



Asset Planning and Delivery Group
Engineering

WELDING AND JOINING SPECIFICATIONS

WS-2 THERMOPLASTICS

VERSION 2
REVISION 1

JUNE 2021

FOREWORD

This Specification has been prepared to inform Corporation staff, designers and service providers of the requirements of the Corporation's standard for thermoplastic welding, welding and joining workmanship and quality assurance related to welded assemblies. These requirements are based on Industry best practice as well as extensive design and field experience gained over time by the Corporation, as an asset owner of a wide range of assets constructed from a wide range of materials.

The Specification is intended for reference and use in the following typical procurement scenarios:

- Capital funded infrastructure asset design and construction work;
- Operationally funded asset procurement, design and construction work;
- Private developer funded subdivision services to be taken over by the Corporation;
- Procurement of welded products and services for period contracts and minor projects.

The text of this Specification should not be modified for project applications. Where a text variation is considered necessary to accommodate particular project needs and where authorised at an appropriate Corporation process level, the project specific modification should be documented only in the project specification.

Proposals for incremental improvement of or deviation from, the technical welding requirements of this Specification should be directed to the Senior Principal Engineer - Mechanical, Engineering – Field Services and shall be subject to consultation with the appropriate Corporation process stakeholders who may be impacted by the proposals.

The aim of this specification is to stipulate the requirements for conventional processes i.e. butt fusion, electro fusion, hot air and extrusion welding used for the joining in the broader sense, of Polyethylene, Polypropylene, PVC and ABS materials. Where alternative materials and processes are considered a full appraisal of the same will need to be conducted and approved by the Corporation.

Head of Engineering

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

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DISCLAIMER

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

This Standard is provided for use only by a suitably qualified professional design engineer who shall apply the skill, knowledge and experience necessary to understand the risks involved and undertake all infrastructure design and installation specification preparation work.

Any interpretation in this Standard that deviates from the requirements specified in the project design drawings and construction specifications shall be resolved by reference to and determination by the design engineer.

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

REVISION STATUS

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

REVISION STATUS						
SECT.	VER./REV	DATE	PAGES REVISED	REVISION DESCRIPTION (Section, Clause, Sub-Clause)	RWV	APRV
1	1/0 (A)	15/03/13	All	New Version	KR	BG
	2/0	28/01/20	All	New Version	GB	DV
2	1/0 (A)	15/03/13	All	New Version	KR	BG
	2/0	28/01/20	All	New Version	GB	DV
	2/1	14/06/21	11	Minor update, Reference document 'WC-OSH 135 Working in a Flammable Gas Area' title changed to 'Flammable Gas Areas (FGA) procedure'.	IB	DV
3	1/0 (A)	15/03/13	All	New Version	KR	BG
	2/0	28/01/20	All	New Version	GB	DV
4	1/0 (A)	15/03/13	All	New Version	KR	BG
	2/0	28/01/20	All	New Version	GB	DV
5	1/0 (A)	15/03/13	All	New Version	KR	BG
	2/0	28/01/20	All	New Version	GB	DV
6	1/0 (A)	15/03/13	All	New Version	KR	BG
	2/0	28/01/20	All	New Version	GB	DV
7	1/0 (A)	15/03/13	All	New Version	KR	BG
	2/0	28/01/20	All	New Version	GB	DV
8	1/0 (A)	15/03/13	All	New Version	KR	BG
	2/0	28/01/20	All	New Version	GB	DV
9	1/0 (A)	15/03/13	All	New Version	KR	BG
	2/0	28/01/20	All	New Version	GB	DV
10	1/0 (A)	15/03/13	All	New Version	KR	BG
	1/5	01/05/17	30	10.1.8: Fast fusion machines not permissible.	GB	DV
	1/5	01/05/17	31	Added Sec 10.1.8.1: BFJ Cooling Cycle	GB	DV

REVISION STATUS						
SECT.	VER./REV	DATE	PAGES REVISED	REVISION DESCRIPTION (Section, Clause, Sub-Clause)	RVW	APRV
	2/0	28/01/20	All	New Version	GB	DV
11	1/0 (A)	15/03/13	All	New Version	KR	BG
	1/1 (B)	05/12/13		Sec 11.2.1: Hydrostatic – Pipeline Testing Requirements Sec 11.7.1.4: Air Pressure Testing – Pressure Stabilisation Time Amended from 5 min. to 2min.	KR/ED	BG
	1/2 (C)	05/05/14		Sec 11.4.1: Hydrostatic Pressure Test – Verification of Inconclusive Results from Pressure Rebound Method by using Pressure Water Loss method	KR	BG
	1/4 (D)	20/12/15		Sec 11.4.1: Hydrostatic pressure testing limited to single nationally accepted test method in accordance with AS/NZS 2033		
	2/0	28/01/20	All	New Version	GB	DV
12	1/0 (A)	15/03/13	All	New Version	KR	BG
	2/0	28/01/20	All	New Version	GB	DV
13	1/0 (A)	15/03/13	All	New Version	KR	BG
	2/0	28/01/20	All	New Version	GB	DV
App A	1/0 (A)	15/03/13	All	New Version	KR	BG
App B	1/0 (A)	15/03/13	All	New Version	KR	BG
	1/1 (B)	05/12/13		Dual Pressure – Low fusion – Minor changes to align with POP003	ED	BG
	2/0	28/01/20	All	New parameter templates – BFJ and EFJ	JP	DV
App C	1/0 (A)	15/03/13	All	New Version	KR	BG

**WELDING AND JOINING SPECIFICATION
WS-2 THERMOPLASTICS**

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1 Scope

This technical specification sets out the requirements for the fabrication and welding of thermoplastics materials that are or are intended to be Corporation assets.

This specification is limited to:

- Polyethylene, including pressure pipe and flexible liner materials;
- PVC including unplasticised PVC pressure and non-pressure pipe and plasticised PVC liner materials;
- Polypropylene including pressure pipe and flexible liner materials; and
- ABS pressure and non-pressure pipe.

This specification sets out requirements for the conventional methods of welding and joining thermoplastics materials using butt fusion, electro-fusion, hot wedge, hot air extrusion welding and solvent welding jointing processes.

Alternative processes other than those stated shall not be used unless authorized by the Corporation.

The construction standards nominated in project specific drawings and specifications shall apply in assessing compliance with workmanship quality requirements.

2 References

The following standards, specifications and other documents are referenced in or related to this technical specification:

AS1674.1	Safety in welding and allied processes - Fire precautions;
AS 1674.2	Safety in welding and allied processes – Electrical;
AS 3894.1	Site testing of protective coatings - Non-conductive coatings - Continuity testing - High voltage ('brush') method;
AS/NZS 1254	PVC-U pipes and fittings for stormwater and surface water applications;
AS /NZS 1260	PVC-U pipes and fittings for drain, waste and vent applications (this standard applies to PVC sewer pipes);
AS 1462.1	Methods of test for plastics pipes and fittings Method 1: Method for determining the dimensions of pipes and fittings
AS/ NZS 1477	PVC Pipes and fittings for pressure applications;
AS /NZS 2032	Installation of PVC pipe systems;
AS /NZS 2033	Installation of polyethylene pipe systems;
AS /NZS 2566.2	Buried Flexible Pipeline - Installation;
AS /NZS 3518	Acrylonitrile butadiene styrene (ABS) pipes and fittings for pressure applications;
AS/NZS 3879	Solvent cements and priming fluids for PVC (PVC-U and PVC-M) and ABS and ASA pipes and fittings;
AS/NZS 4020	Testing of Products for use in contact with drinking water;

AS/NZS 4129	Fittings for polyethylene (PE) pipes for pressure applications;
AS/NZS 4130	Polyethylene (PE) pipes for pressure applications;
AS/NZS 4131	Polyethylene (PE) Compounds
AS/NZS 4765	Modified PVC (PVC-M) pipes for pressure applications;
AS/NZ ISO 3834.3	Quality requirements for fusion welding of metallic materials - Standard quality requirements;
AS/NZS ISO 9001	Quality management systems – Requirements;
ASTM D1785	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, 120
ASTM D2855	Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D6365	Standard Practice for the Non-destructive Testing of Geomembrane - Seams using the Spark Test;
ASTM F439	Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80;
ASTM F441	Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80;
ASTM F493	Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings;
DVS 2007-25	Welding of thermoplastics – heated tool butt welding PVC-U;
DVS 2207-3	Hot gas welding of thermoplastic sheets and pipes;
DVS 2207-3(sup)	Hot gas welding of thermoplastic sheets and pipes - welding parameters;
DVS 2208-1	Machines and devices for the heated tool welding of pipes, piping parts and panels;
DVS 2209-1	Welding thermoplastic materials, extrusion welding procedures – characteristics;
WSA 01	Polyethylene Pipeline Code;
WSA 113	Industry Standard for Reinforced Concrete Pipes with Flexible Thermoplastic Linings;
WSA 117	Industry standard for Acrylonitrile Butadiene Styrene (ABS) compounds, pipes and fittings for drainage and sewerage;
ISO 11413	Plastics pipes and fittings -- Preparation of test piece assemblies between a polyethylene (PE) pipe and an Electrofusion fitting;
ISO 12176-1	Plastic pipes and fittings – Equipment for fusion jointing of polyethylene systems – Part 1: Butt Fusion;
ISO 12176-2	Plastics pipes and fittings – Equipment for fusion jointing polyethylene systems – Part 2: Electrofusion;

ISO 12176-4	Plastics pipes and fittings – Equipment for fusion jointing polyethylene systems – Part 4: Traceability coding;
EN 13100	Non-destructive testing of welded joints of thermoplastics semi-finished products, visual examination;
ISO 13953	Polyethylene (PE) pipes and fittings -- Determination of the tensile strength and failure mode of test pieces from a butt-fused joint;
ISO 13954	Plastics pipes and fittings -- Peel decohesion test for polyethylene (PE) Electrofusion assemblies of nominal outside diameter greater than or equal to 90 mm;
ISO 13955	Plastics pipes and fittings – Crushing decohesion test for polyethylene (PE) electrofusion assemblies;
ISO 13956	Plastics pipes and fittings - Determination of cohesive strength-tear test for Polyethylene (PE) assemblies;
DIN EN ISO 15874 Plastic piping systems for hot and cold water installations	
ISO 21307	Plastic pipes and fittings – Butt fusion jointing procedures for polyethylene (PE) pipes and fittings used in the construction of gas and water distribution systems;
ISO/TS 10839	Polyethylene pipes and fittings for the supply of gaseous fuels – Code of practice for design, handling and installation.
BS EN 12814	Testing of welded joints of thermoplastic semi-finished Part 1: Products. Bend test;
GRI* GM 13	Standard Specification, Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes;
GRI* GM 17	Standard Specification, Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes;
GRI* GM 18	Standard Specification, Test Methods, Test Properties and Testing Frequency for Flexible Polypropylene Non-reinforced (FPP) and Reinforced (FPP-R) Geomembranes;
GRI* GM 19	Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes;
AWWA M25	Flexible- Membrane Covers and Linings for Potable- Water Reservoirs;
AWWA D130	Geomembrane materials for Potable Water Applications;
PMB	Plastics, Rubber and Cablemaking Training Package;
POP Guidelines	All current guidelines published by PIPA.

Note* - Geosynthetic Research Institute

Corporation Specifications and Standards

SPS 115	Unplasticised Polyvinylchloride Pipe for Pressure Applications
SPS 116	Modified Polyvinylchloride Pipe for Pressure Applications

SPS 125	Polyethylene and Polypropylene Pipe and Pipe Fittings
SPR	Strategic Products Register – Water, Wastewater and Drainage Systems
S151	Prevention of Falls Standard
HSEAA-P-143	Falls
HSEEA-P-124	Confined Space
WC-OSH 135	Flammable Gas Area (FGA) Procedure
HSEAA-P-134	Hot Work

3 Definitions

In this Technical Specification unless the context requires otherwise:

ABS means Acrylonitrile Butadiene Styrene;

Butt fusion jointing (BFJ) means a welding process where the pipe ends to be welded are heated against a hot plate and then brought together under pressure to form the weld;

Clearance to Work (CTW) is a document which provides approval to commence work.

