2	6	None	None	Note 26	**UR**
Cast Ductile Iron Pipe	**DI**	AS/NZS 2280	S2	DN 300 to 750	16 (FLCL[12]), 20 & 35	Refer Table 4.4	5	Uncoated	CL	Notes 26, 30	**UR**
Pipe Fittings	**DI**	SPS 106	S2	AS/NZS 2280	16/35[13]	N/A	N/A	FBE	FBE	Note 26, 30	**UR**
Copper	**CU**	AS 1432 Type A		DN 20 to 25	AS 1432 Table C2	N/A	3, 6	None	None	Notes 33, 34	**UR**
		AS 1432 Type A		DN 32 to 200	AS 1432 Table C2	N/A	3, 6	None	None	Note 33	**UR**
Glass reinforced plastic (Pressure)	**GRP**	SPS 130	S2	DN 375 to 2400	16 to 35	SN 10 to 20	6, 12	None	None	Note 26	**UR**
Glass reinforced plastic (Non-pressure)	**GRP**	SPS 130	S2	DN 375 to 2400	NP (PN 3 to 6)[14]	SN 10 to 20	6, 12	None	None	Note 26	**UR**
Pipe Fittings	**GRP**	SPS 130	As pipe	To match pipe	To match pipe	SN 10	N/A	None	None	Note 26	**UR**
Polyethylene	**PE 100**	SPS 125	S1	DN 125 to 630[7]	12.5, 16	Refer Table 4.2	6, 12	None	None	Note 32	**R**
Compression Pipe Fittings	**PP-B**	SPS 125	S1	DN 25 to 63	16	≥ Pipe SN	N/A	None	None	Note 31	**R**
Fabricated Pipe Fittings	**PE**	SPS 125	S1	DN 125 to 630[7]	Table 4.5[15]	≥ Pipe SN	N/A	None	None	Note 32	**R**
Polypropylene[43] (Non-pressure)	**PP-B**	SPS 125	S1	DN 375/400 to 630	NP	SN 10	6	None	None	Note 26	**UR**
Pipe Fittings	**GRP/PVC**	SPS 125	S1	DN 375/400 to 630	NP	> Pipe SN	N/A	None	None	Note 26	**UR**
Polyvinyl Chloride Modified	**PVC-M**	SPS 116	S2	AS/NZS 4765 Table 4.2 DN 100 to 375	12, 16 & 20	Refer Table 4.2	6	None	None	Note 26	**UR**
Biaxial Molecular Oriented	**PVC-O**	SPS 117	S2	AS/NZS 4441 Table ZZ1A S2 DN 100 to 375	12, 16 & 20	Refer Table 4.2	6	None	None	Note 26	**UR**
Unplasticised (Pressure)	**PVC-U**	SPS 115	S2	AS/NZS 1477 Table 4.2 (B) DN 100 to 375	12, 16 & 20	Refer Table 4.2	6	None	None	Note 26	**UR**
Unplasticised (Non-pressure)	**PVC-U**	AS/NZS 1260 (Plain Wall/Sandwich)	S1	DN 100[26]	NP	SN 6, 10, 16[27]	6	None	None	Note 26	**R**
		AS/NZS 1260 (Structured/Profile)	S1	DN 100[26]	NP	SN 8, 16[27]	6	None	None	Note 26	**R**
		AS/NZS 1260 (All Structural Forms)	S1	DN 150 to 300[26]	NP	SN 8, 16[27]	6	None	None	Note 26	**R**
		AS/NZS 1260 (All Structural Forms)	S1	DN 375[26]	NP	SN 8, 16[27]	6	None	None	Note 26	**UR**
Pipe Fittings	**PVC-U**	AS/NZS 1260	S1	DN 100 to 375[26]	NP	SN 6[27]	N/A	None	None	Note 26	As pipe
Reinforced Concrete (Non-pressure)	**RC**	AS/NZS 4058	N/A	DN 750 to 2250	NP	Load Classes 4, 6, 8 & 10	2.44	Uncoated	Plastics lined[25]	Note 35	**UR**
Polymer Resin Concrete[2] (Non-pressure)	**RA**	ISO 18672-1	N/A	DN 800 to 2000	NP	2720 to 13830 kN[44]	3	None	None		**UR**
Mild (Carbon) Steel	**MS(CL)**	SPS 100	S1	DN 100 to DN 1400	68 - 28 (Table 4.3)	Refer Table 4.3	6, 12	PE to AS 4321	CL to AS 1281	Notes 26,/36	**UR/R**
Pipe Fittings	**MS(CL)**	DS 65[4]	S1	DN 100 to DN 1400	16, 21 & 35		N/A	PE to AS 4321	CL to AS 1281	Note 36	R
Stainless Steel Tube	**SS 316**	ASTM A312	S1	DN 20 to 200	**10S**: 254 to 42[16] **40S**: 369 to 93[16]	SN 10000 to 85[16] SN 28000 to 950[16]	6	None	None	Note 36	R
Stainless Steel Pipe	**SS 316**	ASTM A312	S1	DN 250 to 600[8]	**10S**: 38 to 25[16] **40S**: 84 to 38[16]	SN 60 to 18[16] SN 700 to 65[16]		None	None	Note 36	R

Pipe Material[1]	Acronym	Reference Specification[3]	Diameter Series (S1- ISO/Metric or S2 - CIOD)[5]	Diameter Range (DN)[1]	Pressure Rating (PN)[10] or Non-pressure (NP)	Stiffness Rating[11]	Standard Pipe Length (m)	Pipe Coating Specification[45] (PE or FBE[22])	Pipe Lining Specification[45] (CL or FBE[23])	Pipe Jointing Specification[25, 28]	Unrestrained (UR) or Restrained (R)[44]
LEGACY PIPES						CTS or HDS Rating[17]					
Asbestos Cement **(Mazza/Magnani processes 1951 to 1975)**	**AC**	AS 1711	S2	DN 58 (WA only) DN 80 to 600; DN 75 to 600 DN 75 to 300	Class C/D/E = PN9/12/15	23.5 Mpa (CTS[11])	4 4 4 4	Uncoated	Unlined	Note 37	UR
Special High Strength Pipe	**AC**	AS A41 & AS 1711	S2	Project specific only	PN 14/16 (DN 200 to 600)[18] PN 18/20 (DN 200 to 300)[18]	Cl. C Codes 28/31[18] Cl. D Codes 28/31[18]	4 4	Uncoated	Unlined	Note 37	UR
Asbestos Cement **(Sutton process 1929 to 1951)**	**AC**	None	N/A	DN 100, 150	Not recorded	Not nominated[19]	3.35, 4	Uncoated	Unlined	Note 37	UR
Carbon steel (black iron)[24] **Galvanised mild steel (tube)[24]**	**CS** **GMS**	AS A125 AS B105, AS 1074	S1 S1	DN 20 to DN 150 DN 20 to DN 150	Not recorded 25 (5 MPa proof test)	Not nominated[19] Not nominated[19]	6.5 6.5	Uncoated Galvanized[24]	Unlined Galvanized[24]	Note 38 Note 38	R R
Grey Cast Iron (1965 to circa 1986)	**CI(CL)**	AS A145, AS 2544 & AS/NZS 2544	S2	DN 80 to DN 1200 DN 80 to DN 600	PN 14, 21 PN 35[13]	Not nominated[19]	5.5	Uncoated	Cement Lined[24]	Notes 39, 40	UR
Reinforced Concrete (Pressure)	**RC**	AS A124/AS 1392 Tables D1/D2	N/A	DN 100 to 300 DN 300 to 900	50 to 180 PSI (Table D2) (345 to 1241 KPa)	Not nominated[19]	1.83, 2.44	Uncoated	Unlined	Note 39	UR
Reinforced Concrete (Non-pressure)	**RC**	AS A35/AS 1342	N/A	DN 450 to 900	NP	Load classes X, Y, Z[20] Table VI AS A35	1.83, 2.44	Uncoated	Unlined	Note 41	UR
Vitreous Clay (Non-pressure)	**VC**	AS A164 AS 1741	N/A	DN 150 to 375	NP	AS A164 Table 1 AS 1741 Table 3.1	0.91 to 1.83	None	None	Note 41	UR
Polyethylene	LDPE, HDPE, MDPE	AS K119/AS 1159	S1	DN 25 to 110	(Classes) 9, 12	3, 5 & 8 Mpa[21]	6 & 100 (coil)	None	None	Note 42	R

Notes for Table A1

1	Pipeline selection, design and specification should be based on the configuration, engineering performance, installibility of and operational constraints on the supplied pipe, pipe fittings and jointing systems, together with the market availability (Refer Table 4.1.1) of all interconnected components.
2	Polymer (polyester) or resin aggregate (RA) concrete pipe is included because of its particular suitability for pipe jacking applications. Acceptable RA pipe product standards include EN 14636-1, DIN 54815-1/2, ASTM D6783-05 as well as ISO 18672-1. The values under the "Stiffness" heading describe its working compressive strength in kilonewtons.
3	A pipeline product reference specification can include a Corporation developed strategic product standard (SPS), a national - including WSAA - or other (e.g. overseas) product standard or specification that has been agreed as fit for purpose by the Corporation. Where a pipe reference specification (e.g. SPS 125) nominates pipe striping or jacket colour, the over-riding intent is to ensure that pipe for drinking water, non-drinking water, wastewater and drainage applications is coloured or striped light blue, purple, cream and black respectively, notwithstanding colour shade or hue variations specified by different industry sectors e.g. WSAA, PIPA and individual water utilities.
4	Appendices A and B of SPS 100 specify enhanced requirements for steel pipe in seawater and brine applications. DS 65 shows standard shape, configuration and weld arrangements for mild steel (MS) pipe fittings. Welding work requirements are specified in "Welding Specification - Metal Arc Welding" WS-1.
5	Some background information on Australian pipe alignment with imperial cast iron pipe (CIOD or Series 2) diameters, in the face of European trends toward the smaller metric (ISO or Series 1) pipe sizes, is provided in Appendix C.
6	Acrylonitrile butadiene styrene (ABS) pipelines are not listed in Corporation records of conveyance assets, notwithstanding that ABS process pipework forms part of some treatment plants. ABS is a non-preferred plastics pipe material that should not, at present, be considered for general selection on conveyance pipeline projects.
7	Projects for which PE pipeline sizes larger than DN 630 may be under consideration need to be supported by a prior operability & maintainability feasibility case, given the future service constraints and risk to the Corporation's Operating Licence associated with lengthy pipeline outages due to the logistics of large PE pipe fusion jointed repairs and unavailability of large AS/NZS 4129 compliant axially restrained mechanical joint couplings for PE pipe.
8	Corporation asset records do not acknowledge any stainless steel (SS) **conveyance** pipelines, notwithstanding that some treatment plants may include SS process pipework. Selection of SS pipe should be supported by a rational whole-of-business justification.
9	Refer to Table 4.1.1 for high level general guidance on market availability considerations, prior to selecting pipeline components.
10	Pipe nominal pressure (PN) is rated for a baseline temperature of 20ºC. Its actual (allowable) pressure rating will decrease proportionately as mean pipe wall temperature rises above 20ºC. Refer Table 4.5
11	Pipe stiffnesses (resistances to deflection) are defined in terms of a stiffness number (SN), hydrostatic design strength (HDS) in MPa, structural load class e.g. RC pipe or circumferential tensile strength (CTS) e.g. AC pipe
12	The pressure rating of special flanged class (FLCL) DI pipe is determined by the (screwed) flange design as defined in AS/NZS 2280
13	The standard pressure rating for 'traditional' DI pipe fittings in accordance with AS/NZS 2280 is PN 35 except, as provided for in the standard, PN 16 'lightweight' fittings that are generally used in in smaller pipeline sizes (DN 100-250) e.g. for water reticulation applications.
14	Non-pressure GRP pipe, albeit theoretically rated for internal hydraulic pressures between PN 3 and PN 6 to accommodate field test and operational surcharge pressures, is not intended for pressure applications.
15	Refer to Table 4.5 (Note 4) for guidance on the geometry de-rating of the nominal pressure rating of fabricated polyethylene pipe fittings and marking of the de-rated pressure rating on the fittings prior to their supply into projects.
16	The SS tube and pipe pressure rating and estimated stiffness values shown are indicative only, for comparison with the values for other pipe materials
17	Asbestos cement (AC) pipe pressure classes that applied at time of installation are likely to be lower today due to the impacts of fluid pH and other factors on the cement binder over time.
18	AC pipe special pressure classes (Codes 28 & 31) were designed to achieve a minimum circumferential tensile strength of 28 & 31 MPa respectively as compared with 23 MPa for standard AC pipe.
19	Stiffness values were not nominated for legacy AC, CS/GMS, CI and RC pipe, being rigid (not plastics) pipe.
20	Legacy RC pipe load classes X, Y & Z were equivalent to AS/NZS 4058 load or strength classifications 2, 3 & 4 respectively.
21	The minimum required long term strength (MRS) of legacy PE pipe - 3 to 8 Mpa - compares with 10 MPa for PE 100 to AS/NZS 4130
22	The pipe coating designations shown - PE and FBE - mean AS 4321 compliant MDPE and AS/NZS 4158 compliant fusion bonded epoxy respectively. Consideration of alternative coating systems e.g. AS/NZS 2280 compliant metallic zinc coating or polyurethane coating should be supported by a prior pipe and coating performance evaluation that assures corrosion protection longevity and maintainability.
23	The pipe lining designations shown mean FBE - AS/NZS 4158 compliant fusion bonded epoxy and CL or cement mortar lining - AS/NZS 2280 compliant for DI pipe and AS 1281 compliant for MSCL pipe. Consideration of alternative lining systems e.g. AS 4321 compliant MDPE lining, AS/NZS 2280 compliant calcium aluminate cement mortar lining and cement lining seal coat should be supported by a prior lining (and lining seal coat as appropriate) evaluation that assures coating longevity and maintainability.
24	Legacy carbon steel (CS or black iron) and galvanised mild steel (GMS) pipe tended to have been respectively bitumen coated and galvanised in accordance with AS 1650. Grey iron pipe tended to have been coated with bitumen and cement mortar lined in accordance with As 2544. Legacy 'iron' pipelines - particularly those smaller than DN 100 should be retired and replaced wherever cost effective project opportunities that involve them arise.
25	Non-pressure RC pipe should, for longevity (fully functional for > 25 years), be plastics lined in accordance with a proven lining specification acceptable to the Corporation - particularly for wastewater applications.
26	An integral or detachable unrestrained ESJ or SWJ jointing system that is generally fixed or fitted to the pipe or pipe fitting at the time of supply. Defined as "SYS" or "Adaptor A" respectively in Tables 4.6 and 4.7. Solvent weld/cement jointing for sizes ≤ DN 300 should be in accordance with AS 3879 and WS-2. PVC pipe sizes > 300 should be elastomerically seal jointed, to address the consistently elevated temperature conditions - and the consequent impracticability of large diameter SWJ jointing - in WA climatic conditions. Integral pipeline jointing – including elastomeric seal –components should be supplied and/or the jointing compatibility and performance should be validated by the original manufacturer or supplier of the pipeline components to be mated and jointed. Note the requirements in DS 50 for use of 'special' heavy duty DWV PVC pipe fittings in specific applications.
27	AS/NZS 1260 sets out requirements for DN 100 non-pressure PVC-U pipe in plain or sandwich form with stiffness values of SN 6 or 10 and in profile form with a stiffness value of SN 8. It also sets out requirements for DN 150 to 375 non-pressure PVC-U pipe in plain, sandwich or profile form with stiffness values of SN 8 or 16. Non-pressure PVC-U pipelines with a stiffness rating requirement ≤ SN 16 may safely incorporate AS/NZS 1260 compliant injection moulded pipe fittings with a nominal stiffness rating of SN 6 because the jointed pipeline system is manufactured to provide a composite stiffness no lower than that of the inter-connected pipe.