Corporation means the Water Corporation and the Principal for the purposes of externally contracted asset delivery;

Contractor means the person bound to carry out and complete the work under contract (WUC)

Designer means the person or entity contracted to design, document and specify workmanship requirements for Corporation infrastructure assets;

Electrofusion jointing (EFJ) is where the pipe ends are inserted into a socket fitting with implanted electrical heating elements and when an electrical current is applied the socket and pipe surfaces fuse together.

Engineering Design Process means the process to be applied by Designers to the design of Corporation infrastructure assets;

Extrusion welding means a welding process where a compatible polymer to the base material is melted and extruded from the welding gun onto the preheated base material to form a weld;

Heated Tool Butt Welding means a welding process where the sheet or other profiled section ends to be welded are heated against a hot plate and then brought together under pressure to form the weld;

Hot air welding means a welding process which uses a stream of heated air to heat and melt both the thermoplastic parent material and the welding consumable to form the weld;

Hot wedge welding is a semi-automatic thermal technique which melts the two opposing geomembrane surfaces to be seamed by running a hot metal wedge or knife between them. Pressure is applied to the top or bottom geomembrane, or both, to form a continuous bond. Seams of this type can be made with dual bonded tracks separated by a non-bonded gap. These seams are referred to as dual hot wedge seams or double-track seams.

Hot work is defined as welding, thermal or oxygen cutting and /or heating including fire or spark producing operations that may increase the risk of fire or explosion.

HSCR High Stress Crack Resistant polyethylene pipe has a high resistance to Slow Crack Growth (SCG).

ITP means the project/contract Inspection and Test Plan(s);

JAS/ANZ means Joint Accreditation System of Australia & New Zealand;

MAOP means Maximum Allowable Operating Pressure;

Mechanical Coupling means Fittings, such as end connectors intended to join polyethylene pipe systems. AS 4129 and the Corporation's DS 31-01 shall be referred to for further description;

Membrane means a polymer material with a thickness up to and including 3mm which meets the requirements of AWWA D130 and AWWA M25;

MDR means Manufacturer's Material Data Report;

NATA means National Association of Testing Authorities;

PE means Polyethylene;

Pilot Test Weld means the pre-production weld made on site by a qualified welder using a qualified procedure / parameter card for a given pipe / material and thermoplastic welding machine/ equipment;

PIPA means Plastics Industry Pipe Association (Australia);

PP means Polypropylene;

PPE means personal protective equipment;

Preferred Supplier Agreement means the agreement between the Water Corporation and PWSP;

PWSP means Plastics Welding Service Provider that would undertake installation, welding and jointing;

PVC means Polyvinyl Chloride;

PVC-U means unplasticised PVC;

PVC-C means chlorinated PVC;

PVC-M means modified PVC;

RTO means, Registered Training Organisation that is registered by the Australian Skills Quality Authority (ASQA) (or in some cases a state regulator) to deliver vocational education and training (VET) services;

Schedule means Schedule of Quality Assurance Requirements and PWSP's Notifications & Submissions;

Sheet means polymer materials which are greater than 3mm thick;

Socket fusion welding means a welding process where a socket tool is used to preheat the external surface of the pipe and internal surface of the socket. The socket is then pushed onto the pipe to form the weld;

Solvent welding is a process that requires the application of volatile cleaning solvent(s), and the application of a solution of polymer in volatile solvent(s), that partially softens the mating surfaces of the thermoplastics components. On assembly, the welded joint bond strength increases as the solvents evaporate and are absorbed into joint interface materials and as the solvent cement polymerizes;

Specified means specified in the project specification or project drawings;

SPS means a published Water Corporation Strategic Product Specification;

SPR means a published Water Corporation Products and Equipment Register (Strategic Products Register)

SDR means the standard dimension ratio or the ratio of the pipe diameter to wall thickness;

Technical Specification means this technical specification;

Thermoplastic materials soften when heated and harden when cooled. They can withstand many heating and cooling cycles;

TQ means technical query relating to the work specification;

Welder also referred to as the “**Operator**” means the competent person(s) qualified to join thermoplastics;

Welding Procedure and Parameter Card is a document that describes how welding is to be carried out in production and is required for each thermoplastics welding operations. It provides sufficient details on welding parameters to enable any competent person to apply for the delivery of a weld of acceptable quality. The amount of details and the level of controls on a Welding Procedure and Parameter card depend on the application and criticality of the joint to be welded. A welding procedure and Parameter card is developed following successful mechanical testing of a welded joint that meets the requirements of the applicable standards;

WSAA means Water Services Association of Australia;

Work for the purposes of this Technical Specification means the fabrication, welding or repair work to be undertaken by the PWSP to which this Technical Specification applies.

Note:

AS/NZS 4129 and AS/NZS 4130 shall be referred to for a comprehensive list of definitions.

4 Standards and Code

4.1 Australian and International Standards

All installation, welding and joining shall comply with the Standards and Codes of Practice specified for the project work.

The applicable edition of standards/codes shall be those that are current two calendar weeks prior to the date of a work brief or, in the case of tendered work, the tender closing date.

4.2 Corporation Standards

Installation and welding workmanship shall comply with this Technical Specification. Designers shall, by reference to Corporation Design Standards and by copying/adapting Corporation standard drawings, provide the PWSP with project drawings, design details and workmanship specifications that enable the PWSP to produce workshop drawings and fabrication details in sufficient detail to deliver fit for purpose welded thermoplastics assets of the specified quality.

4.3 Industry Standards

The Water Corporation recommends the use WSA 01, Polyethylene Pipe Code and PIPA procedural guidelines as reference material only. Except as may otherwise be specifically authorized, these reference materials shall not supersede any requirement of project specifications.

5 Materials and Joining Processes

5.1 PVC-U, PVC-M, PVC-O & PVC-C Pressure Pipes

Where specified¹, PVC-U pressure pipes and fittings (PN rated) suitable for solvent weld jointing, shall comply with AS/NZS 1477. Schedule 80 PVC-U pipes and fittings shall comply with ASTM D1785 and ASTM D1784 respectively. PVC-M pipe shall comply with AS/NZS 4765; Oriented PVC pipe (PVC-O) shall not be solvent joined. PVC-C pipes and fittings shall comply with ASTM F441 (pipes), ASTM F439 (fittings).

Only pipes and fittings listed on Water Corporations Strategic Product Register and in compliance with SPS 115 (PVC-U) and SPS 116 (PVC-M) may be used.

PVC-U and PVC-M solvent welded jointing work shall comply with the requirements of AS/ NZS 2032 and this technical specification.

Solvent cements and priming fluid for PVC-U and PVC-M (PN rated) shall be type P complying with AS / NZS 3879 and manufacturer's recommendation. For PVC-C, priming fluids and solvent cements shall comply with ASTM F493 and manufacturer's recommendation. Solvent cements used with **Schedule 80** piping shall be the gap filling type as recommended by the piping manufacturer.

PVC pipes and fittings shall only be used if they are less than 12 months old from date of manufacture. If it can be demonstrated that pipes greater than 12 months old have been suitably stored away from UV and are not damaged or locally deformed, they may be used as determined by the Corporation on a project-by-project basis, subject to the quality of supporting documentary evidence provided.

Note 1 – The use of solvent weld jointed PVC pressure pipe is usually limited to chemical and process pipework, higher temperature (PVC-C) and generally small diameter (< DN 80) pipework applications.

5.2 PVC-U Non Pressure Pipes

PVC-U non pressure pipes and fittings shall comply with AS/NZS 1260 for drain waste and vent applications and AS/NZS 1254 for stormwater and surface water applications. Solvent cements and priming fluids for PVC-U shall comply with AS/NZS 3879 and manufacturer's recommendations.

Only pipes and fittings listed on Water Corporations Strategic Product Register may be used.

Solvent cement for PVC fittings with tapered or interference socket design shall be type N. For sockets with parallel or low interference socket design, type G solvent cement shall be used.

PVC-U solvent welded jointing work shall comply with the requirements of AS/ NZS 2032 and this technical specification.

PVC fittings of the injection moulded type shall be used in preference to the fabricated type.

Only non-pressure PVC-U pipe and fittings up to and including DN 300 in diameter shall be solvent weld jointed.

PVC pipe and fittings shall only be used if less than 12 months old from date of manufacture. The use of PVC pipe older than 12 months may be considered where stored under cover, undamaged and not deformed in any way, as determined by the Corporation on a project-by-project basis, subject to the quality of the supporting documentary evidence provided.

5.3 Plasticised PVC and PVC Membrane

PVC compounds shall comprise of high molecular weight polyvinyl chloride combined with plasticisers, stabilisers and pigments so as to be permanently flexible. Polyvinyl chloride shall constitute not less than 99% by mass of the resin used. The PVC compound shall not contain copolymer resins or fillers such as calcium carbonate.

Physical Property	Test Method	Acceptable Limits
Tensile strength (both longitudinal and transverse to key)	ASTM D412 (Refer Note 1)	17.25 MPa minimum
Elongation at break (both longitudinal and transverse to key)	ASTM D412 (Refer Note 1)	225% minimum
Hardness	Shore Durometer D at 20°C ASTM D2240	54 minimum 62 maximum
Plasticiser permanence (24 hours at 90°C on 50 mm diameter disc)	ASTM D1203 Method B	1.0% maximum
Water absorption at 24 hours (sample size 75 mm x 25 mm by thickness of sheet)	ASTM D570	0.10% maximum
Water soluble matter at 24 hours	ASTM D570	0.05% maximum
Tear strength (both longitudinal and transverse to key)	ASTM D1004	80 N/mm minimum

Note 1: Specimens for tensile testing shall be prepared and tested using Die B.

Table 1: PHYSICAL PROPERTY REQUIREMENTS OF PLASTICISED PVC

Plasticised PVC for use in drinking water applications shall meet the requirements of AS/NZS 4020 for the proposed surface area to volume ratio.

The chemical resistance of plasticised PVC in wastewater applications shall meet the requirements of WSA 113 - Industry Standard for Reinforced Concrete Pipes with Flexible Thermoplastic Linings.

Joining of plasticised PVC shall be by hot air welding or extrusion welding and in accordance with this technical specification.

PVC liners / membranes used to line reinforced concrete pipes shall comply with the requirements of WSA 113.

5.4 Polyethylene Pressure Pipe

Only pipes and fittings listed on the Strategic Product Register may be used. Polyethylene pressure pipe and fittings shall comply with SPS 125.

Jointing of PE pipe shall be in accordance with Table 2 below.

Pipe Diameter	Allowable Jointing Technique	Preferred Jointing Technique
≤ DN 90	Mechanical coupling, EFJ	Mechanical coupling
> DN 90 ≤ DN 450	BFJ, EFJ ¹	BFJ
> DN 450	BFJ, EFJ ¹	BFJ

¹ Use of EFJ to be referred to *Principal* for approval

Table 2: JOINING TECHNIQUES FOR PE PIPE

The designer and the PWSP shall only use the BFJ welding process to join PE pipes. The proposed use of EFJ welding shall be raised in a written technical query for each situation, for consideration for approval by the Principal.

The BFJ procedures shall comply with ISO 21307 and this specification. POP 003, as issued by PIPA, should be used for guidance on the butt fusion jointing of PE pipe and fittings.

The pressure rating of PE fittings intended for a PE pipeline shall be equal to or greater than the rated pressure of the specified pipe. The derated pressure ratings of fabricated and molded PE pipe fittings shall be derived by reference to POP 006, as issued by PIPA. The safe pressure ratings of PE pipe fittings are usually lower than those of PE pipe of equivalent material and wall thickness.

PE fittings shall be transported, handled and stored on site in accordance with the relevant requirements of AS/NZS 2033, POP 005 guideline and published requirements of the manufacturer.

Fittings shall be protected by means of under-cover storage or by covering with an appropriate material - such as hessian - that will not entrap heat in the vicinity of the stored fittings. Black plastics or other non-permeable sheeting shall not be a permissible shade material. Larger fittings shall be stored in the proper orientation to prevent them from going out of round. Fittings that have been prematurely removed from their packaging shall not be used.

5.5 Polyethylene Membrane

Polyethylene membranes shall comply with the material requirements of the:

- Geosynthetic Research Institute Standard Specification GM 13: Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes; or
- Standard Specification GM 17: Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes.

Joining of the membrane shall be by single or dual track hot wedge welding and extrusion fillet welding. Welded seams shall be in accordance with GRI – GM 19, Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes and this technical specification.

Polyethylene liners / membranes used to line reinforced concrete pipes shall comply with the requirements of WSA 113.

5.6 Polypropylene Pressure Pipe

Welded polypropylene pipe shall be used only in pressure applications unless otherwise specified.

Polypropylene pipe and fittings shall comply with DIN EN ISO 15874 - Plastic piping systems for hot and cold water installations.

Jointing of PP shall be in accordance with Table 3

Pipe Diameter	Allowable Jointing Technique	Preferred Jointing Technique
≤ DN 125	Socket Fusion, EFJ, BFJ	Socket Fusion, BFJ
> DN 125 ≤ DN 250	EFJ, BFJ	BFJ
> DN 250	BFJ	BFJ

Table 3: JOINING TECHNIQUES FOR PP PIPE

Socket, electrofusion and butt fusion welding of PP pipe and fittings shall be in accordance with DVS 2207 part 11.

As far as practicable the designer and the PWSP shall only use socket fusion and BFJ welding process to join PP pipes. The proposed use of EFJ welding shall be raised in a written technical query for each situation and approved by the Principal's designer.

The pressure class of fittings shall be equal to or greater than the pressure class of the specified pipe.

5.7 Polypropylene Membrane

Polypropylene membranes shall comply with the material requirements of the Geosynthetic Research Institute Standard Specification GM 18, Test Methods, Test Properties and Testing Frequency for Flexible Polypropylene Non-reinforced (fPP) and Reinforced (fPP-R) Geomembranes.

Joining of the membrane shall be by single or dual track hot wedge welding and extrusion fillet welding. Welded seams shall be in accordance with GRI – GM19, Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes and this technical specification.

5.8 ABS (Acrylonitrile Butadiene Styrene) Pressure and Non Pressure Pipe

Pipes and fittings shall comply with AS/NZS 3518, ABS pipes and fittings for pressure applications and WSA117 - Industry Standard for ABS compounds, pipes and fittings for drainage and sewerage. Solvent cement and priming fluids for ABS pipe and fittings shall comply with AS 3691.

Pipes and fittings shall be third-party certified by an accredited certifier under the StandardsMark, or WaterMark schemes or acceptable equivalent.

ABS pipe and pipe fitting solvent welded jointing work shall comply with the requirements of AS/ NZS 3690 and this technical specification.

Only pipe and fittings up to and including DN 300 in diameter shall be solvent weld jointed.

5.9 Sheet Materials

Sheet materials shall be either PVC-U or PE.

PVC-U sheet material shall consist of only PVC to which additives such as lubricants, pigments and stabilizer shall be added to enable the material to be manufactured into sheet. The total additives shall not exceed 20 parts per hundred by weight of the PVC content.

Polyethylene sheet material compounds shall be manufactured from polyethylene containing antioxidant, UV stabilizers and pigments necessary for their manufacture into sheet materials. Polyethylene sheet shall contain $2.25\% \pm 0.25\%$ by mass of carbon black to provide UV resistance.

For both PVC and PE sheet materials:

- all additives shall be evenly dispersed; and
- the material shall have the required chemical resistance for the proposed application and operating environment(s).

Joining of sheet materials shall be by either:

- 1 heated tool butt welding in accordance with DVS 2007-25, Welding of thermoplastics – heated tool butt welding PVC-U; or

- 2 extrusion welding (PE) in accordance with DVS 2209-1, Welding thermoplastic materials, extrusion welding procedures – characteristics; or
- 3 hot air welding (PE and PVC) in accordance with DVS 2207-3, Hot air welding of thermoplastic sheets and pipes and DVS 2207-3 (Supplement). Hot air welding of thermoplastic sheets and pipes - Welding parameters; or
- 4 heated tool butt welding in accordance with DVS 2007-1 for welding of HDPE thermoplastics sheets.
- 5 automated sheet butt welding machine in accordance with DVS 2208-1: *Machines and devices for the heated tool welding of pipes, piping parts and panels* for welding of HDPE thermoplastics sheets.

6 Approval to Commence Work

The PWSP shall formally request Corporation approval 10 working days prior to the planned commencement of thermoplastics installation and jointing work. Installation and jointing work shall not be permissible prior to Corporation approval of the following:

- The Quality Plan as defined in **QUALITY ASSURANCE**;
- A schedule of qualified welding procedures and parameter cards as defined in **WELDING PROCEDURE** and **PARAMETER CARD**.
- Where a qualified welding procedure is not current or available for the project, the welding procedure shall be verified by the preparation of test welds. Test welds shall be produced and tested as required in Section 11 and witnessed by the Corporation;
- Current Equipment Maintenance and Calibration details inclusive of but not limited to: pressure gauges, temperature monitoring instruments and electrofusion machines;
- Individual welding qualifications and welder register;
- PWSP Supervisor qualifications and documented statement of experience;
- Material test certificate register and reports;
- Certificates of Compliance;
- Inspection & Test Plan (ITP) shall be provided to control quality of the works;
- Job Safety Analysis (JSA) or Job Hazard Analysis (JHA), whichever is appropriate; and
- Clearance to Work Permit (CTWP).

Note: Where a PWSP is required to carry out emergency repairs for the purposes of unplanned service interruptions, the requirement for a JSA or JHA shall apply but the requirement for prior formal approval to commence work, whilst being highly desirable, may be relaxed by negotiation on a job by job basis. This notwithstanding, the PWSP shall provide all required documentation within a week of job completion.

7 Quality Assurance

The PWSP shall apply the principles of AS/NZS ISO 3834.3 Quality requirements for fusion welding of metallic materials and this technical specification.

Note: While the above standard applies to welding of metallic materials the principles that underlie the standard are transferable to thermoplastics material welding.

7.1 Contractor / PWSP Organisational Responsibilities

The Contractor / PWSP shall establish a quality management system in accordance with Section 7.2 of this technical specification. The installation, welding and jointing management systems shall be such that they address the manufacturing and installation criteria and the information that is to be provided with the MDR.

The Contractor shall review and approve all QA documentation from the PWSP prior to submission to the Principal.

It is also the responsibility of the Contractor to ensure an approved 'work pack' is available at the weld face for the particular job being undertaken.

Pilot test weld/s shall be witnessed by the Water Corporation or approved and accredited PWSP's supervisor prior to commencement of all works. Test weld/s shall be made on full lengths of pipe (or as deemed specific to the project and approved by the Principal) using Welding Procedures as defined in Section 5. Test weld/s shall be carried out on test pieces from:

- all proposed site welding machines.
- all welders involved in the work and
- different pipe and fitting compounds.

Where stipulated weld samples shall be produced and tested in accordance with Section 11 of this technical specification.

Not less than 10 working days prior to commencement of the works, the PWSP shall nominate a suitably qualified supervisor, who shall be responsible for the co-ordination of fabrication of fittings, welding / joining and field installation of pipe assemblies. The supervisor shall have delegated authority to coordinate all work, organise testing where applicable and be fully responsible for the implementation of the quality management system.

7.2 PWSP Quality Management System Requirements

The PWSP shall establish a quality management system for installation, welding and jointing work elements that comply with ISO 9001.

Quality Management accreditation to AS/NZS ISO 9001 shall only be acceptable where the same is issued by an accredited certification body. Certification issued by other bodies shall be referred to the Corporation for acceptance.

7.3 PWSP Capabilities

The PWSP shall demonstrate that:

1. Thermoplastic welder/s are qualified with records, to PMB competencies for the specified work;
2. Documented welding and joining procedures specifications are in accordance with the welding standard specified with hard copies available onsite;
3. There is a documented welding / joining procedure for repairing defective work that complies with specified requirements;
4. Plant and equipment are maintained, calibrated and in good working order to prepare, execute and deliver the contract in a timely and safe manner;
5. A quality control system is in place to manage documentation such as welding / joining specifications, weld procedure approval records and welder approval certificates;
6. A system is in place to control inspection and testing prior to, during and after welding work;
7. A system is in place to maintain calibration of all equipment specific to the installation, welding and jointing of thermoplastics;
8. A written procedure for controlling and rectifying non-conforming product, for acceptance by the Corporation, is provided prior to construction;
9. An Inspection Release Certificate as per Appendix C is completed prior to the dispatch of any fabricated item to site. Copies of Inspection Release Certificates shall be included in the MDR; and
10. A system of monitoring weld traceability. Semi-automated systems where applicable shall use data loggers where jointing data shall be downloaded and submitted to the Principal on a daily basis or at the discretion of the Principal.

7.4 Welded Joint Traceability

The PWSP shall maintain traceability demonstrating the welder identification number performing the welding / jointing work corresponding with construction chainage and weld mapping as stipulated on the project plans. This shall be made available to the Principal on request. Refer also to 10.1.8 item 7.

The location of welded joints tested by destructive testing shall be shown in the traceability documentation.

Equipment for fusion jointing of polyethylene systems shall comply with the requirements of ISO 12176-4.

7.5 Manufacturers Material Data Report

At the completion of a project the PWSP shall submit a Manufacturers Material Data Report (MDR) to the Contractor prior to submission to the Corporation for review and approval. The MDR shall be compiled concurrently during construction and be available onsite to review against pipe and fittings as they arrive for the project. The following list / index should be used as a guide in compiling the MDR.

1. Section A - Inspection and test plans;
2. Section B - Inspection release certificates;
3. Section C – Parameter cards and welding procedure;
4. Section D - As built drawings;
5. Section E - Fabricated item record list;
6. Section F - Dimensional check records;
7. Section G - Register of welder qualification records;
8. Section H - Site welding / joining traceability;
9. Section I - Destructive testing report of welds;
10. Section J - Non-conformance reports and deviations;
11. Section K - Material test certificate register and reports;
12. Section L - Certificates of Compliance;
13. Section M - TQ (Technical Query) and approvals;
14. Section N - Statutory documentation including design certification; and
15. Section P - Photographic records of critical connections.

8 Qualification and Documentation of Welding and Joining Procedures

As required per section 7 Quality Assurance, the PWSP shall work to a welding procedure and parameter card for a given material and process. Welding and joining procedures shall be qualified prior to the commencement of welding on site. Welding and joining procedures shall be seen as a communication and auditing / inspection tool of the work being carried out, all welding and joining procedures related to the work shall be available at the work site.

An example of welding documentation requirements is detailed in Appendix A.

A welding procedure and parameter card shall be provided for each of the following welding techniques:

8.1 Butt Fusion Welding (ISO 21307)

The welding process requires the square ends of two pipes or fittings to be heated via a heater plate, removing the heater plate when the correct bead up size/time is achieved, bringing the ends together in a timely manner and allowing the joint to cool whilst maintaining the fusion faces under a predetermined pressure based on the approved welding parameter force.

The butt fusion parameter card shall have as a minimum the following information, (also refer to Appendix B for typical example):

1. Pipe diameter;
2. SDR (Standard Dimensional Ratio);
3. PN rating;
4. Material type, manufacturer and date of manufacture;
5. Joint surface preparation;
6. Joint surface treatment / cleaning compounds c/w batch numbers;
7. Procedure unique identification;
8. Fusion machine type, cylinder area;
9. Fusion machine serial No;
10. Fusion parameters as per ISO 21307 – Low / High;
11. Ambient temperature range;
12. Heater plate temperature;
13. Drag Pressure;
14. Bead up pressure;
15. Bead size;
16. Heat soak pressure;
17. Heat soak time;
18. Welding pressure;
19. Cooling times;
20. Welder Name;
21. Welder ID #;
22. Project Description;
23. Supervisor's / PWSP endorsement; and
24. Machine calibration date.

8.2 Electro Fusion Welding

8.2.1 Couplings

The welding process requires the square ends of two pipes or fittings to be fitted into an EFJ coupling, simultaneously heating the interface between the pipe outer diameter and the coupling socket inner diameter by

energising the electrical resistance conductors embedded in the coupling. The plasticised material from the pipe and coupling fuse together and a strong bond is achieved by allowing adequate cooling time under adequate restraint.