Notes for Table A1 (continued)

28	Flexible pipe jointing systems may not be assumed to have significant angular displacement capacity. Most PVC pressure pipe jointing systems are non-deflection, albeit with a **1° deflection tolerance** without loss of seal performance. Joint angular deflection capacity can vary considerably across pipe sizes and from one pipe manufacturer to another. Designers and specifiers, prior to specifying pipeline joint angular configurations, should determine the joint angular deflection limitations to be applied on project drawings, by specific reference to the manufacturers (or suppliers) of the proposed pipes and jointing systems.
29	Flexible joint components (e.g. integral sockets, detachable collars and couplings) should incorporate elastomeric (or 'rubber ring') seals (ESJ or RRJ) in accordance with AS 1646/AS 681. Seals for wastewater applications should be SBR as defined in AS 1646 (Refer to the Notes for Table A2).
30	Pipe/pipe fitting joint flanges should be generally supplied as integral (not screwed) flanges in accordance with AS/NZS 2280 and AS 4087 e.g. "Adaptor C" as defined in Table 4.6.
31	Mechanical compression (fittings) jointing systems should be in accordance with AS/NZS 4129 Section 2.
32	Refer to “Notes for Tables 4.6 and 4.7” for important guidance on the requirement to stiffen PE pipeline joint spigots by means of SS stiffener inserts (supplied by the PE pipe/pipe fitting supplier) where they are to be mechanically (non-fusion) jointed (e.g. “Adaptor A/H). Fusion jointed (using butt-fusion and electro-fusion) fitting systems should be in accordance with AS/NZS 4129 and should be undertaken only by qualified thermoplastics welders who have been duly accredited and have demonstrated sufficient fusion welding experience in accordance with the requirements of WS-2. Refer Note 28 of Table 4.1.1 for the PE resin limitations that apply to water conveyance applications.
33	Welded jointing (Silver Brazing Alloy) system in accordance with AS 1167.1 Table 1 (< 0.05% cadmium) or AS 1167.1 Table 2 (> 5% silver).
34	Mechanical press-fit jointing system (e.g. Viega Propress or other system acceptable to the Corporation), using authorised system equipment, tooling and installation instructions.
35	Integral flexible jointing system that is generally supplied with the pipe, with 'belled' sockets DN < 1800 and in-wall sockets DN > 1800 as defined for "SYS" in Table 4.7.
36	Steel weld jointing (e.g. **WJ-PE**) systems for steel pipes and fittings should comply with the requirements of WS-1 (including AS 4041), DS 60 and DS 65. Designers should calculate steel pipeline MAOP in accordance with the guidance in Table 4.3, having particular regard to limited strength joint configurations including weld restrained elastomeric seal (**RRJ-WR**) joints.
37	Detachable flexible (rubber ring) seal jointing system to the same performance standard as inter-connectible AS B26 CI pipe fittings and - from 1975 - AS 1646 compliant joint seals supplied as an integral part of pipe supply.
38	Threaded BSP, and later, AS 1722.1 steel socket coupling system, with applied thread sealing compounds
39	Round rubber ring jointing system, except most road/bridge crossings which, historically, were lead & hemp yarn jointed and cement mortar/yarn repaired
40	Flanged jointing system in accordance with AS B52 and, later AS 4087, supplied as an integral flange on the pipe.
41	Rigid cement mortar and, circa 1960's, flexible rolling or sliding rubber ring jointing system to AS A139 and, later, AS 1646
42	Mechanical compression (fittings) jointing system in accordance with AS 1460.
43	Polypropylene corrugated profile walled pipe and associated inter-connectible fittings (to AS/NZS 5065) are intended for non-pressure and relatively shallow applications. Design guidance for polypropylene structured wall pipe is provided in PIPA Guideline POP015
44	Unrestrained (UR) means an axially unrestrained (typically. flexible) jointing system. Restrained (R) means an axially restrained jointing system by means of integral flanged (e.g. DI, MS, SS) in accordance with DS 38-02, fusion welding (e.g. PE, MS & SS) in accordance with WS-2 & WS-1 respectively, solvent cement welding (e.g. non-pressure PVC) in accordance with AS/NZS 2032, compression friction grips (e.g. small bore PE & Cu) and threaded (e.g. small bore Cu & iron/steel).
45	Pipeline materials, coatings and linings should be selected to provide the required asset longevity in accordance with guidance in Table A2 for the investigation and identification of potential risks from exposure to corrosive products and contaminants.

Table A2 Pipeline Longevity, Installation and Testing Characteristics[18]

Pipe Material/Acronym	Darmstadt Abrasion Wear per 100,000 cycles[2]	Resistance to Corrosion & Contaminants[4, 5, 6]	Coefficient of Thermal Expansion (10^{-5} m/m per °C)	Transient (Surge) Pressure Capability	Pipeline Seal Suitability for Vacuum Systems	Embedment & Installation Reference Specification	Field Acceptance Test Specification
ABS[3]	0.3-0.6	High[6]	10.1	< MAOP	SWJ, ESJ[13]	AS/NZS 3690	AS/NZS 3690 Sub-clause 7.2.3 and AS/NZS 2566.2 Sub-clauses 6.3.4.2 and M5
DICL[7, 8]	1-2	Limited[6]	1.1	< MAOP	ESJ[13]	AS/NZS 2566 & WSAA TN3	AS/NZS 2566 Sub-clauses 6.3.4.1 and M4
CU	N/A	Limited[6]	1.7	< 1.2 x AOP[11]	N/A	AS 4809	AS/NZS 3500.1 Sub-clause 16.3.1[15]
GRP[3] (Pressure)	0.2-0.8	High[6]	2.5-3.0	< MAOP	ESJ[13]	AS/NZS 2566	AS/NZS 2566 Sub-clauses 6.3.4.1 and M4
GRP[3] (Non-pressure)	0.2-0.8	High[6]	2.5-3.0	N/A	N/A		AS/NZS 2566 Sub-clauses 6.4 and N4
PE 100[3]	0.2-0.5	High[6]	20	< MAOP	SDR ≤ 11, Welded[14]	AS/NZS 2033	AS/NZS 2033 Clause 7.2 including Sub-clause 7.2.4[16]
Fabricated Fittings (PE[3])	N/A	High[6]	N/A	< MAOP[12]	SDR ≤ 11, Welded[14]	AS/NZS 2033	As part of Pipeline
PP[3] (Non-pressure)	0.4-1	High[6]	15	N/A	N/A	AS/NZS 2566	AS/NZS 2566 Sub-Clauses 6.4 and N4
PVC-M (Pressure)[3]	0.1-0.3	High[6]	7	< MAOP[10]	SWJ, ESJ[13]	AS/NZS 2032	AS/NZS 2032 Sub-clause 7.2 and AS/NZS 2566 Sub-clauses 6.3.4.1 and M4, for hydrostatic acceptance; AS/NZS 2566.2 Sub-clauses 6.5 and Appendix O, for deflection acceptance
PVC-O (Pressure)[3]	0.1-0.3	High[6]	7	< PFA (MAOP)[10]	SWJ, ESJ[13]	AS/NZS 2032	
PVC-U (Pressure)[3]	0.1-0.3	High[6]	7	< WP (MAOP)[10]	SWJ, ESJ[13]	AS/NZS 2032	
PVC-U[3] (Non-pressure)	0.1-0.3	High[6]	7	N/A	N/A	AS/NZS 2032	AS/NZS 2032 Sub-Clause 7.3
RC[7] (Non-pressure)	2-2.5	Limited[6]	1	N/A	N/A	AS/NZS 3725	CPAA[17]
RA[1] (Non-pressure)	≤ 0.5	High[6]		N/A	N/A	BS EN 1610	BS EN 1610[17]
MSCL[7, 8]	1-2	Limited[6]	1.2	< MAOP	N/A	AS/NZS 2566	AS/NZS 2566 Sub-clauses 6.3.4.1 and M4 - zero make-up water allowance
SS 316[9]	N/A	Limited[6]	1.5	< MAOP	N/A	AS/NZS 2566	AS/NZS 2566 Sub-clauses 6.3.4.1 and M4 - zero make-up water allowance