10 days prior to the works being undertaken the following information shall be supplied as a minimum:

1. Brand name, type, size and pressure rating of EF couplings;
2. Material type, manufacturer and date of manufacture;
3. Ambient Temperature range;
4. Joint surface preparation;
5. Mechanical Peeler type and details;
6. Joint surface treatment / cleaning compounds c/w batch numbers;
7. Cooling time;
8. Type and brand of welding equipment / transformer to be used. All machinery and equipment shall comply with the coupling manufacturers recommendations;
9. Documentation on maintenance, servicing and calibration of equipment; and
10. Re-rounding clamp and aligning clamp methodologies.

8.2.2 Top Load Branch Saddle

Operators shall have demonstrated competency & experience with the sizes & types of branch saddles being installed with documented experience of constructing load branch saddle joints of the same fitting type & size.

Installers are to be equipped with the correct equipment to ensure all joints are prepared in accordance with both the manufacturers & industry guidelines POP001.

This is to ensure factors including surface preparation, cleaning, permissible joint geometry, control of welding environment & welding parameters are correctly managed.

The equipment to be used for the preparation & installation of a branch saddle is required to be compatible to the brand/manufacturer of the branch saddle that is to be installed.

All pipes to be checked for dimensional conformance & ovality prior to saddle installation.

8.3 Extrusion Welding

The welding process requires a polymer welding filler material with the same composition and melt flow index as the base material, the welding filler material is heated and applied to the weld joint via a nozzle or shoe, the joining faces are heated by hot gas generally air and the joining pressure is applied via the welding shoe. Welding is achieved using a fully automated or semi-automated process.

The extrusion welding procedure at a minimum shall stipulate the following:

1. Material type and thickness;
2. Air / air flow rate in litres/min;
3. Air / air temperature with lower and upper limits;
4. Type of welding gun as applicable to the type of thermoplastic;
5. Surface preparation method and cleaning measures;
6. Cleaning compounds of the weld surfaces prior to welding;
7. Travel speed that will dictate the overheating / underheating;
8. Distance between nozzle and joining face;
9. Environmental conditions prior to and during welding; and
10. Type and grade of material welding shoe.

8.4 Hot Air Welding

The welding process requires a welding filler material with the same composition and melt flow index as the base material. The filler material and the joining faces are heated by hot air, generally air pressure is applied via clamps or pinning the thermoplastic material to concrete or like structures and allowing adequate time for the joint to cool to allow for a fusion bond prior to removal of the clamping pressure. Welding is achieved mostly by a manual process of heating and feeding the filler material.

The hot air welding procedure at a minimum shall stipulate the following:

1. Air / air flow rate in litres/min;
2. Air / air temperature with lower and upper limits;
3. Type of welding gun as applicable to the type of thermoplastic;
4. Type, preparation and cleaning measures;
5. Cleaning compounds of the weld surfaces prior to welding;
6. Material type and thickness;
7. Travel speed that will dictate the overheating / under-heating;
8. Distance between nozzle and joining face;
9. Environmental conditions prior to and during welding; and
10. Type and grade of material of the welding shoe.

8.5 Hot Wedge Welding

The welding process requires the interface between lapping membrane surfaces to be heated simultaneously using an electrically heated wedge. As the heated wedge moves forward and melts the mating faces pressure is applied to the membrane surfaces just behind the heated wedge to create the fusion weld.

The hot wedge welding procedure shall at a minimum stipulate the following:

1. Material type and thickness;
2. Type of welding equipment as applicable to the type of thermoplastic;
3. Surface preparation method and cleaning measures;
4. Cleaning compounds of the weld surfaces prior to welding;
5. Travel speed that will dictate the overheating / underheating;
6. Welding shoe temperature with lower and upper limits;
7. Nip Roller pressure; and
8. Environmental conditions prior to and during welding.

Horizontal tee seams shall be no closer than 1.5m from the toe of the slope.

8.6 Solvent Cement Welding

The welding process requires the surfaces to be joined to be coated with chemically active solvent cement, which softens and plasticises the surfaces to be joined. When joined together the two parts bond almost immediately. As the cement cures the joint strengthens to provide a fully bonded joint.

The solvent cement joining procedure shall at minimum stipulate the following:

1. Material type;
2. Type of primers and solvent cements;
3. Type of joint – parallel or interference fit for pipe or lap joint for membrane;
4. Surface preparation method and cleaning measures;
5. Priming compounds of the weld joints prior to welding;
6. Clamping arrangements; and
7. Curing time.

Note: For other than water and wastewater applications, the Designer should confirm that the chemical resistance of the cured solvent cement is equivalent to that of the pipe material

8.7 Welding of Membrane

The welding of membranes depends on the material type but the following methods can be used singularly or in combination:

- Hot wedge welding;
- Extrusion welding; and
- Solvent welding.

8.8 Welding of Sheet

The welding of sheet depends on the material type but the following methods can be used singularly or in combination:

- Butt fusion welding;
- Extrusion welding; and
- Hot air welding.

8.9 Environmental Conditions for Fusion Welding

The thermoplastic fusion welding process is sensitive to weather and climatic conditions and, as such, the welding process needs to be carried out in clean, dry and draft free conditions. To manage these aspects the following is required:

1. Where necessary, use a weather shelter or cover to keep moisture and dust away from the surfaces being welded;
2. When temperatures fall near or below 10°C during welding, special precautions shall be undertaken. For BFJ at a minimum the pipes ends to be joined shall be pre-heated for 10 sec per mm of wall thickness or as per manufacturer's recommendation using radiated heat from the heater plate that is positioned at 50mm from the pipe edges to be joined. The PWSP shall apply the materials manufacturer's recommendations for all other joining processes; and
3. Cover the remote open ends of the pipes being welded to avoid draughts. Air can be drawn through open ends and pass over the surfaces being welded, cooling them prematurely, which can result in a brittle weld.
4. Where the air temperature is hotter or colder than the ground temperature, tensile stresses may form due to contraction or expansion of the pipe as it adjusts to the ground temperature. To minimize these stresses, final closing / tie-in connections shall be undertaken when the pipeline has stabilized to the final service temp of 20°C unless otherwise specified. Refer also to AS/NZS 2566.2, Section 5 for further details.

8.10 Planning for successful fusion welding

To ensure the integrity of the welds the following procedures shall be adopted:

1. Select a qualified welding contractor referred to as the PWSP in this specification. A qualified PWSP shall have –
 - Demonstrated experience in the type of fusion welding;
 - Suitably sized equipment which has been maintained in good condition with calibration status documentation available for temperature and pressure measurement;
 - Qualified welders who have an up to date log, detailing project and welding experience.
2. Assess the proposed welding procedures –

- Carry out pilot test welds on the actual pipe/fitting poly compound materials to be used for the contract and have these destructively tested to meet the specified performance requirements (testing and minimum performance requirements are detailed in Section 11 – Inspection and Testing);
 - Determine and document the agreed welding parameters, procedures, and welding equipment (this may also include the use of welding tents, pipe end covers etc.);
 - The agreed welding parameters, procedures and welding equipment then become the contract requirements and should not be varied without additional evaluation and testing.
3. Determine quality control and assurance requirements including but not limited to –
- Maintaining a detailed welding log for each joint (Appendix A);
 - Destructive testing of a percentage of joints as per clause 11.2.2;
 - Assessment of weld bead (for butt fusion welding) if called for by the Designer or Principal.
4. Continuously review process and results.

9 Personnel Training and Qualification

All welding and joining shall be carried out by suitably qualified welders who have satisfactorily completed a welding / joining course for the process(es) that are intended to be used in construction.

Personnel engaged in the joining of thermoplastics materials shall be trained and certified through an RTO to PMB Competency Standards.

9.1 Joining of PE – Butt Fusion and Electro fusion welding

Thermoplastic welders shall have the following minimum qualifications and experience:

1. Butt Fusion Welding (PE) - PMBWELD 301;
2. Electrofusion Welding (PE) - PMBWELD 302;
3. Electrofusion branch saddles (PE) – training provided by saddle manufacturers;
4. Training needs to be complemented with a minimum field experience of 6 months continuous welding providing evidence of test welds over this period in either butt fusion or electrofusion welding, including the equipment, skills and processes as required in construction.
5. For pipe sizes larger than DN315 mm, test reports and previous project log sheets shall be submitted for review to provide evidence of the competency obtained in welding of larger pipe diameters with relevant specific experience on all welding machine(s) to be used on the project.

9.2 Solvent Cement Welding and Joining of PVC and ABS Pipelines

Personnel engaged in the solvent cement welding and joining of PVC or ABS pipe shall have:

1. Successfully completed the PVC Pipe Handling and Installation program through the South Metropolitan Tafe, Rockingham campus or other acceptable equivalent program delivered by an accredited RTO; and
2. Minimum of 3 months field experience in solvent cement welding and joining PVC and 3 months field experience in solvent cement welding and joining ABS piping or work under direct supervision of a competent person.

9.3 Extrusion Welding

Personnel engaged in welding and joining of thermoplastics materials shall have the following minimum qualifications and experience:

1. Extrusion Welding (PE) - PMBWELD 309 (Extrusion Welding); and
2. Minimum of 6 months experience in welding of thermoplastic membrane / linings and sheeting providing evidence of test welds and log sheets on previous projects over this period.

9.4 Hot Air Welding

Personnel engaged in hot air welding of PVC or PE sheet shall have the following minimum qualification and experience:

1. Successfully completed an approved course through an accredited RTO or approved product manufacturer;

2. Successfully completed and certified to PMBPROD287, Weld Plastic Materials; and
3. Minimum of 6 months experience in welding of thermoplastics as applicable.

9.5 Membrane Welding

Personnel engaged in geomembrane welding shall have the following minimum qualification and experience:

1. Be a Certified Welding Technician (CWT) in accordance with the International Association of Geosynthetic Installers (IAGI) program and governed by the specific IAGI Proctor Manual for that membrane.
2. The welder shall have installed a minimum of 10 projects and seamed a minimum of 90,000 sq. metres of material.

9.6 Plastics Welding and Joining Supervisor

The supervisor shall have the same minimum qualifications as the welders and in addition shall have a minimum of 2 years' experience in welding, installation and plastic weld testing standards and methods.

9.7 Re-assessment of welding / joining personnel qualifications

Welding and joining personnel who have not produced any fusion joint in the previous 12 months shall be re-qualified. Evidence of continuity of skills can be made available via QA documentation and records of previous projects where the welder was actively engaged in producing fusion joints in thermoplastic materials.

Re-qualification may be carried out by completing a refresher course through an RTO.

10 Workmanship Standards and Equipment

10.1 Polyethylene Pipe Work

10.1.1 Pipe Jointing Requirements

Weld Jointing of polyethylene pipes shall be undertaken by personnel experienced in working with polyethylene pipe as stipulated in Section 9 of this specification. The PWSP shall provide evidence that personnel are qualified to joint and install the pipe, using welding techniques. Work shall not commence until the PWSP has provided evidence and documentation as required by Section 6. Pilot welds shall be made and tested in accordance with Section 11 of this specification and requirements outlined by the Water Corporations modular construction specification PE - Polyethylene Pipelines, section PE11.3.1 prior to the start of pipe jointing work and with results submitted to the Corporation for approval.

10.1.2 Transportation of Pipe

Pipes and pipe fittings shall be loaded and unloaded in such a manner so as to avoid shock or damage. Non-abrasive webbing type slings shall be used to handle pipe coils or bundles. Pipes and fittings shall not be dropped, dumped or scraped along hard surfaces which may score or notch them. The supplier of the pipes, i.e. manufacturer, contractor or PWSP shall ensure that pipes and pipe fittings to be supplied comply dimensionally with the specified manufacturing standards and are not cut, kinked, or otherwise damaged during loading, transportation and unloading operations.

10.1.3 Storage of Pipe and Fittings

Pipe storage sites and layouts shall be in accordance with manufacturer's recommendations and shall be secure and provide protection against physical damage to the pipes. Pipes shall be stored on level sand mounds, preferably clean sand, free of sharp objects which could damage the pipe. Stacking of polyethylene pipe shall be limited to a height that will not cause excessive permanent deformation of the bottom layer of pipe under anticipated temperature conditions. Permanent deformation shall not exceed the ovality limits in AS/NZS 4130. Where necessary, the pipe shall be stored above ground on suitably constructed pallets, sand mounds or equivalent in an approved manner. In addition to these requirements the PWSP shall also adhere to storage requirements specified in AS 2566.2, or AS 2033.

Pipes exceeding 24 months of age from the date of manufacture shall not be used for construction of pipelines unless approved by the Corporation. Pipes showing irregularities or abnormalities shall not be used under any circumstances.

Sand and other materials shall be prevented from entering the pipes.

The inside of the pipe ends shall be inspected immediately prior to joining to ensure that sand or foreign matter has not entered the pipe. Any foreign matter found in the pipe shall be removed.

NOTE 1: Products shall be stored in original product packaging in accordance with the published requirements of the manufacturer, prior to installation.

NOTE 2: Pipe fittings and jointing materials should be stored separately and under cover. Individual discrete or loose pipe components should be stored in original product packaging, prior to their installation.

10.1.4 Handling of Materials

PE pipes and fittings shall at all times be handled in a manner that does not over stress the pipe.

PE pipes and fittings shall not be damaged by dragging over sharp objects. Ropes, fabric, or rubber protected slings and straps shall be used when handling pipes. Chains, steel cables, or hooks shall not be used.

Spreader bars or beams can be used for lifting pipes 6 metres in length or longer. Slings (soft or roller) shall be used for handling/lifting the pipeline and shall be positioned away from butt fused joint positions. Pipes and fittings shall be loaded and unloaded by lifting in such a manner as to avoid shock or damage, in accordance with the manufacturer's handling specification. A pipe or fitting that is dropped during loading or unloading operations shall be subject to inspection and rejection where damaged. A damaged or buckled section of pipe shall be removed and replaced with undamaged pipe.

Open ends of installed pipeline sections shall be secured by blanking off at night and during lengthy work stoppages. Waterproof nightcaps of an acceptable design and material - excluding cloth or paper based - shall be fabricated, and fastened to open pipe ends with ducting tape to provide wind resistance and prevent ingress of natural precipitation.

Wherever practicable, pipe shall be raised, physically aligned and supported so as to facilitate emptying of residual fluids by gravity through open pipe ends.

PWSP safety procedures shall provide for the safe unpacking and handling of coiled pipe including its release from packing bands and any tendency to forcefully recoil or uncoil.

10.1.5 Acceptability of Damaged Pipe and or Materials

The Water Corporation shall be notified immediately by the main Contractor for damage to pipe or materials as described below:

- Sections of pipe and pipe fittings other than EFJ fittings with cuts or gouges that reduce the wall thickness by more than 10 percent and kinked pipe or pipe fitting sections shall be cut out, removed and the remaining pipe ends (but not pipe fitting) shall be rejoined. Repair of cuts and gouges in pressure pipes that reduce the wall thickness by more than 10 percent shall not be permissible.
- Pipe scratches or notches that extend into the pipe wall by more than 2% but less than 10% of its thickness and are less than 100 mm in length shall be repaired by extrusion welding where the notch is sharp.
- Shallow well profiled (e.g. rounded) gouges that do not represent a sharp notch effect and where the loss in wall thickness is between 2 -10% may be accepted without repair subject to inspection and evaluation by the Corporation – including referral to the pipe manufacturer as necessary.

10.1.6 Pipe Assembly

If space permits, pipe shall be welded / fused together in one length.

Pipe shall be placed on suitable pipe rollers before pulling into pipe trench to minimize damage to pipe.

The external dimensions of pipe ends and the internal dimensions of EFJ pipe fittings to be joined by fusion processes shall be measured and checked for dimensional fit in good time prior to commencement of pipeline installation work. The method for determining these dimensions shall be in accordance with AS/NZS 1462.1 with a misalignment tolerance of 0.1% of the wall thickness as defined by ISO/TS 10839 clause 8.3.2.2. Where delivered pipe ovality or other dimensional characteristics do not comply with those prescribed by the manufacturing standard for the pipe or pipe fitting, this should be rectified by replacement with dimensionally compliant product or by submission to the Corporation of an acceptable remedial work method proposal. Where, for example, pipe has been ovalised as a result of storage, transportation or other cause, remedial proposals shall provide for the use of re-rounding and alignment clamps during the electro-fusion process in accordance with pipe manufacturer or industry (PIPA) EF jointing and pipe re-rounding guidelines.

Rotating mechanical surface peelers shall be used to prepare the surfaces of the pipe ends to be fused with electrofusion fittings. It is critical that all oxidized pipe surfaces be removed in order for fusion to take place. The peeling process requires the outer oxidized pipe skin be removed to ensure adequate bonding of the pipe in

accordance with manufacturers recommendations. Peeling procedure shall be as per EF fitting manufacturer's specification.

Hand scrapers shall not be permissible.

Both rerounding and aligning clamps for electrofusion fittings shall both be used during welding and cooling processes. Cooling shall be considered complete only when welded fittings have reached ambient temperature. Adequate witness marks shall be provided during assembly to enable monitoring of EFJ weld movement.

Temporary shelter tarpaulins or equivalent shall be provided on the ends of pipes to be joined by an EFJ weld to allow for temperature equalization of pipe ends and the packed / boxed couplings.

EFJ welded pipe strings welded outside the pipe trench shall not be handled or lifted for installation purposes until the last welded pipe joint cools down to ambient temperature.

When coiled pipe is used, a minimum of 1 metre of straight PE pipe of the same SDR shall be BFJ to the start and end of the coil (and fitting if within the coiled area). This is required to reduce stresses on the pipe ends during EFJ or BFJ.

10.1.7 Pipe Rollers

Pipelines shall be adequately supported by rollers, side booms or “dollies” (refer illustration) and monitored during installation so as to prevent over stressing or buckling during the pullback operation. Such support / rollers shall be spaced (relevant to ambient temperatures) at a maximum of 10 metres centers, and the rollers to be comprised of a non-abrasive material arranged in a manner to provide support to the bottom and bottom quarter points of the pipeline allowing for free movement of the pipeline during pullback. Pipeline surface damaged shall be repaired by the PWSP before pulling operations resume.



10.1.8 Jointing Process

Joints between plain end pipes and pipe fittings shall be made by BFJ. The proposal to use EFJ as an alternative shall be raised in a written technical query, for each situation, for review and consideration for approval by the Principal.

BFJ shall be carried out to comply with the requirements of ISO 11414, ISO 12176-1 and ISO 21307. BFJ shall be carried out predominantly outside the pipe trench. Joining of pipe strings in the trench is permitted however there shall always be one end of the pipe free to move to ensure the required drag is achieved.

Butt fusion welding can be carried out only with pipe or fittings of the same SDR unless a suitable transition piece, approved by the manufacturer, is used or the pipe end is transitioned to the acceptance of the manufacturer.

EFJ shall be carried out to comply with the requirements of POP001.

Extrusion welding for joining of Polyethylene pipe ends for pressure applications shall not be permissible.

Use of a fast fusion cooling process during welding shall not be permissible.

All pipes shall be carefully examined for damage and other defects immediately before being installed. Ends to be butt welded shall be examined with particular care.

The removal of weld beads post welding using BFJ shall be as specified by the designer, this requirement shall be project specific. Where de-beading is required a procedure is to be submitted for approval by the Principal.

Defective pipe shall not be used. Care shall be taken to remove all sand and other material from the inside of the pipes before they are lowered into the trench.

BFJ test welds shall be allowed to cool to ambient temperature prior to test samples being cut out to ISO 13953 standard dimensions.

During welding and joining operations, the PWSP shall ensure:

1. All surfaces are clean and free of contaminants prior to assembly and welding.;
2. Surfaces prepared for assembly and welding shall be wiped with isopropanol having a minimum concentration of 90% and a lint free cloth. Use of methylated spirits, acetone, methyl ethyl ketone (MEK) or other solvents is not permitted.
3. Pipe ends shall be blanked off during the welding process.
4. A shelter shall be used during the welding process when the weld area has the potential to be effected by environmental conditions;
5. Protect against contamination such as dust, sand and rain;
6. The welder shall work to the procedure parameters in relation to the heating cycle, cooling cycles (refer Section 10.1.8.1) and joint restraint requirements for each joint type to be welded;
7. No tapping of saddles should occur or movement of the pipe until the required cooling times has elapsed and hydrotesting of the weld joint has been carried out (refer Section 10.1.8.1);
8. Weld map, traceability of welding joints to welders correlating to the chainage on construction drawing shall be maintained;
9. Welding procedure documentation including manufacturer's instructions, shall be available on site;
10. Welder identification number to be embedded on all weld joints completed in the case of butt fusion welded joints;
11. Welder identification number to be written in white permanent marker on the completed electro fusion welded coupling;
12. The date and time the joints is completed and the cooling time shall be written on the joints to avoid premature handling and potential joint failure;
13. A pilot test weld for each operator, welding machine, pipe diameter, rated SDR as per table 4 (11.1.1) and pipe material compound type with a record of the parameter values for each weld shall be made. Pilot test welds shall be destructively tested to the testing requirements;
14. Provide QA documentation / certification for shop fabricated / vendor purchased fittings; and
15. Marking of fabricated fittings shall correspond with the certification documentation and requirements in accordance with AS/NZS 4129.

10.1.8.1 BFJ Cooling Cycle

Rough handling of the pipe prior to the appropriate cooling cycles being completed is detrimental to the integrity of the welded joint. Rough handling can include excessive pulling or bending of the pipe; pressure testing; stresses induced by backfilling and burying; lifting the pipe by not using appropriate placed spreader bars; dragging the pipe out of the machine along the ground; or not using pipe roller supports along its length.

To protect the joint from rough handling and ensuring optimum joint strength for butt fusion welds, the following rules shall be applied under all circumstances:

- for BFJ made in accordance with the *single low-pressure fusion jointing* procedure, cooling times shall be in accordance with ISO 21307 where t_6 shall be the minimum cooling time IN the machine without pressure. (*The exception to this rule is for pipe end welds, inclusive of fittings, where t_6 can be out of the machine*).
- for BFJ made in accordance with the *single high-pressure fusion jointing* procedure, cooling times shall be in accordance with ISO 21307 with an additional allowance of 30 minutes minimum cooling time in the machine.

10.2 Solvent Cement Joining of PVC and ABS Pipework

Where solvent welding is required the jointing procedure shall be as follows:

1. Select the appropriate type of solvent cement for the pipe material, for pressure and non-pressure applications and for tapered or parallel sockets, as specified by the pipe and pipe fittings manufacturer. Check the 'use by' date of solvent cement and discard if expired;
2. Cut the spigot end square and remove all burrs and sharp edges outside and inside. Chamfer pipe ends with a 15° bevel or in accordance with the pipe manufacturer's recommendations;
3. Mark the spigot with a witness mark (e.g. pencil line or other method that does not physically damage the pipe) at a distance equivalent to the internal depth of the socket. Scoring or etching of the pipe shall not be permissible;
4. Dry the area between the witness mark and spigot end, then clean and degrease with a clean cloth moistened with the pipe or fitting manufacturer's specified priming fluid. Dry, clean and degrease the interior of the socket in a similar way. Repeat until the surface appears matt to observe;
5. Use clean, suitably sized brushes or applicators, which shall not contaminate the solvent cement, to evenly coat the joints with solvent cement. Apply a coating of solvent cement evenly to the internal surface of the socket for the full engagement length, and then to the external section of the spigot up to the witness mark. Solvent shall be brush applied, brush strokes shall be parallel to the pipe to prevent air entrapment. (Solvent cement should not be applied in a circumferential manner as it increases the likelihood of air entrapment when pipes/fittings are joined). Use the minimum amount of solvent cement necessary to fully solvent weld the joint socket, to minimize excess solvent accumulation and solvent extrusion into the pipeline bore when jointed;
6. Insert the spigot close to, but not beyond, the witness mark. Do not use excessive force. Firmly restrain the joint for the minimum period recommended by the pipe manufacturer;
7. Where accessible, excess solvent cement should be removed from both internal and external joint surfaces; and
8. Allow welded joints to cure for 24 hrs. Maintain the pipeline free of water for at least 1 hr. and do not pressurize for at least 24 hrs after welding the last joint.