Notes for Table A2

1	Resin Aggregate (RA) pipe is better known as polymer concrete and is generally best suited to trenchless (jacked pipe) applications
2	The Darmstadt abrasion wear values shown are only broadly indicative of the comparative scale of the internal abrasion wear potential of different pipe materials. Reliable measured abrasion resistance test data should be provided by the respective pipe manufacturers. DICL and MSCL values reflect lining rather than substrate or structural (DI, MS) pipe material wear.
3	ABS is a non-preferred conveyance pipeline material, at present. Some plastics pipe materials (PE and PVC) can be permeated by (usually petroleum based) volatile and aromatic hydrocarbons and organic solvents. In particular: • **PVC** tensile strength is reduced by exposure to esters, ketones, ethers and aromatic or chlorinated hydrocarbons. • **PE** strength and structural performance is susceptible to degradation by strong oxidants including halogens and inorganic acids and is known to be prone to permeation of BTEX (benzene, toluene, ethylbenzene & xylene) with consequent 'tainting' of PE pipe contents which, in the case of drinking water, would be unacceptable. • **GRP/FRP** (polyester resin based) susceptibility to ozone, alkaline conditions (where pH < 10.5), chlorinated hydrocarbons, nitric acid and concentrated hydrofluosilicic acid.
4	Refer to AS 1646/AS 681 for material composition, technical standards and conformity information on elastomeric seal materials. The longevity performance of pipeline joint seal materials can be reduced significantly as follows: • **EPDM** - exposure to strong acids, alkalis, mineral oils, solvents and aromatic hydrocarbons; • **NR & SBR** - exposure to ozone, strong acids, fats, mineral oils, greases and most hydrocarbons; • **CR** - exposure to strong oxidising acids, esters, ketones and chlorinated, aromatic & nitro hydrocarbons; • **NBR** - exposure to ozone, ketones, esters, aldehydes and chlorinated & nitro hydrocarbons.
5	Notwithstanding default corrosion & contaminants resistance rate guidance shown in this Table, the potential risks from internal and external exposure to corrosive products and contaminants should be investigated, identified and addressed by selecting pipeline (including flexible joint seal) components, materials, coatings and linings by reference to the geological, hydrogeological, chemical corrosivity and (soil) electrical resistivity characteristics of the pipeline environment as appropriate. Investigations should reference manufacturer and relevant scientific data related to the corrosion and chemical resistance characteristics of pipeline components. Guidance on the "Investigation and identification of acid sulfate soils and acidic landscapes" is available from the Department of Environment and Conservation. Guidance on the risk based management of acid sulfate soils. Asset installation and dewatering work in the vicinity of acid sulfate soils may be referenced in "Water Corporation Acid Sulfate (ASS) Procedure" (#81136903).
6	Guidance for protecting drinking water pipelines in contaminated ground is given in the UK Foundation for Water Research report "Laying Potable Water Pipelines in Contaminated Ground" available for purchase at www.fwr.org.
7	Unprotected concrete and GP cement based pipe linings are unsuitable for extended exposure to aggressive fluids and corrosive gases and should not be selected for • non-pressure wastewater and drainage applications with any potential for exposure to acidic, corrosive and trade/commercial waste fluids or gas environments; • exposure to negative pressures or to fluid flows bearing erosive/abrasive matter over pipeline design lifetime; • pressure wastewater applications where operating pressures could routinely fall below +10 KPa during pipeline design life; Concrete and cement mortar pipeline surfaces should be protected against contact with aggressive/corrosive environments. Portland (GP) Cement based concrete surfaces can be thermo-plastically lined to prevent direct contact with aggressive materials. Degradation of unprotected GP cement mortar lining alkalinity by internal carbonation, chloride attack or pH level fluctuation over time can be mitigated by using acceptable corrosion inhibiting coatings or corrosion resistant base ingredients e.g. calcareous aggregate, calcium aluminate and sulfate resistant cement, as appropriate.
8	Ferro-metallic pipeline components and associated lining & coatings systems and treatments should be selected and designed to protect them against internal and external exposure to corrosive chemical, gaseous and active microbial environments. DS 95 specifies protection requirements to secure & maintain metallic pipeline longevity. Appendices A and B of SPS 100 specify enhanced requirements for steel pipe in seawater and brine applications.
9	Notwithstanding a pitting resistance equivalent number (PREN) ≥ 22, SS 316 pipe and tube material can be susceptible to crevice and pitting corrosion where: • in contact with fluids containing high (250 to 1000 mg/L) chloride levels - particularly (even at the lower chloride level values) - in the presence of oxidizing agents; • pipeline fluid velocities are routinely low (< 0.75 m/s) and where bacterial slimes and sediments can reside and nourish microbial growth activity; • pipeline borne fluid pH levels are between 4 and 10 (SS de-passivation range). Lower pH (< 4) levels are particularly corrosive and higher levels (> 10) are not significantly corrosive. • entrained gas and air/oxygen levels are significantly high e.g. where the pipeline fluid is subject to mechanical aeration; • the integrity of pipeline and joint welds may be inferior (e.g. porous, creviced or cracked); • pipeline components are supplied with adhesive information or identifying labels attached to the SS material surface. Welded pipeline components should be made from 316L SS material as a minimum or, where a number of potentially corrosive agents are present, 'super-duplex' SS material with a PREN value > 40.
10	The terminology for maximum allowable operating (or working) pressure (MAOP) for PVC pipe differs in different Australian product standards, being "WP" in AS/NZS 1477, "MAOP" in AS/NZS 4765 and "PFA" in AS/NZS 4441.
11	AOP for copper pipe is the allowable steady state pressure excluding dynamic pressure excursions (surges) i.e. the safe working pressure as defined in AS 1432 Table C2
12	Polyethylene pipe fittings should be selected and **supplied** on the basis of **declared** pressure rating (i.e. guaranteed MAOP – at 20ºC) which should be expressly and clearly marked on each fitting. The marking of standard dimension ratio (SDR) **alone** on a PE pipe fitting is not an acceptable nor safe basis for assuming or presuming a particular operating pressure rating in any application. Declared pressure rating values should be supported by documented records of fitting design basis calculations and pressure testing by accredited (e.g. NATA) testing facilities in accordance with AS/NZS 4129 **and** POP006 "Derating Requirements for Fittings" as appropriate to moulded **and** fabricated fitting geometry (as defined in POP 006). Fabricated PE pipe fittings include those manufactured in various geometric configurations from AS/NZS 4130 compliant pipe segments, sweep bends, pull-out tees, transition pieces and spigot ends - all as defined in POP 006. PE pipe fitting pressure de-rating should be in accordance with the rules in POP 006 (including called up ISO 4427.3 requirements).
13	The acceptability of elastomeric seal joints (ESJ) for vacuum pipeline applications should be subject to written confirmation by the pipe joint manufacturer of their safe sealing performance capability for exposure to full vacuum (-100KPa) pressures, given that pipe product standards generally specify joint seal performance testing for pressure values no lower than -80KPa.
14	The structural stiffness selected for PE pipeline components should safely sustain negative pressures and resist buckling in vacuum applications. They should be welded in accordance with the requirements of WS-2.
15	Site test pressure for Type A copper pipe should not exceed the $\mathbf{P_t}$ values shown for Type A in AS 1432 Table C2 (e.g. < 1.5 MPa for DN ≤ 150). The selection/use of copper pipe is generally limited to property services applications.
16	PE pipe (particularly in larger diameters) should not be selected for pipeline sections that may underlie significant structures or built assets whose integrity or stability may be compromised by significant viscoelastic expansion and contraction movement arising from pipeline internal pressure fluctuations in service and from PE pipeline field pressure testing operations

17	Field acceptance testing of RC pipe should be in accordance with Concrete Pipe Association of Australasia (CPAA) "Field Testing of Concrete Pipelines and Joints". Field acceptance testing of RA pipe should be in accordance with BS EN 1610 or, where agreed with pipeline owner, ASTM D6783-05.
18	Refer to Table 4.1.1 and Sub-clause 4.3.6 for material and installation characteristics to be considered prior to pipeline component selection, installation design and specification and the pipeline warning signage requirements of DS 101.

APPENDIX B

Table B1 Typical Outside Diameter Dimension Data for CIOD and Metric Pipe (DN 50 - 900)

Pipe Material:	Asbestos Cement		Grey/Cast Iron		Ductile Iron	Steel			Reinforced Concrete		PVC Blue	PVC White	GRP	PE	Copper	PVC	PE; PP	Asbestos Cement		VC	Grey Cast Iron	GRP
Australian Standard	AS 1711		AS 1723 AS 2544		AS/NZS 2280	AS1074	AS1579		AS/NZS 4058		AS/NZS 1477 AS/NZS 4765 AS 4441		AS 3571	AS/NZS 4130	AS 1432	AS 1260	AS 5065	AS 1712		AS 1741	AS 1631 EN 877	AS 3571.1 AS 3571.2
Pipe Diameter Series		**CIOD**		**CIOD**	**CIOD**	GWI	Imperial	Metric		Maximum Pressure	**CIOD** Series 2	Metric Series 1	**CIOD** Series 2			SH, SEH,		35	50		B	**CIOD**
Pressure or Stiffness Class/Rating	A & B	C & D	B	C & D	PN 12/16											SN8, SN16						
	PRESSURE PIPE NOMINAL SIZES and DIAMETERS															**NON-PRESSURE PIPE NOMINAL SIZES & ODS**						
Nominal Diameter (DN)	**Internal Diameter (ID)**									**PSI**	**Internal Diameter (ID)**					**Internal Diameter (ID)**						
	Mean Outside Diameter (**OD**)										Mean Outside Diameter (**OD**)					Mean Outside Diameter (**OD**)						
20														**25** 25.15	**20** 19							
25														**32** 32.15	**25** 25.3							
50						**50/2"** 67	**2"** 60.3					**50** 60.4		**63** 63.3	**65** 63.4							
80		**58** 77.6				**65/2.5"** 76					**58** 77.6	**65** 75.4			**80** 76.1							
80						**80/3"** 88.8						**80** 88.9		**90** 90.45	**90** 88.8							
80	**80/3"** 95.6	**80/3"** 95.6	**80/3"** 95.5	**80/3"** 95.5	**80** 96										**100** 101.5							
100						**100/4"** 114.1		**100** 114.3				**100** 114.3				**100** 110.2		**100/4"** 119.9			**100/4"** 111.5	
100	**100/4"** 121.9	**100/4"** 121.9	**100/4"** 121.9	**100/4"** 121.9	**100** 122		**4"** 120.7				**100** 121.9			**125** 125.6	**125** 126.9				**100/4"** 122.1			
100	**100/4"** 134	(Sutton) 1929-51																				
125						**125/5"** 140.2															**125/5"** 138.5	
125			**125/5"** 149.9	**125/5"** 149.9								**125** 140.2								**100/4"** 140.2		
150									**4"** 158.8	**180**					**150** 152.2							
150						**150/6"** 165.1		**150** 168.3	**100/4"** 160	**180**		**150** 160.3				**150** 160.2					**150/6"** 163.5	
150	**150/6"** 177.3	**150/6"** 177.3	**150/6"** 177.3	**150/6"** 177.3	150 177		**6"** 177.8				**150** 177.3							**150/6"** 177.3	**150/6"** 182.9			
150												**155** 168.3		**180** 180.85						**150/6"** 194.6		
200			**175/7"** 204.7	**175/7"** 204.7					**150/6"** 210	**180**		**175** 200.3			**200** 203	**175** 200.3					**200/8"** 210	
200								**200**				**195**						**200/8"**				

Pipe Material:	Asbestos Cement		Grey/Cast Iron		Ductile Iron	Steel			Reinforced Concrete		PVC Blue	PVC White	GRP	PE	Copper	PVC	PE; PP	Asbestos Cement		VC	Grey Cast Iron	GRP
Australian Standard	AS 1711		AS 1723 AS 2544		AS/NZS 2280	AS1074	AS1579		AS/NZS 4058		AS/NZS 1477 AS/NZS 4765 AS 4441		AS 3571	AS/NZS 4130	AS 1432	AS 1260	AS 5065	AS 1712		AS 1741	AS 1631 EN 877	AS 3571.1 AS 3571.2
Pipe Diameter Series		**CIOD**		**CIOD**	**CIOD**	GWI	Imperial	Metric		Maximum Pressure	**CIOD** Series 2	Metric Series 1	**CIOD** Series 2			SH, SEH,		35	50		B	**CIOD**
Pressure or Stiffness Class/Rating	A & B	C & D	B	C & D	PN 12/16											SN8, SN16						
	PRESSURE PIPE NOMINAL SIZES and DIAMETERS															**NON-PRESSURE PIPE NOMINAL SIZES & ODS**						
Nominal Diameter (DN)	**Internal Diameter (ID)** Mean Outside Diameter (**OD**)									**PSI**	**Internal Diameter (ID)** Mean Outside Diameter (**OD**)					**Internal Diameter (ID)** Mean Outside Diameter (**OD**)						
								219.1				219.1						229.6				
200	**200/8"** 232.2	**200/8"** 232.2	**200/8"** 232.2	**200/8"** 232.2	**200** 232		**8"** 235				**200** 232.2	**200** 225.3		**250** 251.15					**200/8"** 235.8		**225/9"** 242	
225	**225/9"** 259.1	**225/9"** 259.1	**225/9"** 259.1	**225/9"** 259.1	**225** 259						**225** 259.2	**225** 250.4				**225** 250.3		**225/9"** 256.5	**225/9"** 262.1			
250								**250** 273	**225/9"** 279	**50**		**250** 280.4						**250/10"** 283		**225/9"** 277		
250	**250/10"** 286	**250/10"** 286	**250/10"** 286	**250/10"** 286	**250** 286		**10"** 292.1		**220/8.75"** 292	**135**	**250** 286.2			**315** 316.45					**250/10"** 289.2			
300									**250/10"** 318 **215/8.5"** 312	**75** **180**		**300** 315.5				**300** 315.4						
300								**300** 323.9													**300/12"** 323	
300	**300/12"** 333.8		**300/12"** 333.8						**250/10"** 337	**100**								**300/12"** 336.2	**300/12"** 344.2			
300		**300/12"** 345.4		**300/12"** 345.4	**300** 345		**12"** 349.3	**350** 355.6			**300** 345.4		**300** 345	**355** 356.6			**300** 344		**300/12"** 344.2			**300** 345
300									**300/12"** 362 **11/11.5/12"** 381	**50** **135**												
375			**350/14"** 386.6	**350/14"** 399.3			**14"** 390.5	**400** 406.4				**375** 400.5	**350** 399			**375** 400.5						**350** 399
375	**375/15"** 413	**375/15"** 426.2	**375/15"** 413	**375/15"** 426.2	**375** 425		**15"** 425.5				**375** 426.2		**375** 426				**375** 429	**375/15"** 418.6	**375/15"** 424.8	**375/15"** 428	**400/16"** 429	**375** 426
400				**400/16"** 453.1			**16"** 441.3	**450** 457	**375/15"** 445	**50**		**400** 450.5	**400** 453	**450** 452.05								**400** 453
450	**450/18"** 492.2	**450/18"** 507	**450/18"** 492.3	**450/18"** 507	**450** 507		**18"** 497.3	**500** 508	**375/15"** 495	**120**	**450** 507	**450** 500.5	**450** 507	**500** 502.75		**475/19"** 500.5	**450** 514	**450/18"** 496.8	**450/18"** 505			**450** 507
500	**525/21"** 571.5		**525/21"** 571.5	**500/20"** 560.3	**500** 560		**21"** 568.3				**525/500** 560.3	**500** 560.5		**560** 562.5				**525/21"** 576.1				
500	**525/21"** 571.5	**525/21"** 587.2	**525/21"** 571.5	**525/21"** 587.2			**21"** 577.9		**450/19.5"** 597 **450/17.5"**	**75** **120**			**525** 587				**525** 601	**525/21"** 576.1	**525/21"** 585.3			**525** 587