NOTES:

- a) Burrs and protruding edges on the spigot can cause the solvent cement to be wiped from the surface of the socket and affect dimensional compatibility. This will result in a weaker joint, which might leak.
- b) Reference should be made to suppliers of special or rapid-curing solvent cements to determine pipe material compatibility and minimum curing time requirements.
- c) For sound jointing of pipes of 100 mm diameter and above, mechanical assistance may be required. Under most conditions, a lever placed against the protected end of the pipe will be sufficient.
- d) ASTM D2855 provides an acceptable alternative solvent cement jointing methodology that specifies chamfering of the pipe spigot end.

To minimize the risk of making poor joints, the following precautions shall be observed:

1. Ensure that the end of the pipe is in the socket squarely, and in the same alignment and grade as the preceding pipes or fittings;
2. Solvent cements and priming fluids shall be stored away from direct heat sources and shall be kept in tightly sealed containers when not in use to prevent loss of solvent and lower cement bond strengths.

3. Solvent cements have a limited shelf life and shall be used in strict accordance with the manufacturer's instructions;
4. Dilution or thinning of solvent cement with priming/cleaning fluid shall not be permissible;
5. Ensure that excessive solvent cement does not enter pipes or pipe fittings when applying solvent cement to joint surfaces. Wipe excess solvent cement from the outside and where possible, the inside of joints when made;
6. Prevent any spilt solvent cement from contacting the pipe or fittings. Immediately wipe any spillage off the affected parts;
7. Keep jointing surfaces dry during solvent application work;
8. Keep joints dry and free from ice; allow extra curing time to compensate for the lower temperature. Restrain joints for longer periods at lower temperatures. Refer to the manufacturer for installation requirements when temperatures fall below 0°C; and
9. Adhere to any additional requirements stipulated by the pipe manufacturer in making the joint.

10.3 Joining of Membrane and Liners

The following sections are intended to address the workmanship requirements of membrane and liners other than thermoplastic liners used in reinforced concrete pipes. The requirements for reinforced concrete pipe linings are stated in Section 10.4 of this specification.

10.3.1 Seaming Equipment and Products

Approved methods for field seaming are thermal fusion (hot wedge, hot air, or combination) seaming and extrusion seaming. Proposed alternate methods shall be documented and submitted to the Corporation for approval. Only apparatus that has been specifically approved by make and model shall be used. The PWSP shall use appropriately calibrated measuring equipment to ensure that required temperatures are being achieved.

The PWSP shall submit all documentation to the Corporation.

10.3.1.1 Fusion Seaming

Fusion seaming must be done with automated self-propelled machines. The fusion seaming machines shall be equipped with gauges giving hot wedge temperatures.

Temperature, speed, and nip roll pressure settings shall be verified by the PWSP prior to each seaming period. Nip roll and wedge geometries shall be such as to minimize residual stresses at the edge of the seam, i.e. to minimize reduction in stress cracking resistance of the geomembrane.

The PWSP shall log ambient conditions, geomembrane temperatures, seaming apparatus temperatures and speeds, equipment serial number, and welder initials.

The Corporation or delegate will verify that:

- the PWSP maintains the agreed number of operable seaming machines on-site;
- equipment used for seaming does not damage the geomembrane;
- for tee seam intersections, all edge flaps are cut back to the edge of the outer-most peel-tested track of the seam prior to seaming;
- electric generators and fuel containers are placed on a smooth protective layer with bunding such that no damage occurs to the geomembrane;
- a smooth insulating plate or fabric is placed beneath the hot seaming apparatus after usage;
- the geomembrane is protected from damage in heavily-trafficked areas; and
- build-up of moisture between the sheets is prevented. To accomplish this, a movable protective layer may be used directly below each overlap of geomembrane that is to be seamed.

10.3.1.2 Extrusion Seaming

Extrusion-seaming apparatus shall be equipped with gauges giving the relevant temperatures of the apparatus such as the temperatures of the extrudate, nozzle, and preheat air.

The PWSP shall provide documentation (including QC certificates) regarding the welding rod or resin pellets to the Project Manager and the Corporation or delegate, that show that the resin is the same PE resin as the geomembrane itself. Other seaming resins must be approved by the Corporation or delegate.

The PWSP shall log apparatus temperatures, extrudate temperatures, ambient conditions, and geomembrane temperatures at appropriate intervals.

The Corporation or delegate will verify that:

- the PWSP maintains the agreed number of operable seaming machines on-site;
- equipment used for seaming will not damage the geomembrane;
- the extruder is purged prior to seaming until all heat-degraded extrudate has been removed from the barrel;
- feed resin is maintained clean and dry;
- the electric generator and fuel containers are placed on a smooth intermediate layer with bunding such that no damage occurs to the geomembrane;
- a smooth insulating plate or fabric is placed beneath the hot seaming apparatus after usage; and
- the geomembrane is protected from damage in heavily trafficked areas.

10.3.2 Seam Preparation

The Corporation or delegate will verify that:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, foreign material, and any mechanical damage;
- if seam overlap grinding is required, the process is completed according to the Manufacturer's instructions but within 30 minutes of the seaming operation, and in a way that does not damage the geomembrane;
- the abrading does not remove more than 10 percent of the thickness of the geomembrane, and the resulting abrasion marks are covered by the finished extrusion bead;
- any visible abrasion marks, after seaming, are essentially perpendicular to the direction of the seam;
- the abrading does not introduce damaging gouges in the geomembrane; and
- seams /panels are aligned with a minimum of wrinkles and "fishmouths".

10.3.3 Weather Conditions for Seaming

The following protocols shall be observed during seaming:

- Unless authorized in writing by the Corporation, no seaming shall be attempted at geomembrane temperatures below -0°C or above 75°C ;
- Below a geomembrane temperature of 5°C , the need for pre-heating and additional testing should be discussed with the Corporation or delegate;
- In all cases, the geomembrane in the seaming area shall be dry and protected from wind and airborne particulates; and
- Geomembrane temperatures shall be measured with a surface temperature thermocouple or a calibrated infrared pyrometer.

If the PWSP wishes to use methods which may allow seaming at geomembrane temperatures below 0°C or above 75°C , the PWSP shall demonstrate (by testing trial seams) that such methods produce seams which are entirely equivalent to seams produced at geomembrane temperatures above 0°C and below 75°C , and that the overall quality of the seam and durability of the geomembrane are not adversely affected. In addition, the PWSP shall

prepare written certification that states that the seaming procedure does not cause any physical or mechanical modification to the geomembrane that will generate any short or long-term damage to the geomembrane liner.

10.3.4 Overlapping and Temporary Bonding

The Corporation or delegate will verify that:

- the panels of geomembrane have an overlap of approximately 100 mm, sufficient to allow peel tests to be performed on the inner track of the seam;
- there is a free flap at the edge of the top geomembrane a minimum of approximately 10 mm wide, to allow a peel test to be performed on the outer track of the seam;
- no solvent or adhesive is used unless the product is approved in writing by the Corporation;
- any procedure used to temporarily bond adjacent panels together does not damage the geomembrane. In particular, the temperature of hot air at the nozzle of any spot seaming apparatus shall be controlled such that the geomembrane is not damaged. "Damage" includes a loss in durability.
- temporary bonds do not interfere with the ability to perform shear and peel tests on the actual production seam.

If protective layers of geomembrane are placed on the barrier layer geomembrane for any purpose (e.g. puncture protection in drainage trenches), they shall not be tack or spot welded to the barrier layer. They shall be fully welded, except a small pressure relief segment, along the complete periphery of the protective layer or they shall not be welded at all.

10.3.5 Trial Seams

Trial seams shall be made by each machine/welder combination on strips of geomembrane to verify that seaming can be successfully performed. Such trial seams shall be made at the beginning of each seaming period (i.e., at the beginning and middle of each working shift), but at least once every four hours, for each seaming apparatus/welder combination used in the seaming period. In addition, a new trial seam shall be conducted when a welding apparatus has been restarted after being switched off. A trial seam shall also be made in the event that the geomembrane temperature changes more than 25°C since the last passing trial seam. Trial seams shall be made under the same conditions as production seams shall be made. When geomembrane temperatures are below 5°C or higher than 75°C more frequent trial seams may be required. In general, trial seams shall be conducted as follows:

The trial seam sample shall be at least 1.5 m long by 0.3 m wide with the seam centred lengthwise. Seam overlap shall be as indicated in Section 10.3.4. The Corporation or delegate will observe all trial seam procedures.

Four specimens, each 25 mm wide and a minimum of 150 mm long, shall be cut from the centre section of the trial seam sample by the PWSP. Two specimens shall be tested in shear and two in peel using a calibrated field tensiometer. They should meet project specifications. If any specimen fails, the entire operation shall be repeated. If the second trial seam fails, the seaming apparatus and seamer shall not be approved for production seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved. The remainder of the successful trial seam sample shall be assigned a number and marked accordingly by the PWSP Supervisor, who shall also log the date, time, geomembrane temperature, number of seaming unit, settings, name of seamer, and pass or fail description.

A trial seam shall also be prepared by each seaming machine/welder at the completion of seaming each day to determine whether changes in seam quality might have occurred during the last part of the seaming period.

10.3.6 General Seaming Procedure

Unless otherwise specified, the general seaming procedure used by the PWSP shall be as follows:

- For fusion seaming, a movable protective layer of thermoplastic may be placed directly below each overlap of geomembrane that is to be seamed. This is to help prevent any moisture build-up between the sheets to be seamed;

- If required, a firm substrate may be provided by using a flat board, or other similar hard surface placed directly under the seam overlap;
- Fishmouths or wrinkles at the seam overlaps shall be cut along the peak of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane material extending a minimum of 150 mm beyond the cut in all directions. The end of the cut should be rounded;
- If seaming operations are carried out at night, adequate illumination shall be provided;
- Seaming shall extend to the outside edge of panels placed in the anchor trench.

Each seam shall be labelled with the seaming machine number, the welder's initials, machine temperature and speed settings, date, time, and direction seamed. The Corporation or delegate will monitor the above seaming procedures, and will inform the Project Manager of any unsatisfactory deviations from standard practice.

10.3.7 Defects and Repairs

10.3.7.1 Identification

All seams and non-seam areas of the geomembrane shall be examined by the PWSP and the Corporation for identification of defects, protruding and penetrating objects, lack of subgrade support, overheating, overgrinding, holes, blisters, undispersed raw materials, scratches and gouges, and any sign of contamination by foreign matter. To facilitate the examination the geomembrane surface shall be kept clean by the PWSP or as agreed at a pre-installation Meeting.

10.3.7.2 Evaluation

Each suspected defect in-seam and non-seam areas shall be non-destructively tested using an appropriate method, such as vacuum box testing. Additional test methods, such as electrical methods and infrared thermography, may also be used. The position of each sample that fails to pass non-destructive testing shall be marked by the PWSP's Supervisor and shall be repaired. Repair work shall not be acceptable until destructive and nondestructive test results have confirmed compliance with specified requirements.

10.3.7.3 Repair Procedures

Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be by agreement between the PWSP and the Corporation.

The procedures available include:

- Patching, used to repair all penetrating holes, tears, undispersed raw materials, and contamination by foreign matter;
- Spot beading, used to repair small surface scratches, or other minor, localized non-penetrating flaws; and
- Capping with a strip of geomembrane, used to repair long lengths of failed seams.
- Surfaces of the geomembrane which are to be repaired shall be abraded no more than 30 minutes prior to the repair;
- All surfaces must be clean, free of all particulate matter, and dry at the time of the repair;
- All seaming equipment used in repairing procedures must be approved;
- The repair procedures, materials, and techniques shall be subject to advance approval of the specific repair by the Corporation or delegate;
- Patches and caps shall extend at least 150 mm beyond the edge of the defect, and all corners of patches shall be rounded with a radius exceeding 75 mm;
- The geomembrane below large caps should be appropriately cut to avoid fluid entrapment between the two sheets and resultant pressure increases (that stress the seams) as the liner is covered;
- Sharp ends of slits and cuts in the geomembrane should be rounded before patches are placed over them; and

- No more than one extrusion bead at any location shall be used to make a repair - multiple beading (more than two beads at any one location) is not permitted and must be replaced with a patch.

10.3.7.4 Verification of Repairs

Each repair shall be numbered and logged. Each repair shall be non-destructive tested using one of the methods described in Section 11.7 or another approved method. Repairs which pass the non-destructive test shall be considered acceptable. Failed tests shall require the repair to be redone and retested until a passing test results.

10.3.7.5 Large Wrinkles

When seaming of the geomembrane is completed (or when seaming of a large area of the geomembrane is completed) and prior to placing overlying materials, the Corporation or delegate will observe the sizes and distribution of geomembrane wrinkles. The PWSP shall seek agreement with the Corporation or delegate which wrinkles should be cut and re-seamed. The seam thus produced shall be tested like any other seam.

10.4 Plastic Lining – Reinforced Concrete Pipes

The joining and or repair of PVC or PE liners where used in reinforced concrete pipes shall comply with WSA 113.

11 Inspection and Testing

11.1 Inspection and Test Plans

Inspection and testing forms an integral part of the welding system. It ensures all parts of the pipeline including the material manufacture, design, and installation have been carried out in accordance with this code of practice. The PWSP shall ensure that the appropriate inspections and testing are carried out during the works.

Inspection and Test Plans shall be designed, approved and implemented for the required parts of the works including materials handling, installation and commissioning. Inspection and Test Plans (ITP) shall as a minimum include:

1. Description and item number of the activity;
2. Description of each test, examination (visual and holiday spark method) or inspection to be performed;
3. Responsible persons;
4. Reference documents, controlling specifications and procedures;
5. Acceptance criteria;
6. Verifying documents or check sheets; and
7. Provision for Hold, Witness, Verify and Review points.

ITPs shall be applied to specified sections of the works so as to allow sign off in discreet stages, not just at final completion. ITPs shall be approved and cover all stages of the works.

NOTE: The ITP itself may also be used as a check sheet.

11.1.1 Weld testing - Butt and Electrofusion joints

Joining pipes and fittings by electrofusion or butt welding shall be to an approved joining procedure that has been qualified by destructive testing in accordance with ISO 13954 “Plastics pipes and fittings - Peel decohesion test for polyethylene (PE) electrofusion assemblies of nominal outside diameter greater than or equal to 90 mm” and ISO 13953 “(Polyethylene (PE) pipes and fittings - Determination of the tensile strength and failure mode of test pieces from a butt-fused joint)” respectively.

Qualified Procedures may be grouped by diameter to reduce the amount of qualification testing. The recommended groupings are shown in table 4 below. The exception to this rule shall be for EFJ coupling welds where **all** pipe sizes shall be individually tested inclusive of electrofusion saddle welds.

Procedure Qualification Test Pipe Diameter and for each SDR	Type of Joining Process	Qualifies for Sizes
Any ≤ DN 225	Butt Weld	Any ≥ DN90 to DN225
Any > DN 225 to DN 355	Butt Weld	Any > DN 225 to DN 355
Any > DN 355 to DN 450	Butt Weld	Any > DN 355 to DN 450
Any > DN450	Butt Weld	All pipe sizes shall be individually tested.
Any ≥ DN90	Electrofusion Couplings and Electrofusion Saddle Welds	All pipe sizes shall be individually tested.

Table 4: Weld testing qualification requirements

11.2 Pipe Butt Fusion Welding - BFJ

11.2.1 Visual Examinations

Pipe joints made by butt fusion welding shall be visually inspected by the PWSP's supervisor prior to requesting the Corporation's representative to audit and provide acceptance of the same. *POP014 – Assessment of Polyethylene Welds* shall be used as the industry guideline for visual inspection.

Weld beads shall be uniform and symmetrical without sharp notches and shall also comply with the requirements of POP014. Pipe joints deemed by the Corporation not to meet these criteria shall be removed and re-welded.

11.2.2 Mechanical / Destructive Tests - BFJ

The PWSP shall provide samples of BFJ for destructive weld evaluation testing as follows. This shall apply for each welder and for each welding machine used on the job and repeated for any subsequent changes:

1. Pilot test/s weld joint in accordance with table 4. (Results for any test welds need to be reviewed prior to undertaking any production welds. To do so shall be at the Contractors/PWSP own risk);
2. One (1) production joint test weld in every 50 pipe joints maximum. If the project has less than 50 pipe joints then a single production joint test weld is required; and
3. Where testing reveals defects as determined by the test requirements, then welds either side of the weld that failed shall be cut out and tested. Testing shall continue till the PWSP can demonstrate the welds meet the testing requirements.

The test sample shall be prepared in accordance to ISO 13953. The test sample shall be joined with a *butt fusion* weld using the particular welding machinery, welders and welding process nominated by the PWSP for the particular PE pipeline project. Test samples shall be identified by pipe OD, SDR, PE material composition grade, date, chainage /location, welder number, machine and welding conditions at the time of welding.

BFJ weld samples shall be submitted by the PWSP for destructive testing to an approved NATA registered testing laboratory. The testing criteria shall be tensile fracture testing to ISO 13953. Bend testing to BS EN 12814 Part 1 is required where the specific installation includes deflection of the pipe or as deemed necessary by the Principal.

The PWSP shall pay for all testing and associated costs and shall provide the Corporation with the test results within 10 days of the test being undertaken or it shall be deemed as non-compliant.

The acceptance criteria for tested weld samples shall be in accordance with ISO 13953. The PWSP shall reinstate all butt fusion welds from the area of the pipeline represented by the test sample and identified from testing as not meeting the acceptance criteria.

All re-welds shall be inspected by the PWSP and shall be to the acceptance of the Corporation.

11.3 Electrofusion Pipe Joints – EFJ

11.3.1 Visual Examinations

Pipe joints made by electrofusion welding shall be visually inspected by the PWSP's supervisor prior to requesting the Corporation's representative to audit the same. *POP014 – Assessment of Polyethylene Welds* shall be used as the industry guideline for visual inspection.

Couplings and saddles that indicate alignment or deflection errors, short circuiting, exposed wires, failure of coupling melt indicators and or melt outside the weld zone shall be cut out and re-welded. Pipe joints deemed by the Corporation not to comply with the requirements of POP014 shall be re-welded.

11.3.2 Mechanical / Destructive Tests – EFJ Couplings

The PWSP shall provide samples of EFJ Couplings for destructive weld evaluation testing as follows. This shall apply for each welder and welding machinery used on the job and repeated for any subsequent changes:

1. Pilot test/s weld joint shall be carried out in accordance with table 4. (Results for any test welds shall be reviewed prior to undertaking any production welds.);
2. One (1) production joint test weld in every five (5) EF joints; and
3. Where testing reveals defects as determined by the test requirements, then welds either side of the weld that failed shall be cut out and tested. Testing shall continue till the PWSP can demonstrate the welds meet the testing requirements.

The samples shall consist of two pipe lengths joined with an electrofusion weld made on site using welding machinery and welders engaged in the pipeline and the welding process. Test samples shall be cut such that there is a minimum of 300mm of pipe protruding either side of the coupling joint. Test samples shall be identified by pipe OD/SDR, PE grade, date, chainage / location, welder number, machine and welding conditions at the time of welding.

Electrofusion pipe weld samples shall be submitted by the PWSP for testing to an approved NATA registered testing laboratory. Electrofusion coupling welds shall be tested for Peel de-cohesion in accordance with requirements of ISO 13954.

Electrofusion saddle joints shall be tested in accordance with ISO 13954 or ISO 13955.

The PWSP shall pay for all testing and associated costs and shall provide the Corporation with test results within 10 days of the test being undertaken or it shall be deemed as non-compliant.

The acceptance criteria for tested weld samples for EFJ shall be 100% ductile at the plane of the fusion zone or 100% ductile at the pipe or coupling as outlined in ISO 13954.

11.3.3 Mechanical / Destructive Tests - EFJ Saddles

The PWSP shall provide samples of EFJ Saddles for destructive weld evaluation testing as follows. This shall apply for each welder, welding machinery and different manufacturer's EF couplings used on the job and repeated for any subsequent changes:

1. Pilot test/s weld joint shall be carried out in accordance with table 4. (Results for any test welds shall be reviewed prior to undertaking any production welds.);
2. One (1) production joint test weld in every ten (10) EFJ Saddles; and
3. Where testing reveals defects as determined by the test requirements, then welds either side of the weld that failed shall be cut out and tested. Testing shall continue till the PWSP can demonstrate the welds meet the testing requirements.

11.3.4 Field Pressure Test – EFJ Saddles

The PWSP shall undertake a field pressure test on each welded saddle between the saddle and pipe OD in accordance with manufacturer's requirements. The test shall be witnessed by a WC representative prior to removal of the coupon. Formal notification shall be provided to WC a minimum of 3 days prior to test being undertaken.

Where testing reveals defects, investigate and rectify cause of failure prior to resumption of welding. The defective saddle shall be left in place unless otherwise directed.

11.4 Hydrostatic testing of welded pipelines

11.4.1 Pipeline testing requirements

Pipeline installation, construction and testing requirements are specified in project documents including technical workmanship specifications. In the absence of pressure testing requirements, testing shall be undertaken in accordance with Water Corporation's PT modular specification.

The Contractor / PWSP shall pay for all testing and associated costs and shall provide the Corporation with the test results within 10 days of the test being undertaken or it shall be deemed as non-compliant.

11.5 Hot Air Welding and Extrusion Welding

11.5.1 Visual Examination

Pipe joints made by hot air welding shall be visually inspected by the PWSP's supervisor prior to requesting the Corporation's representative to audit the same. All welded joints shall meet the requirements of DVS 2202-1, evaluation group 2. Joints in sheet and membranes deemed by the Corporation not to meet these criteria shall be re-welded. The cost of remedial works shall be the responsibility of the PWSP.

11.5.2 Mechanical Destructive Testing

Destructive tests are only required of test samples to qualify a procedure or provide assurance on the application of a process.

Following the completion of the weld and allowing enough time to cool, the area at the toes of the newly made weld need to be tested.

11.5.3 High Voltage Spark Testing

Following visual examination and repairs of production welds where necessary, all welded joints shall be tested with high voltage spark testing. Testing to be carried out in accordance with AS 3894 or as specified by the thermoplastic supplier. The test voltage parameters need to be agreed by the PWSP and the Corporation during submission of quality plans and the ITP. Prior to testing each spark tester shall be calibrated using a calibrated and certified Crest Meter. The Crest meter shall be calibrated at a frequency of no greater than two years.

A permanent record shall be prepared and made available to the Principal for review and approval for the spark testing of works completed noting compliance.

11.6 Solvent Welding

Pipelines shall be pressure tested as per the requirements of the project specifications.

11.7 Membrane and Liner Welding

The following sections are intended to address the testing requirements of membrane and liners other than thermoplastic liners used in reinforced concrete pipes. The requirements for reinforced concrete pipe linings are stated in Section 11.7.3 of this specification.

11.7.1 Nondestructive Seam Continuity Testing

11.7.1.1 Concept

The PWSP shall non-destructively test all field seams over their full length using a vacuum test unit, air pressure test (for double fusion seams only), spark test, or other approved method. Vacuum testing, air pressure testing and spark testing are described in Sections 11.7.1.3, 11.7.1.4 and 11.7.1.5 respectively. The purpose of non-destructive testing is to check the continuity of seams. It does not provide any information on seam strength. Continuity testing shall be carried out as the seaming work progresses, not at the completion of all field seaming. Non-destructive testing shall not be permitted unless there is adequate illumination.

The PWSP Supervisor shall:

- Observe all non-destructive testing;
- Record location, date, test unit number, welder, and outcome of all testing;
- Log and inform the Corporation or delegate of any required repairs.

The PWSP shall complete any required repairs in accordance with Section 10.3.7.3.

The PWSP Supervisor shall:

- Observe the repair and re-testing of the repair;
- Mark on the geomembrane that the repair has been successfully made and tested; and
- Document the results.