Pipe Material:	Asbestos Cement		Grey/Cast Iron		Ductile Iron	Steel			Reinforced Concrete		PVC Blue	PVC White	GRP	PE	Copper	PVC	PE; PP	Asbestos Cement		VC	Grey Cast Iron	GRP
Australian Standard	AS 1711		AS 1723 AS 2544		AS/NZS 2280	AS1074	AS1579		AS/NZS 4058		AS/NZS 1477 AS/NZS 4765 AS 4441		AS 3571	AS/NZS 4130	AS 1432	AS 1260	AS 5065	AS 1712		AS 1741	AS 1631 EN 877	AS 3571.1 AS 3571.2
Pipe Diameter Series		**CIOD**		**CIOD**	**CIOD**	GWI	Imperial	Metric		Maximum Pressure	**CIOD** Series 2	Metric Series 1	**CIOD** Series 2			SH, SEH,		35	50		B	**CIOD**
Pressure or Stiffness Class/Rating	A & B	C & D	B	C & D	PN 12/16											SN8, SN16						
	PRESSURE PIPE NOMINAL SIZES and DIAMETERS															**NON-PRESSURE PIPE NOMINAL SIZES & ODS**						
Nominal Diameter (DN)	**Internal Diameter (ID)** Mean Outside Diameter (**OD**)									**PSI**	**Internal Diameter (ID)** Mean Outside Diameter (**OD**)					**Internal Diameter (ID)** Mean Outside Diameter (**OD**)						
									597													
600							**24"** 647.7	**600** 610	**500/21/20.75"** 635 **500/20"** 635	**75** **115**		**575** 630.5		**630** 632.85		**600/24"** 630.5						
600	**600/24"** 650.2	**600/24"** 667	**600/24"** 650.2	**600/24"** 667	**600** 667						**600** 667		**600** 667				**600** 683	**600/24"** 657	**600/24"** 664.4			**600** 667
600			**650/26"** 702.6	**650/26"** 702.6				**700** 711												**600/24"** 692		
675		**675** 746.8		**675** 746.8									**675** 747									**675** 747
900									**750/30"** 914 **750/28"/29"** 915	**75** **120**			**900** 924									**900** 924

NOTES

Cast Iron Outside Diameter (CIOD) means the range of ODs of Imperial Grey/Cast Iron (CI) Pipe Classes C & D and of other pipes subsequently manufactured to the same ODs, including CI Pipe Class B < DN 250, Ductile Iron (DI), Asbestos Cement (AC) Pipe Classes C & D (and Class B < DN 250), PVC Pipe Series 2 and GRP Pipe. It excludes Steel Pipe, Copper Pipe, RC Pipe, CI Pipe Class B (DN 300 and larger), AC Pipe Class B (DN 300 and larger), PVC Pipe Series 1 (ISO) and non-pressure pipe except GRP.

Nominated AC pipe ODs relate to factory machined pipe spigot ends only. There are no published manufacturing data for un-machined or 'wrinkly' AC pipe barrel ODs or OD tolerances. Suitability of pipe fittings for use with pressure and non-pressure pipes is based on published pipe manufacturing data. It is recommended that the OD of older/legacy pipes are verified by direct measurement prior to the selection of a particular inter-connecting pipeline fitting or jointing arrangement.

More detailed information on older vintage pipe manufacturing history and dimensional variations is provided under “Legacy Pipeline Considerations”

APPENDIX C Legacy Pipeline Characteristics

C1 General

Corporation water, sewerage and drainage pipeline infrastructure, at present, comprises:

Material	Pressure (km)	Non-pressure (km)	All (km)
AC	11,910	610	12,520
PVC	10,300	9,923	20,223
MS	6,764	12	6,776
CI/DI	3,351	9	3,360
VC	NIL	3,693	3,693
RC	3,163	665	3,828
PE	2,825	20	2,845
CU	334	NIL	334
BI/GWI/GS	270	NIL	270
GRP	83	33	116
totals	39,000	14,965	53,965

These pipeline lengths exclude open drainage channels. Table B1 (Appendix B) provides typical outside diameter dimension data for DN 50 to DN 900 pipe sizes across various pipe materials as respects compatibility with CIOD and metric pipe diameter series. Some background to the extent of alignment of Corporation pipeline diameters with CIOD (Series 2) and metric (Series 1) diameter series is described in greater detail below.

C2 Cast Iron

The outside diameter dimensions of cast grey iron (CI) pipes and fittings for pressure applications, mostly imported from the UK since circa 1930, were compatible with those of like product specified in manufacturing standards BS 44:1909 and BS 78:1938 (for products typically cast in sand-lined moulds) and BS 1211:1945 (for centrifugally spun products). The scope of AS/NZS 2544-1995 limited it to cast grey iron pipe fittings only to the exclusion of pipe because the adoption of AS 2280-1979 for cast ductile iron (DI) pipe and fittings rendered use of heavier thicker-walled cast grey iron pipe in the marketplace uncompetitive and, in effect, virtually obsolete.

Publication of AS/NZS 2280:1999 marked virtual domination of the cast iron pipe and fittings market by the spheroidal graphite (i.e. ductile) iron product. Use of pressure pipelines with imperial cast iron outside diameters (CIOD) from circa 1890 has resulted in an overwhelming preference for CIOD (as distinct from ISO metric) compatible pipe and fitting diameters in Corporation pipeline systems. This preference was confirmed by an evaluation of the business cost/risk impacts of acquiring, operating and maintaining pipeline systems with an indeterminate mix of CIOD (imperial) and smaller ISO (metric) pipe diameters.

The Corporation owns circa 3,350 km of cast iron pressure pipelines of which over 300 km are spun ductile iron acquired after 1990 and the remainder grey iron. The spigot dimensions of cast (grey and ductile) iron pipes and fittings in Australian manufacturing standards from AS A145/146-1965 through to AS 2544-1982 have retained dimensional compatibility with imperial (CIOD/Series 2) outside diameters and applies across commonly used working pressure classifications as follows:

- Class B - 200 ft - for non-standard (e.g. PN 6 or low pressure irrigation) applications;
- Class C - 300 ft - for non-standard (PN 9 or medium pressure) applications; and
- Class D - 400 ft - for standard (PN 12) applications.

Up to 1921, CI pipes were typically cast in horizontal sand moulds and were imported from overseas up to 1929, when locally manufactured pipes became available. Pre-1926 CI pipes were unlined. Up to 1935, they were lead jointed and, after that, had rubber ring and cement packed joints until the adoption in 1963 by the MWSSD Board of CI pipe and fitting products with the patented Tyton rubber ring jointing system which is still used today.

Prior to the use of centrifugal spinning techniques, CI pipes, typically, had rough and uneven external surfaces and an inconsistent structure with many casting faults and inclusions. These together with the absence of protective coatings and poor quality of some (or no) cement linings have contributed to poor corrosion performance and premature failure in service during the early years. Poor performance was particularly exacerbated by soil environments where acidity, salt content, resistivity, moisture and aeration and sulphide levels led to extensive pitting, tuberculation and graphitisation of CI pipe structure. The rate of corrosion was considerably reduced by the adoption in 1980 of polyethylene sleeve wrapping, as a requirement for CI pipelines.

Note: Australian and New Zealand cast grey and ductile iron pipes are sized to an independent specification, AS/NZS 2280, that does not directly align with European pipe sizes. While Australia adopted the imperial British cast iron pipe standard BS 78, it opted for a 'soft' conversion from imperial to metric units (as published in AS/NSZ 2280) in preference to adopting, like the UK, the new metricated ISO 2531 standard. Hence, the physical outer diameters of AS/NZS 2280 pipes remain unchanged from those of the original BS 78, which has enabled continuity of Australian CI/DI pipe manufacture and backwards pipeline diameter compatibility.

C3 Asbestos Cement

Asbestos fibre-reinforced cement (AC) pipes for pressure and non-pressure applications commenced manufacture in Australia in 1926, using a locally developed (Sutton) production process which differed from the traditional (Mazza) European process. This was displaced by the Magnani process in 1951. AC pipes were used in limited quantities (< 250 km) in Corporation infrastructure until about 1961, following introduction of an automated autoclave steam curing manufacturing (Mazza) process and adoption of manufacturing standards AS A41-1959 and, later, AS 1711-1975.

The Corporation owns circa 11,910 km of asbestos cement pressure pipelines of which only 415 km (3.5%) is larger than DN 300, while 30% is DN 58 (nominally equivalent to DN 65). About 220 km AC pipelines (largely DN 100/150) were installed before 1950 and were most likely manufactured by the Sutton process. The machined spigot dimensions of AC pressure pipe in AS A41-1959 and successor product standards were dimensionally compatible with traditional CI pipe outside diameters i.e. CIOD.

Table F1 (Appendix F) provides typical pressure class and dimensional data for standard Asbestos Cement pipes, post-1959. The outside diameter dimensions of older AC pipe spigots - particularly pre-1951 vintage produced by the Sutton manufacturing process - should be confirmed by check measurement where extensions of, inter-connections with or cut-ins to AC pipelines are proposed.

AC pressure pipes installed after the late 1950s tended to conform to dimensions in alignment with those of CI pipe, with some exceptions, across common working pressure classifications as follows:

- Class B for PN 6 (non-standard low pressure e.g. irrigation) applications – CIOD (Series 2) for pipe diameters ≤ DN 250 and Metric (Series 1) for pipe diameters DN 300 to DN 600;
- Class C for PN 9 (medium pressure) applications - CIOD (Series 2) for all pipe diameters;
- Class D for standard PN 12 pressure applications - CIOD (Series 2) for all pipe diameters;
- Class E for DN 150 pipe only in high pressure PN 15 applications;
- Class F for DN 80 to 150 pipe only in high pressure PN 18 applications;
- Special Class C Codes 28 and 31 (circumferential tensile strength 28 and 31 MPa respectively) in high pressure (PN 14/16 equivalent) applications for pipe sizes DN 200 to 600 only;
- Special Class D Codes 28 and 31 (circumferential tensile strength 28 and 31 MPa respectively) in high pressure (PN 18/20 equivalent) applications for pipe sizes DN 200 to 300 only.

The Corporation acquired circa 610 km of asbestos cement non-pressure pipelines, manufactured in accordance with AS 1712-1976, in non-pressure sewerage applications since the late 1970s. Given the observed rate of structural deterioration over time - mostly due to loss of cement binder - it is desirable to replace (retire) whole sections of non-pressure AC pipeline between access chambers in preference to a partial replacement or cut-in of service connections, subject to project justification and funding.

Conformity with the Corporation Safety and Wellbeing “Asbestos Procedure” should be a pre-requisite planning, design and construction activity for safely delivering infrastructure assets that adjoin or may be located in the vicinity of AC pipelines.

C4 Steel

C4.1 Mains

Over the early (pre-1960) years, polyethylene sleeve wrapped steel pipe steel pipe was imported at various times from New Zealand (Steel Mains P/L) and South Africa. A number of entities were involved in the manufacture and supply of steel pipe after completion of the “Golden Pipeline” (560 km of 30 inch - DN 750) locking bar steel pipe to Kalgoorlie in 1903. These included Stantons (formerly British Steel) from 1920, Stewarts & Lloyds in partnership with BHP and Tube Investments (UK) from 1934. These diverse commercial interests were consolidated into Tubemakers Australia in 1946 which was restructured and publically listed in 1969.

Steel pipe for WA was produced in Somerton Victoria by Tubemakers who also produced coal tar enamelled steel pipe in smaller diameters (in Kwinana, WA). The latter ceased production when it was declared unacceptable due to in-service handling/installation damage, coating penetration, cement lining failures and potential environmental and health risks. The imminent closure of the Tubemakers Kwinana plant due to loss of its sole enamel wrapped steel pipe customer, led to negotiations resulting in a plant upgrade to produce Sintakote cement lined steel pipe in all required sizes on the basis of guaranteed minimum pipe purchases by the Water Authority (now Water Corporation) over a 5 year contract period from 1989.

Water industry need for steel pipe with consistently acceptable structural, dimensional and corrosion protection parameters led to the development of Australian steel pipe manufacturing standard AS A125-1963 which later became AS 1579-1993 through to AS 1579-2001.

A fusion bonded low-density polyethylene (LDPE) coating system “Sintakote” for steel pipe was developed by Tubemakers circa 1970 and was applied up to the early 1990s in accordance with AS 2518:1982 and, later, AS 2518:1992. Tyco Water (which absorbed Tubemakers, in 1990) developed a new generation MDPE coating system “Sintakote II” in accordance with AS 4321:1995. Sintakote coated and cement mortar lined steel pipe has been considered very cost effective and the product of choice for large (DN500 - 1400) Corporation water conveyance pipes for many years.

In 2012, US companies Pentair and Tyco Flow Control (owner of Tyco Water) merged under the Pentair name. The Australian steel pipeline business, operated by Pentair Water Solutions since 2012, was acquired by Steel Mains P/L in 2015.

The Corporation owns circa 6,760 km of steel pressure pipelines mostly acquired since 1930. Steel pipeline applications tend to be in larger (DN500 - 1000) sizes although small steel pipe sizes were typically used for conveyance system pumping mains.

Steel pipe dimensional requirements in AS1579 were selected for compatibility with ISO 559 and, through this, compatibility with the steel pipe standards of ISO aligned countries. Notwithstanding this, AS 1579/ISO 559 outside diameter series dimensions directly match neither metric ISO Series 1 nor CIOD Series 2 as applicable to CI, AC and PVC pipes in Corporation. In addition, the ODs of DN 100, 150 and 200 steel pipes manufactured for Corporation infrastructure up to the early 1990s were CIOD compliant while those supplied to east coast markets were ISO/metric (AS 1579) compliant.

Tables D2 and D1 (Appendix D) provide typical structural and dimensional data for steel pipes of pre and post 1975 manufacturing vintage respectively. The dimensions of steel pipes supplied by the manufacturer have varied over the years. Hence, it should not be assumed that Corporation infrastructure contains steel pipes across all the listed diameters or that pipes supplied before or after 1975 necessarily aligned with those listed in Tables D2 or D1 respectively. The outside diameter and wall thickness dimensions of steel pipes - particularly pre-1990 vintage – should be confirmed by check measurement in situ, where extensions of, inter-connections with and cut-ins to steel pipelines are proposed.

C4.2 Services

The Corporation owns circa 270 km of small diameter (< DN 150) steel pipes of which all was installed before 1980 with nearly 75% being DN 80 or smaller. Some, particularly in the larger (DN 100/150) diameters are likely to be installed in pumping main and associated mechanical pipework applications. Over 99% of these are galvanized, being colloquially termed either galvanized steel (GS) or galvanized wrought iron (GWI). Steel tubes (pipes) DN 150 and smaller in diameter were produced in accordance with manufacturing standards AS B105:1951 through to AS 1074:1989 and were originally in close alignment with BS 1387:1957.

The use of copper pipe (330 km from 1960 to 1990) and plastics from the late 1980s onward obviated the demand for small diameter steel pipe and replaced considerable sections of steel pipe/tube that had reached the end of their useful life. Copper pipelines were produced in accordance with copper tube manufacturing standards AS B2:1928 through to AS 1432:2004. There were no formal documented national standards for metallic (copper) pipe fittings nor for the installation and commissioning of copper pipe and fittings until the publication of AS 3688:1994 and 4809:2003 respectively.

C4.3 Stainless Steel

The lengths of stainless steel tubing incorporated in process pipeline networks (e.g. treatment plants) and – as pipework specials - in larger conveyance systems has not been specifically recorded by Corporation GIS systems. Stainless steel (SS) tube/pipe is typically produced in accordance with manufacturing standard ASTM A269 or ASTM A312 for general service - low temperature, non-corrosive and schedule piping for high temperature applications respectively, using austenitic SS material. Pipe for high temperature and corrosive fluid applications is usually ferritic or austenitic (duplex or super-duplex) SS material e.g. ASTM A790, A789 or A928 as appropriate to the particular fluid, chemical process, temperature and pressure applications.

C5 Concrete

The Corporation owns circa 3,170 km of RC pressure pipelines and 710 km of non-pressure RC pipelines in DN375 to 2250 sizes. 90% of RC pressure pipelines are smaller than DN 225 and 99% of all RC pipelines were acquired since 1950.

Tables E1 and E2 (Appendix E) provide typical structural and dimensional data for legacy RC pressure pipe used for water conveyance up to the 1980s and beyond. Table E3 outlines how RC non-pressure pipe load class designations varied (or not) in strength value from pre 1934 manufacturer designated classes through 1957 (when the first Australian RC pipe Standard was published) up to the current AS/NZS 4058 RC pipe class designations.

Non-pressure RC pipe dimensions have generally been as nominated by the pipe manufacturer (e.g. Humes and Rocla) with ID values approximating nominal diameters (or DN) as nominated in the RC pipe manufacturing standard AS/NZS 4058. The outside diameters of RC pressure pipes did not generally conform to recognized (e.g. CIOD, ISO) water industry dimensions which existed from the early 1900’s. Given the extent and uncertainty of OD variation across the (buried) RC pressure pipe legacy ‘population’, these should be confirmed by check measurement in situ, prior to detailing any extension of, inter-connection with or cut-in to an RC pressure pipeline and prior to selecting pipe fittings and associated inter-connectors or couplings.

C6 Vitrified Clay

The Corporation owns circa 3,690 km of vitrified (or vitreous) clay (VC) non-pressure pipelines in DN 100 to 450 sizes of which over 80% are in the DN 100 to 150 size range. VC pipelines were typically used for ‘gravity’ sewerage applications from the 1920s with over 63% being installed between 1960 and 1990. Production of VC pipes for pressure applications did not prove commercially viable.

VC pipe dimensions generally conformed with VC pipe manufacturing standards from AS B57-1935 through to AS 1741-1991. VC pipe and fitting joints were traditionally rigid – typically cement mortar packed – until the introduction of a 4” (DN 100) rubber ring joint design in AS A165-1968 to accompany AS A164-1968 for pipe with both rigid and flexible joint sockets. Publication in 1975 of manufacturing standard AS 1741, provided for flexible (or rubber ring) VC pipe and fitting joints across all manufactured diameters. VC pipes are known to have been imported from the UK over the years but little is known about when and where installed.

The outside diameters of VC pipes spigots do not directly align with those of other commonly used non-pressure or pressure pipe materials. Imported VC pipe dimensions - typically manufactured to UK standards – also differed from Australian Standard VC pipe dimensions. In the unlikely event that a VC pipe spigot is to be directly connected to a pipe spigot of another pipe material, both ODs should be verified prior to selecting inter-connection couplings.

Given the performance history of VC pipeline joint integrity including resistance to root intrusion, the replacement of whole - in preference to partial - VC pipeline sections should be considered, subject to project requirements justification and funding.

C7 Plastics

C7.1 Polyethylene

First generation PE pipe materials – low and high density polyethylene (LDPE & HDPE) – date back to the early 1930s and 1950s respectively. Manufacturing standards AS K119-1962 through to AS 1159-1973, 1979 and 1988 classified pressure pipe made from these PE materials as Type 30 - LDPE with a tensile strength of 3 MPa - and Type 50 - HDPE with a tensile strength of 5 MPa - respectively. PE pressure pipe manufactured with second generation PE polymers – medium density polyethylene (MDPE) – became available and was to dominate the PE pipe market in the late 1980s.

Minimum performance requirements for polyethylene (PE) compounds for Australian PE pressure pipes and fittings were formally published in AS K125-1963, based on UK requirements in BS 1973:1953. These requirements were substantially upgraded in AS/NZS 4131:2001 and, later, in AS/NZS4131:2003 to reflect the modern PE compounds market.

The availability of third generation polymers PE 80B ('MDPE') - with an 8 MPa tensile strength - and PE 100 ('HDPE') with a 10 MPa tensile strength - led to the publication of AS/NZS 4130:2003 for PE pressure pipe. The higher tensile strength, better resistance to slow crack growth and material efficiency of PE 100 has rendered the use of PE 80B pressure pipe obsolete.

A number of recent significant failures of PE water pipelines, when exposed to chlorinated water conveyance and elevated temperatures, have resulted in special material requirements for the use of PE pipe and fittings in water conveyance applications. These include requirements for the use of PE resins that conform with High Stress Crack Resistant (HSCR), Disinfectant Resistant (DR) or Resistant to Cracks (RC) resin specifications, as now defined in SPS 125.

Australian manufacturing and performance requirements for PE pressure pipe fittings were first published in AS 1460-1973, followed by AS 1460-1989 and, in 1997, AS/NZS 4129 (Int). The latter evolved into AS/NZS 4129:2000 which was modernized to AS/NZS 4129:2008.

The first documented national standard for installing PE pipelines, AS 2033, was published in 1977. This was substantially revised and upgraded as AS/NZS 2033 in 2008. AS/NZS 2033 is the currently accepted basis for installing PE pipe systems across the water industry nationally.

The Corporation owns circa 2,840 km of polyethylene (PE) pipelines of which 20 km represent non-pressure pipelines including a (failed & decommissioned) cohort of ribbed profile PE sewers. PE pressure pipes were installed mostly from 1980 onwards with nearly 90% being DN 100 or smaller. Nearly 50% of PE pipelines are DN 63, the predominant size/material combination in urban cul-de-sac water service applications in preference to the older traditional DN 50 copper service pipe.

C7.2 PVC

Australian manufacturing and performance requirements for Unplasticised Polyvinyl Chloride (uPVC) pressure and non-pressure pipes and fittings (with metric/ISO diameters) were first published in AS K138-1963 and AS A159-1969 respectively. This was progressively revised between 1988 and 1990 and re-designated AS 1477, Parts 1 to 6 – 1973. Parts 1, 2, 4 & 6 were scoped for pressure applications only. A new manufacturing standard AS 2977, Parts 1 to 3 (pipes, fittings and joints) was introduced to cater for PVC pipe diameters with CIOD dimensions, given the dominance of cast iron pipe diameters in legacy pipeline systems. AS/NZS 1477:1996 replaced the separate need for AS 1477 and AS 2977 by designating Series 1 and Series 2 diameters for equivalence with metric/ISO and CIOD dimensions respectively, whilst incorporating performance requirements for both in common. The current PVC-U (uPVC) pressure pipe and fittings manufacturing standard is AS/NZS 1477:2006.

Instances of premature failure of uPVC pressure pipes - many related to impact resistance performance and overall material sustainability of this relatively thick-walled product - resulted in the introduction of modified PVC (PVC-M) pressure pipes and publication of a manufacturing standard AS/NZS 4765 (Int):2000. PVC-M pipes were thinner walled and exhibited more predictable rupture characteristics by virtue of added impact modifiers. On the other hand, the higher ductility of PVC-M pipe material and its consequently 'poorer' cyclic fatigue performance has limited its use to lower pumping frequency applications, as compared with other plastics - including PVC-U and PVC-O pipe materials. Although molecular-oriented PVC (PVC-O) pipe was introduced in Australia in the 1980s, its competitive production was enabled only by comparatively recent advancements in PVC-O pipe manufacturing technology. The early manufacturing standard for PVC-O pressure pipe AS/NZS 4441 (Int):1996 evolved into the current standard AS/NZS 4441:2008.

The limited resistance of PVC - particularly PVC-M and, to a lesser extent, PVC-U - pressure pipelines to frequent cyclic pressure fluctuations – usually generated by pump and valve operations – is unlikely to have been considered or quantified in the past by designers. The cyclic fatigue characteristics and longevity of legacy PVC pipelines should accordingly be evaluated as a pre-requisite of new pipeline system designs that incorporate legacy PVC pipe into new pipeline systems.

The Corporation owns circa 10,400 km of PVC pressure pipelines and 9,920 km of PVC non-pressure (sewerage and drainage) pipelines. Virtually all were installed from the late 1980s onwards. 94% of PVC pressure pipelines and 99% of PVC non-pressure pipelines are DN 300 or smaller.

C7.3 GRP

Manufacturing and performance requirements for Glass Reinforced thermo-Plastics (GRP) pipe systems (with CIOD compatible diameters) were first published in AS 3571-1989. These formally confirmed Australian performance requirements for centrifugally cast GRP pipes, produced under licence from the (Swedish/Swiss) proprietors of the HOBAS GRP pipe system manufacturing process.

The manufacture of cast GRP pipes systems (HOBAS) ceased in Australia circa 2006, following the establishment in Australia of a filament wound (Flowtite) GRP pipe manufacturing process. AS 3571.1:2009 and AS 3571.2:2009 were developed by Australian GRP pipe system users by adopting GRP pipe system standards ISO 10467 and ISO 10639 respectively for drainage/sewerage and water supply applications. An Australia-specific Appendix ZZ in both parts of AS 3571 includes provision for CIOD compliant pipe diameters (Table 5) for Australian water industry applications. In 2021, ISO 10467 and ISO 10639 were combined into a single standard ISO 23856 and, pending adaptation of AS 3571 to align with ISO 23856 and include an Australian Appendix, Australian specific requirements may be referenced in WSA PS 219.

The Corporation owns circa 83 km of GRP pressure pipelines and 33 km of GRP non-pressure (sewerage and drainage) pipelines. Virtually all were installed from the early 1980s onwards. 96% of GRP pressure pipelines and all GRP non-pressure pipelines are DN 375 or larger.

APPENDIX D

Table D1 Steel Pipes - Dimensions (Vintage 1975 to Current)

Dimensions						MAOP	Min Yield Strength	Paper Record Date
DN	O.D.	Steel Plate Thickness	I.D. (Unlined)	Cement Mortar Lining	I.D. (Lined)			
mm	mm	mm	mm	mm	mm	m	MPa	
100	114.00	4.80	104.40	9.00	86.40	>350	300	Nov-08
100	114.00	5.00	104.00	6.00	92.00	>300		Jan-78
100	120.65	5.00	110.65	9.53	91.59			Nov-75
100	121.00	5.00	111.00	8.00	95.00	>300		Apr-90
100	121.00	5.00	111.00	8.00	95.00	>300		1989
150	168.00	5.00	158.00	9.00	140.00	>350	300	Nov-08
150	178.00	5.00	168.00	8.00	152.00	>300		Apr-90
150	168.00	5.00	158.00	6.00	146.00	>300		Jan-78
150	177.80	4.76	168.28	9.53	149.22			Nov-75
150	178.00	5.00	168.00	8.00	152.00	>300		1989
200	219.00	5.00	209.00	9.00	191.00	>350	300	Nov-08
200	235.00	5.00	225.00	8.00	209.00	>300		Apr-90
200	219.00	5.00	209.00	6.00	197.00	>300		Jan-78
205	234.95	4.76	225.43	9.53	206.37			Nov-75
200	235.00	5.00	225	8	209	>300		1989
250	273.00	5.00	263.00	9.00	245.00	>350	300	Nov-08
250	273.00	5.00	263.00	10.00	243.00	>300		Jan-78
255	292.10	4.76	282.58	9.53	263.52			Nov-75
300	324.00	5.00	314.00	12.00	290.00	>350	300	Nov-08
300	324.00	5.00	314.00	10.00	294.00	>300		Apr-90
305	349.25	4.76	339.73	9.53	320.67			Nov-75
300	324.00	5.00	314.00	10.00	294.00	>300		1989
350	356.00	5.00	346.00	10.00	326.00	>300		Jan-78
380	425.45	4.76	415.93	12.70	390.53			Nov-75
400	406.00	5.00	396.00	12.00	372.00	>350	300	Nov-08
400	406.00	5.00	396.00	10.00	376.00	>300		1989
400	406.00	5.00	396.00	10.00	376.00	>300		Jan-78
450	457.00	5.00	447.00	10.00	427.00	>300		Jan-78
460	488.95	4.75	479.45	12.70	454.05			Nov-75
460	498.48	6.35	485.78	12.70	460.38			Nov-75

Dimensions						MAOP	Min Yield Strength	Paper Record Date
DN	O.D.	Steel Plate Thickness	I.D. (Unlined)	Cement Mortar Lining	I.D. (Lined)			
mm	mm	mm	mm	mm	mm	m	MPa	
500	508.00	5.00	498.00	12.00	474.00	>350	300	Nov-08
500	508.00	5.00	498.00	10.00	478.00	285		Jan-78
500	508.00	5.00	498.00	10.00	478.00	285		1989
535	568.33	4.76	558.81	12.70	533.41			Nov-75
535	571.50	6.35	558.80	12.70	533.40			Nov-75
535	577.85	9.53	558.79	12.70	533.39			Nov-75
600	610.00	6.00	598.00	12.00	574.00	>350	300	Nov-08
600	610.00	5.00	600.00	12.00	576.00	180		Jan-78
610	647.70	6.35	635.00	12.70	609.60			Nov-75
600	610.00	6.00	598.00	12.00	574.00	295		1989
700	711.00	6.00	699.00	12.00	675.00	>350	300	Nov-08
700	711.00	6.00	699.00	12.00	675.00	210		Apr-90
700	711.00	6.00	699.00	12.00	675.00	>350		Nov-08
700	711.00	7.00	697.00	12.00	673.00	300		Jan-78
700	711.00	6.00	699.00	12.00	675.00	210		1989
760	800.10	6.35	787.40	12.70	762.00			Nov-75
760	803.28	7.94	787.40	12.70	762.00			Nov-75
800	813.00	7.00	799.00	16.00	767.00	>350	300	Nov-08
800	813.00	6.00	801.00	16.00	769.00			Jan-78
800	813.00	7.00	799.00	16.00	767.00	225		Jan-78
800	813.00	8.00	797.00	16.00	765.00	300		Jan-78
800	813.00	7.00	799.00	16.00	767.00	225		1989
900	914.00	7.00	900.00	16.00	868.00	337	300	Nov-08
900	914.00	7.00	900.00	16.00	868.00	160		Apr-90
900	914.00	8.00	898.00	16.00	866.00	235		Apr-90
900	914.00	7.00	900.00	16.00	868.00	337		1989
900	914.00	7.00	900.00	16.00	868.00	160		Jan-78
900	914.00	8.00	898.00	16.00	866.00	235		Jan-78
900	914.00	9.00	896.00	16.00	864.00	300		Jan-78
900	914.00	7.00	900.00	16.00	868.00	160		1989
900	914.00	8.00	898.00	16.00	866.00	235		1989
915	965.20	9.53	946.14	15.88	914.38			Nov-75
1000	1016.00	8.00	1000.00	16.00	968.00	300		Nov-08

Dimensions						MAOP	Min Yield Strength	Paper Record Date
DN	O.D.	Steel Plate Thickness	I.D. (Unlined)	Cement Mortar Lining	I.D. (Lined)			
mm	mm	mm	mm	mm	mm	m	MPa	
1000	1016.00	8.00	1000.00	16.00	968.00	180		Apr-90
1000	1016.00	9.00	998.00	16.00	966.00	250		Apr-90
1000	1016.00	10.00	996.00	16.00	964.00	305		Jan-78
1000	1016.00	8.00	1000.00	16.00	968.00	347		Undated
1000	1016.00	8.00	1000.00	16.00	968.00	180		1989
1000	1016.00	9.00	998.00	16.00	966.00	250		1989
1065	1123.95	9.53	1104.89	19.05	1066.79			Nov-78
1065	1127.12	11.11	1104.90	19.05	1066.80			Nov-78
1200	1219.00	9.00	1201.00	16.00	1169.00	271		Nov-08
1200	1220.00	9.00	1202.00	20.00	1162.00	140		Apr-90
1200	1220.00	10.00	1200.00	20.00	1160.00	210		Apr-90
1200	1219.00	9.00	1201.00	19.00	1163.00	271		Undated
1200	1220.00	11.00	1198.00	20.00	1158.00	255		Jan-78
1200	1220.00	12.00	1196.00	20.00	1156.00	300		Jan-78
1220	1279.53	11.11	1257.31	19.05	1219.21			Nov-75
1200	1220.00	9.00	1202.00	20.00	1162.00	140		1989
1200	1220.00	10.00	1200.00	20.00	1160.00	210		1989
1370	1428.75	9.53	1409.69	19.05	1371.59			Nov-75
1370	1431.92	11.11	1409.70	19.05	1371.60			Nov-75
1370	1433.50	11.91	1409.68	19.05	1371.58			Nov-75
1370	1435.10	12.70	1409.70	19.05	1371.60			Nov-75
1370	1436.69	13.50	1409.69	19.05	1371.59			Nov-75
1370	1441.45	15.88	1409.69	19.05	1371.59			Nov-75
1400	1422.00	11.00	1400.00	19.00	1362.00	284	250	Nov-08
1400	1422.00	11.00	1400.00	19.00	1362.00	340	300	Nov-08
1400	1420.00	11.00	1398.00	20.00	1358.00	170		Jan-78
1400	1420.00	12.00	1396.00	20.00	1356.00	220		Jan-78
1400	1420.00	13.00	1394.00	20.00	1354.00	260		Jan-78
1400	1420.00	14.00	1392.00	20.00	1352.00	300		Jan-78
1400	1420.00	12.00	1396.00	20.00	1356.00	220		Apr-90
1400	1422.00	11.00	1400.00	19.00	1362.00	284		Undated
1400	1420.00	11.00	1398.00	20.00	1358.00	170		1989
1400	1420.00	12.00	1396.00	20.00	1356.00	220		1989

Dimensions						MAOP	Min Yield Strength	Paper Record Date
DN	O.D.	Steel Plate Thickness	I.D. (Unlined)	Cement Mortar Lining	I.D. (Lined)			
mm	mm	mm	mm	mm	mm	m	MPa	
1400	1420.00	13.00	1394.00	20.00	1354.00	260		1989
1520	1587.50	12.70	1562.10	19.05	1524.00			Nov-75
1600	1620.00	12.00	1596.00	25.00	1546.00	135		Jan-78
1600	1620.00	13.00	1594.00	25.00	1544.00	185		Jan-78
1600	1620.00	14.00	1592.00	25.00	1542.00	225		Jan-78
1600	1620.00	15.00	1590.00	25.00	1540.00	260		Jan-78
1600	1620.00	16.00	1588.00	25.00	1538.00	295		Jan-78
1600	1620.00	12.00	1596.00	25.00	1546.00	135		1989
1600	1620.00	13.00	1594.00	25.00	1544.00	185		1989
1600	1620.00	14.00	1592.00	25.00	1542.00	225		1989
1600	1620.00	15.00	1590.00	25.00	1540.00	260		1989
1675	1701.80	12.70	1676.40	25.00	1626.40			Nov-75
1800	1872.00	16.00	1840.00	25.00	1790.00			Apr-90
1830	1905.00	19.05	1866.90	19.05	1828.80			Nov-75
1800	1872.00	16.00	1840.00	25.00	1790.00			1989
1920	2057.40	19.05	2019.30	19.05	1981.20			Nov-75
2090	2108.20	10.32	2087.56	25.00	2037.56			Nov-75

Note 1: All data and data gaps shown have been transcribed, unaltered, from known historical paper records. Duplicate entries have not been removed, as the intent is to present data paper records for posterity.
Note 2: Pipes were low density polyethylene (LDPE) coated prior to 1990 and, after this, medium density polyethylene (MDPE). PE coating thickness ranged from 1.6 mm for DN ≤ 250 to 3 mm for DN ≥ 900.
Note 3: Cement mortar lining thickness tolerances can, typically, range from ± 3 mm for DN < 300 to ± 4 mm for DN ≥ 300.

Assumptions

Density of steel 7850 kg.m^3

Density of concrete 2400kg/m^3

Mass of Coating 925 kg/m^3

Standards

AS1579 - Arc Welding Steel Pipes

AS1281 - Cement Mortar Lining of Steel Pipes

AS 4321 - Fusion Bonded medium Density PE Coating

Pipe lengths

Standard length of all pipes = 12.3m (12m nominal) or 9m nominal

Table D2 Steel Pipes - Dimensions & Weight (Vintage pre-1975)

External Diameter		Plate Thickness		Internal Diameter (Unlined)		Cement Mortar Lining Thickness		Internal Diameter (Lined)	
inches	mm	**inches**	mm	**inches**	mm	**inches**	mm	**inches**	mm
3 1/2	88.90	1/8	3.18	3 1/4	82.55	3/8	9.53	2 1/2	63.50
3 1/2	88.90	3/16	4.76	3 1/8	79.38	3/8	9.53	2 3/8	60.33
4 1/2	114.30	1/8	3.18	4 1/4	107.95	3/8	9.53	3 1/2	88.90
4 1/2	114.30	3/16	4.76	4 1/8	104.78	3/8	9.53	3 3/8	85.73
4 1/2	114.30	1/4	6.35	4	101.60	3/8	9.53	3 1/4	82.55
4 3/4	120.65	1/8	3.18	4 1/2	114.30	3/8	9.53	3 3/4	95.25
4 3/4	120.65	3/16	4.76	4 3/8	111.13	3/8	9.53	3 5/8	92.08
5 7/8	149.23	3/16	4.76	5 1/2	139.70	3/8	9.53	4 3/4	120.65
6 1/2	165.10	1/8	3.18	6 1/4	158.75	3/8	9.53	5 1/2	139.70
6 1/2	165.10	3/16	4.76	6 1/8	155.58	3/8	9.53	5 3/8	136.53
6 1/2	165.10	1/4	6.35	6	152.40	3/8	9.53	5 1/4	133.35
7	177.80	3/16	4.76	6 5/8	168.28	3/8	9.53	5 7/8	149.23
7	177.80	3/16	4.76	6 5/8	168.28	3/8	9.53	5 7/8	149.23
7	177.80	1/8	3.18	6 3/4	171.45	3/8	9.53	6	152.40
7	177.80	3/16	4.76	6 5/8	168.28	3/8	9.53	5 7/8	149.23
7	177.80	1/4	6.35	6 1/2	165.10	3/8	9.53	5 3/4	146.05
7 1/2	190.50	1/8	3.18	7 1/4	184.15	3/8	9.53	6 1/2	165.10
7 1/2	190.50	3/16	4.76	7 1/8	180.98	3/8	9.53	6 3/8	161.93
7 1/2	190.50	1/4	6.35	7	177.80	3/8	9.53	6 1/4	158.75
8 5/8	219.08	1/4	6.35	8 1/8	206.38	3/8	9.53	7 3/8	187.33
8 5/8	219.08	5/16	7.94	8	203.20	3/8	9.53	7 1/4	184.15
9	228.60	1/8	3.18	8 3/4	222.25	3/8	9.53	8	203.20
9	228.60	3/16	4.76	8 5/8	219.08	3/8	9.53	7 7/8	200.03
9 1/8	231.78	3/16	4.76	8 3/4	222.25	3/8	9.53	8	203.20
9 1/8	231.78	1/4	6.35	8 5/8	219.08	3/8	9.53	7 7/8	200.03
9 1/4	234.95	3/16	4.76	8 7/8	225.43	3/8	9.53	8 1/8	206.38
10	254.00	1/8	3.18	9 3/4	247.65	3/8	9.53	9	228.60
10	254.00	3/16	4.76	9 5/8	244.48	3/8	9.53	8 7/8	225.43
11 1/2	292.10	3/16	4.76	11 1/8	282.58	3/8	9.53	10 3/8	263.53
11	279.40	1/8	3.18	10 3/4	273.05	3/8	9.53	10	254.00
11	279.40	3/16	4.76	10 5/8	269.88	3/8	9.53	9 7/8	250.83
11	279.40	1/4	6.35	10 1/2	266.70	3/8	9.53	9 3/4	247.65

External Diameter		Plate Thickness		Internal Diameter (Unlined)		Cement Mortar Lining Thickness		Internal Diameter (Lined)	
inches	mm	**inches**	mm	**inches**	mm	**inches**	mm	**inches**	mm
11 1/8	282.58	3/16	4.76	10 3/4	273.05	3/8	9.53	10	254.00
11 1/8	282.58	1/4	6.35	10 5/8	269.88	3/8	9.53	9 7/8	250.83
11 1/2	292.10	3/16	4.76	11 1/8	282.58	3/8	9.53	10 3/8	263.53
11 1/2	292.10	1/4	6.35	11	279.40	3/8	9.53	10 1/4	260.35
12 1/4	311.15	1/8	3.18	12	304.80	3/8	9.53	11 1/4	285.75
12 3/8	314.33	3/16	4.76	12	304.80	3/8	9.53	11 1/4	285.75
12 1/2	317.50	3/16	4.76	12 1/8	307.98	3/8	9.53	11 3/8	288.93
12 1/2	317.50	1/4	6.35	12	304.80	3/8	9.53	11 1/4	285.75
12 3/4	323.85	3/8	9.53	12	304.80	3/8	9.53	11 1/4	285.75
13 1/4	336.55	1/8	3.18	13	330.20	3/8	9.53	12 1/4	311.15
13 1/4	336.55	3/16	4.76	12 7/8	327.03	3/8	9.53	12 1/8	307.98
13 1/4	336.55	1/4	6.35	12 3/4	323.85	3/8	9.53	12	304.80
13 3/4	349.25	1/4	6.35	13 1/4	336.55	3/8	9.53	12 1/2	317.50
13 3/4	349.25	3/16	4.76	13 3/8	339.73	3/8	9.53	12 5/8	320.68
15 3/8	390.53	3/16	4.76	15	381.00	1/2	12.70	14	355.60
15 3/8	390.53	1/4	6.35	14 7/8	377.83	1/2	12.70	13 7/8	352.43
16 3/4	425.45	1/4	6.35	16 1/4	412.75	1/2	12.70	15 1/4	387.35
16 3/4	425.45	3/16	4.76	16 3/8	415.93	1/2	12.70	15 3/8	390.53
17 3/8	441.33	3/16	4.76	17	431.80	1/2	12.70	16	406.40
18 3/16	461.96	1/2	12.70	17 3/16	436.56	1/2	12.70	16 3/16	411.16
19 1/4	488.95	3/16	4.76	18 7/8	479.43	1/2	12.70	17 7/8	454.03
19 1/2	495.30	3/16	4.76	19 1/8	485.78	1/2	12.70	18 1/8	460.38
19 1/2	495.30	1/4	6.35	19	482.60	1/2	12.70	18	457.20
19 5/8	498.48	1/4	6.35	19 1/8	485.78	1/2	12.70	18 1/8	460.38
20 1/2	520.70	1/4	6.35	20	508.00	1/2	12.70	19	482.60
21 3/8	542.93	3/16	4.76	21	533.40	1/2	12.70	20	508.00
21 1/2	546.10	1/4	6.35	21	533.40	1/2	12.70	20	508.00
22 3/8	568.33	3/16	4.76	22	558.80	1/2	12.70	21	533.40
22 1/2	571.50	1/4	6.35	22	558.80	1/2	12.70	21	533.40
22 3/4	577.85	1/4	6.35	22 1/4	565.15	1/2	12.70	21 1/4	539.75
22 3/4	577.85	3/8	9.53	22	558.80	1/2	12.70	21	533.40
24 1/2	622.30	1/4	6.35	24	609.60	1/2	12.70	23	584.20
25 3/8	644.53	3/16	4.76	25	635.00	1/2	12.70	24	609.60
25 1/2	647.70	1/4	6.35	25	635.00	1/2	12.70	24	609.60
28 1/2	723.90	1/4	6.35	28	711.20	1/2	12.70	27	685.80
30 1/2	774.70	1/4	6.35	30	762.00	1/2	12.70	29	736.60
30 3/4	781.05	5/16	7.94	30 1/8	765.18	1/2	12.70	29 1/8	739.78
30	762.00	3/8	9.53	29 1/4	742.95	1/2	12.70	28 1/4	717.55
31 1/2	800.10	1/4	6.35	31	787.40	1/2	12.70	30	762.00
31 5/8	803.28	1/4	6.35	31 1/8	790.58	1/2	12.70	30 1/8	765.18
31 5/8	803.28	5/16	7.94	31	787.40	1/2	12.70	30	762.00
31 3/4	806.45	5/16	7.94	31 1/8	790.58	1/2	12.70	30 1/8	765.18

External Diameter		Plate Thickness		Internal Diameter (Unlined)		Cement Mortar Lining Thickness		Internal Diameter (Lined)	
inches	mm	**inches**	mm	**inches**	mm	**inches**	mm	**inches**	mm
31 3/4	806.45	3/8	9.53	31	787.40	1/2	12.70	30	762.00
34 7/8	885.83	5/16	7.94	34 1/4	869.95	5/8	15.88	33	838.20
34 5/8	879.48	5/16	7.94	34	863.60	5/8	15.88	32 3/4	831.85
34 7/8	885.83	9/16	14.11	33 3/4	857.60	5/8	15.88	32 1/2	825.85
36 1/2	927.10	1/4	6.35	36	914.40	5/8	15.88	34 3/4	882.65
36 5/8	930.28	5/16	7.94	36	914.40	5/8	15.88	34 3/4	882.65
36 3/4	933.45	3/8	9.53	36	914.40	5/8	15.88	34 3/4	882.65
37 3/4	958.85	3/16	4.76	37 3/8	949.33	5/8	15.88	36 1/8	917.58
37 3/4	958.85	3/8	9.53	37	939.80	5/8	15.88	35 3/4	908.05
37 1/4	946.15	5/16	7.94	36 5/8	930.28	5/8	15.88	35 3/8	898.53
37 3/4	958.85	1/4	6.35	37 1/4	946.15	5/8	15.88	36	914.40
37 3/4	958.85	3/8	9.53	37	939.80	5/8	15.88	35 3/4	908.05
37 7/8	962.03	5/16	7.94	37 1/4	946.15	5/8	15.88	36	914.40
38	965.20	3/8	9.53	37 1/4	946.15	5/8	15.88	36	914.40
38	965.20	3/8	9.53	37 1/4	946.15	5/8	15.88	36	914.40
38 1/8	968.38	7/16	11.11	37 1/4	946.15	5/8	15.88	36	914.40
38 1/4	971.55	1/2	12.70	37 1/4	946.15	5/8	15.88	36	914.40
38 3/8	974.73	9/16	14.29	37 1/4	946.15	5/8	15.88	36	914.40
40 3/4	1035.05	3/8	9.53	40	1016.00	5/8	15.88	38 3/4	984.25
40	1016.00	3/8	9.53	39 1/4	996.95	5/8	15.88	38	965.20
41	1041.40	3/8	9.53	40 1/4	1022.35	5/8	15.88	39	990.60
42	1066.80	1/4	6.35	41 1/2	1054.10	5/8	15.88	40 1/4	1022.35
42	1066.80	5/16	7.94	41 3/8	1050.93	5/8	15.88	40 1/8	1019.18
42	1066.80	5/8	15.88	40 3/4	1035.05	5/8	15.88	39 1/2	1003.30
42 1/2	1079.50	1/4	6.35	42	1066.80	3/4	19.05	40 1/2	1028.70
42 5/8	1082.68	5/16	7.94	42	1066.80	3/4	19.05	40 1/2	1028.70
42 3/4	1085.85	3/8	9.53	42	1066.80	3/4	19.05	40 1/2	1028.70
44 1/8	1120.78	5/16	7.94	43 1/2	1104.90	3/4	19.05	42	1066.80
44 1/4	1123.95	3/8	9.53	43 1/2	1104.90	3/4	19.05	42	1066.80
46	1168.40	3/8	9.53	45 1/4	1149.35	3/4	19.05	43 3/4	1111.25
50 1/4	1276.35	3/8	9.53	49 1/2	1257.30	3/4	19.05	48	1219.20
50 3/8	1279.53	7/16	11.11	49 1/2	1257.30	3/4	19.05	48	1219.20
53 1/4	1352.55	3/8	9.53	52 1/2	1333.50	3/4	19.05	51	1295.40
56 1/4	1428.75	3/8	9.53	55 1/2	1409.70	3/4	19.05	54	1371.60
56 3/8	1431.93	7/16	11.11	55 1/2	1409.70	3/4	19.05	54	1371.60
56 1/2	1435.10	1/2	12.70	55 1/2	1409.70	3/4	19.05	54	1371.60
56 3/4	1441.45	5/8	15.88	55 1/2	1409.70	3/4	19.05	54	1371.60

Values in mm are unrounded direct conversions of nominal imperial dimensions. All data have been transcribed from known historical paper records unchanged. Duplicate entries have been removed for user clarity. Flat “**suitable** (steel) plate size” entries in the original paper records have been omitted from this summary table for simplicity but have been retained/saved in Nexus spreadsheet file records, for reference. Irrespective of the historic information herein, legacy steel pipe sizes, dimensions and lining condition should be verified by site checks before committing to any particular structural or hydraulic performance outcomes.

APPENDIX E

Table E1 Reinforced Concrete Pressure Pipe - Dimensions - MWSS & DD

Nominal Diameter **(Inches)**	Test Pressure **PSI**	Internal Diameter (Inches)	External Diameter **OD** **(Inches/mm)**		Effective Length **(Feet)**	total length **(Feet - Inches)**	Weight **(lbs)**
			in	**mm**			
4	50, 75, 100, 115, 120, 135, 180	4	6 1/4	158.75	6	6 - 2 ½”	138
6	50, 75, 100, 115, 120, 135	6	8 1/4	209.55	6	6 - 2 ½”	190
6	180	5 1/2	8 1/4	209.55	6	6- 2 ½”	
8	50, 75, 100, 115, 120, 135	8 3/4	11 1/2	292.10	6	6 - 2 ¾”	
	180	8 1/2	12 1/4	311.15	6	6-3 ¼”	
10	50, 75	10	12 1/2	317.50	6	6-2 ¾”	328
	100	10	13 1/4	336.55	6	6-3"	446
12	50, 75	12	15	381.00	6	0-3”	475
	100, 115	11 1/2	15	381.00	6	6-3"	
	120	11 1/2	15	381.00	8	8-3"	
	135	11	15	381.00	8	8-3"	
15	50	15	17 1/2	444.50	8	8-2 ¾”	611
	120	15	19 1/2	495.30	8	8-3"	1188
18	50, 75	18	23 1/2	596.90	8	8- 3 ½”	1780
	115, 120	17 1/2	23 1/2	596.90	8	8 - 3 ½”	
21	50, 75	20 3/4	25	635.00	8	8-3 ½”	
	100, 115	20	25	635.00	8	8-3 ½”	1685
24	50	24	28 1/2	723.90	8	8 - 3 ½”	1812
	80	23 3/4	28 1/2	723.90	8	8-3 ½”	2058
	100	23 3/4	30	762.00	8	8- 4 ¼”	2716
	115, 120	23 1/2	30	762.00	8	8-4 ¼”	
30	50	30	34	863.60	8	8-3 ⁷/₈”	
	75	28 7/8	34	863.60	8	8-3 ⁷/₈”	2465
	100	29	36	914.40	8	8-3 ⁷/₈”	3410

Equivalent metric values are direct conversions of nominal imperial values.

Table E2 RC Pressure Pipe Dimensions - Humes Ltd

Equivalent Metric Dimensions					Imperial Dimensions			
External Diameter	Internal Diameter	Wall Thickness	Test Pressure	Effective Length	Internal Diameter	Wall Thickness	Test Pressure	Effective Length
mm	**mm**	**mm**	**KPa**	**m**	**Inches**	**Inches**	**PSI**	**Feet**
160	102	29	930	1.83	4	1 1/8	135	6
160	102	29	1241	1.83	4	1 1/8	180	6
210	152	29	930	1.83	6	1 1/8	135	6
210	140	35	1241	1.83	5 1/2	1 3/8	180	6
292	222	35	930	1.83	8 3/4	1 3/8	135	6
312	216	48	1241	1.83	8 1/2	1 7/8	180	6
381	305	38	345	2.44	12	1 1/2	50	8
380	292	44	827	2.44	11 1/2	1 3/4	120	8
381	279	51	930	2.44	11	2	135	8
597	495	51	517	2.44	19 1/2	2	75	8
596	444	76	827	2.44	17 1/2	3	120	8
635	527	54	345	2.44	20 3/4	2 1/8	50	8
636	508	64	689	2.44	20	2 1/2	100	8
724	610	57	345	2.44	24	2 1/4	50	8
725	597	64	517	2.44	23 1/2	2 1/2	75	8
761	603	79	689	2.44	23 3/4	3 1/8	100	8
763	597	83	827	2.44	23 1/2	3 1/4	120	8
864	762	51	345	2.44	30	2	50	8
914	762	76	517	2.44	30	3	75	8
915	737	89	689	2.44	29	3 1/2	100	8
915	711	102	827	2.44	28	4	120	8
1092	914	89	517	2.44	36	3 1/2	75	8

Equivalent metric values are direct conversions of nominal imperial values.

Table E3 RC Non-pressure Pipe Load Class Strength Values

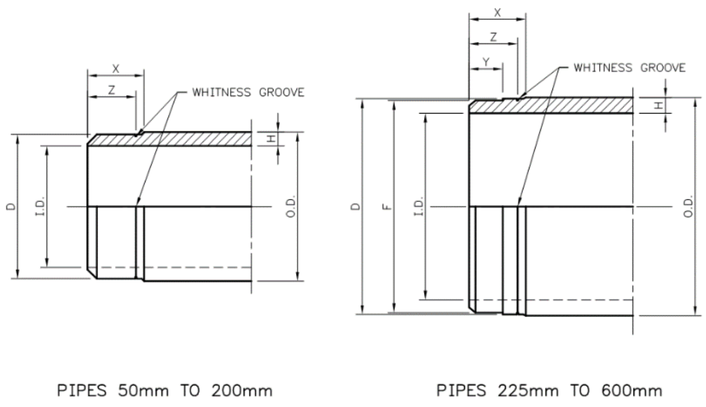
Manufacturer Designated Pipe Strength Description	Australian and Local RC Pipe Standard (Note 2) Load Classification					
	AS/NZS 4058:2007	AS 4058-1992	AS 1342-1973	AS A35-1957	MWB **Drainage** Pipes pre-1934 (Note 3)	MWB **Sewerage** Pipes pre-1934 (Note 4)
Unreinforced (Note 5)	LDU (Note 1)	LDU	C	C		
Standard	N/A	N/A	S (Note 8)	S (Note 8)	A	C
Note 6 (pre 1934 only)	N/A	N/A	N/A	N/A	B	D
Extra Strength (Note 5)	2	2	X	X		
Note 7 (pre-1934 only)	N/A	N/A	N/A	N/A	S	E
Special Strength (Note 5)	3	3	Y	Y	T	F
Special Strength (Note 5)	4	4	Z	Z	U	G
Note 5	6	6	N/A	N/A		
Note 5	8	8	N/A	N/A		
Note 5	10	10	N/A	N/A		

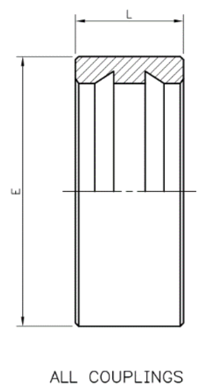
NOTES FOR TABLE E3

1 LDU means "Light Duty Unreinforced". RC pipes used in **new** Corporation infrastructure applications should be **reinforced**;
2 The first Australian Standard for RC pipes was published in 1957. RC pipe load classifications prior to 1957 were as defined by the pipe manufacturer and are presumed to have also informally applied to pipes supplied between 1934 and 1957.
3 Load classifications for RC drainage pipes supplied to the Perth Metropolitan Water Board (MWB) prior to 1934 were designated by the pipe manufacturer as shown. The load classifications for some did not directly align with later (post-1934 and AS A35-1957) defined load classifications – see Notes 6/7.
4 Load classifications for RC sewerage pipes supplied to the Perth Metropolitan Water Board (MWB) prior to 1934 were designated by the pipe manufacturer as shown so as to directly align with (MWB) drainage pipe load classifications – see Note 3 – but were also pressure tested to assure pipeline joint leak integrity up to 90 kPa or 30 feet of internal pressure head.
5 The kN/m strength values for pipe load classifications LDU and 2 to 10 are as defined in AS 4058-1992 and AS/NZS 4058:2007.
6 According to a key WA based RC pipe manufacturer, pre 1934 load classes B and D were closer to (post 1957) class S than class X values – assume post 1957 class S equivalence for strength design check purposes.
7 According to a key WA based RC pipe manufacturer, pre 1934 load classes S and E were closer to (post 1957) class X than class Y values – assume class X equivalence for strength design check purposes.
8 Post 1957 load class S is unrelated to and lower in structural strength than pre 1934 (drainage pipe) load class S.

APPENDIX F

Table F1 Standard Asbestos Cement Pipes 1959 to 1981





Nominal Diameter of Pipe (mm)	Class	AS 1711 - 1975 Factory Test Head (mm)[3]	Nominal Working Head (m)	Pipe Dimensions							Coupling Dimensions		Mass	
				Overall Dimensions		Machining Dimensions								
				Internal Diameter ID (mm)	Wall Thickness H (mm)	D ± 0.8 (mm)	X min (mm)	F ± 0.8 (mm)	Y ± 1 (mm)	Z ± 2 (mm)	External Diameter E (mm)	Length L (mm)	Pipe Complete (kg)	Coupling Complete (kg)
58[1]	F	Note 2	183.00	57.40	10.10	77.60	68.00	-	-	62.00	125.00	130.00	20.50	2.00
80	B	122.00	61.00	76.80	9.40	95.60	68.00	-	-	62.00	139.00	130.00	24.00	2.00
80	D	245.00	122.00	75.20	10.20	95.60	68.00	-	-	62.00	143.00	130.00	26.00	2.50
80	F	367.00	183.00	69.60	13.00	95.60	68.00	-	-	62.00	151.00	130.00	32.00	3.00
100	Irrigation	Note 2	45.00	100.50	10.70	121.90	81.00	-	-	75.00	170.00	156.00	36.00	3.50
100	B	122.00	61.00	100.50	10.70	121.90	81.00	-	-	75.00	170.00	156.00	36.00	3.50
100	D	245.00	122.00	96.50	12.70	121.90	81.00	-	-	75.00	178.00	156.00	42.00	4.00
100	F	367.00	183.00	88.90	16.50	121.90	81.00	-	-	75.00	194.00	156.00	53.00	5.50
150	Irrigation	Note 2	45.00	154.50	11.40	177.30	83.00	-	-	78.00	227.00	172.00	57.00	5.50
150	B	122.00	61.00	154.50	11.40	177.30	83.00	-	-	78.00	227.00	172.00	57.00	5.50
150	C	184.00	92.00	146.30	15.50	177.30	83.00	-	-	78.00	238.00	172.00	75.00	7.00
150	D	245.00	122.00	141.70	17.80	177.30	83.00	-	-	78.00	246.00	172.00	85.00	8.00
150	E	306.00	153.00	139.10	19.10	177.30	83.00	-	-	78.00	251.00	172.00	91.00	8.50
150	F	367.00	183.00	133.50	21.90	177.30	83.00	-	-	78.00	262.00	172.00	103.00	10.00
200	Irrigation	Note 2	25.00	208.20	12.00	232.20	83.00	-	-	78.00	281.00	172.00	79.00	7.00
200	A[4]	61.00	30.00	208.20	12.00	232.20	83.00	-	-	78.00	281.00	172.00	79.00	7.00
200	B	122.00	61.00	203.20	14.50	232.20	83.00	-	-	78.00	287.00	172.00	94.00	8.00
200	C	184.00	92.00	195.60	18.30	232.20	83.00	-	-	78.00	299.00	172.00	116.50	10.00
200	D	245.00	122.00	186.40	22.90	232.20	83.00	-	-	78.00	315.00	172.00	143.00	12.50
225	Irrigation	Note 2	25.00	233.70	12.70	259.10	91.00	257.10	54.00	78.00	307.00	172.00	93.00	8.00
225	A[4]	61.00	30.00	233.70	12.70	259.10	91.00	257.10	54.00	78.00	307.00	172.00	93.00	8.00
225	B	122.00	61.00	228.50	15.30	259.10	91.00	257.10	54.00	78.00	314.00	172.00	110.00	9.50
225	C	184.00	92.00	218.90	20.10	259.10	91.00	257.10	54.00	78.00	329.00	172.00	142.50	12.00
225	D	245.00	122.00	209.30	24.90	259.10	91.00	257.10	54.00	78.00	346.00	172.00	173.50	15.00
250	Irrigation	Note 2	25.00	259.60	13.20	286.00	91.00	284.00	54.00	78.00	335.00	172.00	107.00	9.00
250	A[4]	61.00	30.00	259.60	13.20	286.00	91.00	284.00	54.00	78.00	335.00	172.00	107.00	9.00
250	B	122.00	61.00	253.40	16.30	286.00	91.00	284.00	54.00	78.00	344.00	172.00	130.50	11.00
250	C	184.00	92.00	243.40	21.30	286.00	91.00	284.00	54.00	78.00	359.00	172.00	167.00	13.50
250	D	245.00	122.00	231.00	27.50	286.00	91.00	284.00	54.00	78.00	380.00	172.00	211.00	18.00
300	Irrigation	Note 2	25.00	304.80	14.50	333.80	91.00	331.80	54.00	78.00	385.00	172.00	137.00	11.00
300	A[4]	61.00	30.00	304.80	14.50	333.80	91.00	331.80	54.00	78.00	385.00	172.00	137.00	11.00
300	B	122.00	61.00	299.20	17.30	333.80	91.00	331.80	54.00	78.00	393.00	172.00	161.50	12.50
300	C	184.00	92.00	294.60	25.40	345.40	91.00	343.40	54.00	78.00	429.00	172.00	239.50	18.50
300	D	245.00	122.00	279.40	33.00	345.40	91.00	343.40	54.00	78.00	454.00	172.00	305.00	24.50
375	Irrigation	Note 2	25.00	381.00	16.00	413.00	107.00	410.00	67.00	91.00	468.00	208.00	190.50	17.50
375	A[4]	61.00	30.00	381.00	16.00	413.00	107.00	410.00	67.00	91.00	468.00	208.00	190.50	17.50
375	B	122.00	61.00	370.40	21.30	413.00	107.00	410.00	67.00	91.00	482.00	208.00	249.00	22.00
375	C	184.00	92.00	363.20	31.50	426.20	107.00	423.20	67.00	91.00	526.00	208.00	371.50	33.00
450	Irrigation	Note 2	25.00	457.20	17.50	492.20	107.00	489.20	67.00	91.00	557.00	208.00	250.50	24.50
450	A[4]	61.00	30.00	457.20	17.50	492.20	107.00	489.20	67.00	91.00	557.00	208.00	250.50	24.50
450	B	122.00	61.00	444.00	24.10	492.20	107.00	489.20	67.00	91.00	568.00	2008.00	335.50	28.50
450	C	184.00	92.00	432.40	37.30	507.00	107.00	504.00	67.00	91.00	621.00	208.00	521.00	44.50
525	Irrigation	Note 2	25.00	533.30	19.10	571.50	107.00	568.50	67.00	91.00	633.00	208.00	314.00	26.50
525	A[4]	61.00	30.00	533.30	19.10	571.50	107.00	568.50	67.00	91.00	633.00	208.00	314.00	26.50
525	B	122.00	61.00	515.70	27.90	571.50	107.00	568.50	67.00	91.00	657.00	208.00	449.50	37.00
525	C	184.00	92.00	506.00	40.60	587.20	107.00	584.20	67.00	91.00	709.00	208.00	660.50	56.50
600	Irrigation	Note 2	25.00	609.60	20.30	650.20	107.00	647.20	67.00	91.00	714.00	208.00	379.50	31.50
600	A[4]	61.00	30.00	609.60	20.30	650.20	107.00	647.20	67.00	91.00	714.00	208.00	379.50	31.50
600	B	122.00	61.00	586.80	31.70	650.20	107.00	647.20	67.00	91.00	745.00	208.00	579.50	46.00
600	C	184.00	92.00	575.60	45.70	667.00	107.00	664.00	67.00	91.00	821.00	208.00	851.00	78.00

Extract from Hardies textbook of Pipeline Design 1981 “Hardies Fibrolite Asbestos Cement Pressure Pipe”

Note 1 WA only. Irrigation Class pipes not available in QLD and WA;
Note 2 Not contained in AS1711 - 1975
Note 3 Pressure Pipes up to 600 mm are tested to 50% above these requirements.
Note 4 Not a stock item in Queensland
Note 5 **Standard** pipe manufactured to AS 1711, has a minimum ultimate circumferential tensile strength of 23.5 MPa. Refer Table E2 for **Special** - Codes 28/31 - tensile strengths (28/31MPa).

Table F2 Maximum Working Pressures for Special Asbestos Cement Pipe

DN	Pressure Class	A	B	C	D	E	F	C Code 28	C Code 31	D Code 28	D Code 31	BP/WP ≥	TP/WP ≥
	Ultimate Circumferential Tensile Strength	23.5 MPa						28 MPa	31 MPa	28MPa	31 MPa		
	AS 1711 Minimum Working Pressure MPa	0.30	0.60	0.90	1.20	1.50	1.80	Special Class – not defined in AS 1711					
	James Hardie Proof Test Pressure **TP**	0.90	1.80	2.70	3.60	4.50	5.40	Working Pressure - 75% of BP					
	(AS 1711 Table 1 test pressure plus 50%)												
80	**Maximum Working Pressures for James Hardie AC Pipes (MPa)**	**-**	**0.90**	**-**	**1.40**	**-**	**1.85**					4.00	2.00
100		**-**	**0.90**	**-**	**1.37**	**-**	**1.84**					4.00	2.00
150		**-**	**0.90**	**1.29**	**1.50**	**1.62**	**1.90**					3.50	2.00
200		**0.45**	**0.90**	**1.15**	**1.47**	**-**	**-**	**1.37**	**1.52**	**1.75**	**1.94**	3.50	2.00
225		**0.45**	**0.90**	**1.32**	**1.67**	**-**	**-**	**1.57**	**1.74**	**1.98**	**2.20**	3.00	2.00
250		**0.45**	**0.90**	**1.26**	**1.67**	**-**	**-**	**1.50**	**1.66**	**1.99**	**2.20**	3.00	2.00
300		**0.45**	**0.86**	**1.24**	**1.65**	**-**	**-**	**1.48**	**1.64**	**1.97**	**2.18**	3.00	2.00
375		**0.45**	**0.85**	**1.25**	**-**	**-**	**-**	**1.49**	**1.65**	**-**	**-**	3.00	2.00
450		**0.45**	**0.81**	**1.24**	**-**	**-**	**-**	**1.48**	**1.64**	**-**	**-**	3.00	2.00
525		**0.45**	**0.80**	**1.16**	**-**	**-**	**-**	**1.39**	**1.53**	**-**	**-**	3.00	2.00
600		**0.45**	**0.80**		**-**	**-**	**-**			**-**	**-**	3.00	2.00
600				**1.38**	**-**	**-**	**-**	**1.54**	**1.71**	**-**	**-**	2.50	2.00

NOMENCLATURE

Ø	=	Nominal Diameter in millimetres
WP	=	Normal Working (Operating) Pressure
TP	=	James Hardie & Coy Pty Ltd - **PROOF TEST PRESSURE** (Applied to all pipe prior to despatch)
BP	=	Minimum Hydrostatic Burst Pressure (Refer 14.1 and Appendix B of AS 1711-1975)
Code 28	=	Pipes manufactured to minimum ultimate circumferential tensile strength of **28 MPa**
Code 31	=	Pipes manufactured to minimum ultimate circumferential tensile strength of **31 MPa**

NOTES

1 All heads are given in Megapascals (MPa) rounded off to the nearest metre head of water.

2 **Standard pipe** manufactured to AS 1711, has a minimum ultimate circumferential tensile strength of **23.5 MPa**

Published by James Hardie & Coy.Pty Limited Welshpool W.A (Blue text added by Killian Roddy for clarity)

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