The following procedures shall apply to segments of seams that cannot be non-destructively tested:

- All such seam segments shall be cap-stripped with the same type of geomembrane material, or
- All such seam segments shall be very carefully prepared and welded by the master seamer under the observation of the consultant.
- If the seam is accessible to testing equipment prior to final installation (e.g. after prefabrication), the seam shall be non-destructively tested prior to final installation.

The seaming and cap-stripping operations must be observed for proper procedures by the PWSP Supervisor.

The PWSP shall write the details of each seam non-destructive test on the geomembrane. For air pressure tests this shall include the initials of the tester, the date, start time and pressure, end time and pressure, and pass or fail result. For vacuum testing this shall include the initials of the tester, the date, and pass or fail result. For spark testing this shall include the initials of the tester, the date, voltage setting, and pass or fail result. When a test fails, the number of the appropriate repair shall also be recorded on the geomembrane.

11.7.1.2 Submittals

Prior to any non-destructive testing, the PWSP shall submit to the Corporation calibration certificates for all pressure gauges to be used during vacuum and air pressure testing, or shall otherwise demonstrate that all gauges are in satisfactory working condition.

11.7.1.3 Vacuum Box Testing

The equipment shall be comprised of the following:

- A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole, valve assembly, and a vacuum gauge;
- A vacuum tank and pump assembly equipped with a pressure controller and pipe connections;
- A pressure/vacuum hose with fittings and connections;
- A soapy solution that does not cause environmental stress cracking in the geomembrane, and
- A soap solution applicator.

The following procedure shall be followed:

- For fusion seams (not normally tested with a vacuum box), cut off the free flap with an approved cutter (so that the lower geomembrane is not damaged) prior to testing the seam;
- Energize the vacuum pump and reduce the tank pressure to approximately 5 kPa gauge;
- With a soapy solution, wet a strip of geomembrane which is wider and longer than the vacuum box;
- Place the box over the wetted area;
- Close the pressure relief valve and open the vacuum valve;
- Ensure that a leak-tight seal is created;
- Examine the geomembrane seam through the viewing window for the presence of soap bubbles (large bubbles, or fine froth) for a period of not less than 5 seconds;
- If no bubbles or foam appear after 5 seconds, close the vacuum valve and open the pressure relief valve. Move the box over to the adjoining section of seam, with some overlap, and repeat the process;
- All areas where soap bubbles appear shall be marked and repaired in accordance with Section 10.3.7; and
- Excess soap solution shall be cleaned or rinsed off the geomembrane and seam.

11.7.1.4 Air Pressure Testing

The following procedure is applicable to those seaming processes which produce a double track seam with a central channel.

The equipment shall be comprised of the following:

- An air pump equipped with a pressure gauge capable of generating and sustaining a pressure between 160 and 280 kPa mounted on a cushion to protect the geomembrane;
- A pressure hose with fittings and connections;
- A sharp hollow needle, or other approved pressure-feed device attached to a pressure gauge; and
- Clamps or other devices to seal the ends of the seam to be tested.

The following procedures shall be followed:

- Seal both ends of the seam to be tested;
- Insert the pressure-feed device into the channel of the seam;
- Energize the air pump to a pressure between 165 and 275 kPa (depending on geomembrane thickness) as indicated in Table 5, close the valve, and allow the temperature of the air in the channel, and thus the pressure, to stabilize for about 2 minutes;

Geomembrane Thickness		Minimum Pressure		Maximum Pressure	
(mm)	(in.)	(kPa)	(psi)	(kPa)	(psi)
1.0	0.040	165	24	240	35
1.5	0.060	185	27	275	40
2.0	0.080	205	30	275	40

Table 5: AIR CHANNEL TEST PRESSURES FOR HDPE GEOMEMBRANES

- Verify that the stabilized pressure is within the required range and note the pressure loss after a further 2 minutes. If loss of pressure exceeds the amount indicated in Table 6, or if the pressure does not stabilize, locate the faulty area and repair it in accordance with Section 10.3.7

Geomembrane Thickness		Maximum Pressure Drop	
(mm)	(in.)	(kPa)	(psi)
1	0.040	28	4.0
1/5	0.060	21	3.0
2.0	0.080	14	2.0

Table 6: ALLOWABLE PRESSURE LOSS IN AIR CHANNEL TEST

- Verify that the full length of the seam section has been tested by observing the air pressure gauge for a decrease in pressure when the seal at the end of the channel away from the air pump is removed. If there is a blockage in the channel, the entire seam must be capped, with cap seams being non-destructively tested, or the location of the blockage must be found and the untested part of the seam must be properly tested and
- Remove the needle or other approved pressure-feed device and seal the hole using extrusion welding or an approved process.

NOTE: A decrease in the geomembrane temperature (e.g. due to clouds /over cast day) shall also cause a reduction in air channel pressure.

11.7.1.5 Spark Testing

Spark Testing performed according to ASTM D6365 or AS 3894 is frequently used in awkward positions and extrusion welds that cannot be tested by vacuum box testing. Occasionally it is used on long extrusion seams as the primary non-destructive test method. The same general test method can also be applied to the geomembrane panels themselves when they are manufactured with an electrically conductive bottom surface layer.

For seams, a copper wire or tape is placed within the geomembrane overlap, just to the inside of the centre of the extruded bead. The wire is exposed at one end of the seam or it is buried in the conductive subgrade.

Prior to testing, a trial calibration seam must be made to confirm the minimum voltage required to discharge across a hole in the seam between the search electrode and the copper wire.

The test procedure is as follows:

- Connect the negative (ground) electrode of the testing equipment to the end of the copper wire, or to a grounding rod if the copper wire is buried in the subgrade;
- Connect the positive electrode to the wire brush or other type of search electrode;
- Clean all debris and moisture from the seam area;
- Apply a potential difference, as determined in the calibration test, between the electrodes. ASTM D6365 and AS 3894 recommends the following equation to determine the required potential difference:
 - $V = 250\sqrt{T}$ where T is the thickness in microns
- Sweep the wire brush electrode over the surface of the seam, maintaining contact with the extruded bead and the top of the lower geomembrane at the edge of the bead;
- Monitor for audible and/or visible spark discharges that are indicative of a defect. Mark defects for repair. Spark testing must not be performed when the liner is wet.

11.7.1.6 Visual Examination

Air pressure, vacuum box, and spark testing methods apply only to seams. PWSP personnel shall continuously visually examine the geomembrane panels for the presence of other penetrating and non-penetrating defects and shall continuously feel for protuberances when walking on the geomembrane.

Visual examination should take advantage of low angles of sunlight and early morning condensation on the geomembrane.

11.7.2 Destructive Testing

Destructive seam tests shall be performed at selected locations and shall be guided by ASTM D6392. The purpose of these tests is to evaluate seam bond strength and the effects of seaming on the adjacent geomembrane. Seam strength testing shall be done as the seaming work progresses, not at the completion of seaming.

11.7.2.1 Location and Frequency

The Corporation or delegate will select locations where seam samples shall be cut out for laboratory testing. Those locations shall be established as follows:

- A minimum frequency of one sample for every 150 m of seam made by each extrusion machine/welder combination and each fusion machine each day - unless a different frequency is stated in the project specifications.
- Conditions under which testing frequency may be increased or decreased as the project progresses shall be agreed upon by the PWSP and the Corporation.
- Test locations shall be determined during seaming at the Corporation's discretion. Selection of such locations may be prompted by suspicion of overheating, contamination, offset seams, or any other evidence of imperfect seaming;
- If trial seams are not made at the end of the day one sample for destructive testing shall be removed from the last seam made by each seaming machine at the end of each working day.

The PWSP will not be informed in advance of the locations where the seam samples will be taken.

Test frequencies may be increased or decreased at the Corporation's discretion depending on the consistency of the test results.

11.7.2.2 Sampling Procedure

Samples shall be cut by the PWSP as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material.

The PWSP's Supervisor shall:

- Observe sample cutting;
- Assign a number to each sample, and mark it accordingly; and
- Record the sample location on the layout drawing.

All holes in the geomembrane resulting from destructive sample removal shall be immediately repaired in accordance with repair procedures described in Section 10.3.7. The continuity of the new seams in the repaired area shall be tested according to Section 11.7.1.

11.7.2.3 Size of Samples

At a given sampling location, two types of samples shall be taken by the PWSP, (refer sketch below). First, two pairs of specimens for field peel and shear testing shall be taken. Each of these specimens shall be 25 mm wide by at least 150 mm long, with the seam centred across the width.

The distance between these two pairs of specimens shall be 0.8 m. If both pairs of specimens pass the field tests described in Section 11.7.2.4, a sample for laboratory testing shall be taken. The sample for laboratory testing shall be located between the two pairs of specimens taken for field testing. Unless determined otherwise at the Preconstruction Meeting, or in the Project Specifications, the destructive sample shall be 0.3 m wide by 0.8 m long with the seam centred lengthwise.

The sample shall be cut into two parts and distributed as follows:

- one portion, measuring 0.3 m x 0.5 m, to the PWSP for QC laboratory testing;
- one portion, measuring 0.3 m x 0.3 m, to the Corporation to be retained for further testing if required.

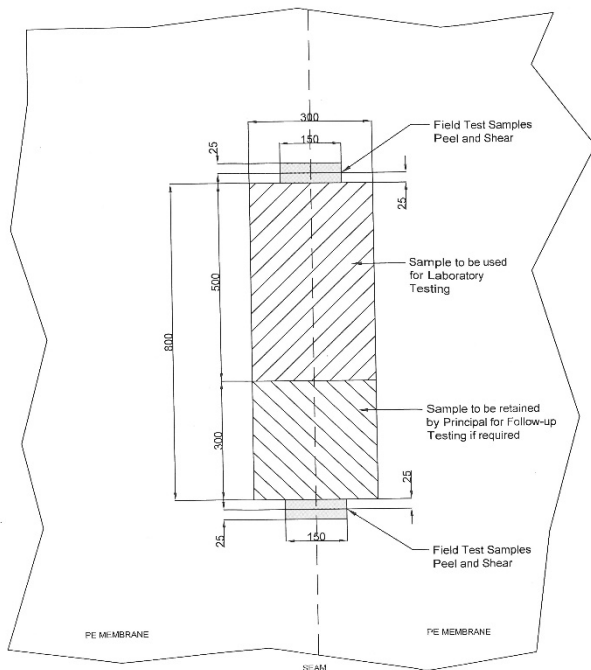


Figure 1: Membrane Sample Dimensions

11.7.2.4 Field Testing

The four 25 mm wide specimens mentioned in Section 11.7.2.3 shall be tested in the field, by calibrated gauge tensiometer, one of each pair in peel and one in shear. If any field test specimen fails to pass the criteria of Table 7 and the project specifications, then the procedures outlined in Section 11.7.2.5 shall be followed.

The Corporation shall witness - field tests and mark all samples and portions with their unique sample number.

If the two pairs of specimens meet the project specifications, the sample qualifies for testing in the nominated laboratory; if they fail, the seam should be repaired in accordance with section 10.3.7.

Parameters	Criteria
Peel Strength	Fusion seam > 70% Extrusion seam > 65% Minimum specified* geomembrane yield strength
Seam Separation	Zero
Shear Strength	> 95% minimum specified* geomembrane yield strength
Elongation	> 100% of distance between edge of seam and nearer grip
Location of Failure	Outside the weld

Table 7: SEAM SPECIMEN TEST (ASTM D4437) SPECIFICATIONS

* The yield strength specified by the Manufacturer, which is usually the population average value, less 2 standard deviations.

11.7.2.5 Procedures if Destructive Sample Fails

The following procedures shall apply whenever a sample fails a destructive test, whether that test is conducted by the testing laboratory, or on the field tensiometer.

The PWSP has two options:

1. Reconstruct the seam between the nearest passing destructive test locations on each side of the failed sample; or
2. Trace the seaming path to an intermediate location (3 m minimum from the failed test location in each direction) and take a small sample for an additional field test at each location. If these additional samples pass tensiometer testing, then full destructive test samples should be taken. If these laboratory destructive test samples pass the tests, then the seam should be reconstructed between these locations by capping. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

If a fusion-type seam fails destructive testing and the Installer chooses to repair the seam, the only acceptable repair method is as described in Section 10.3.7.

Applying topping (bead of extrudate) is not an approved method of capping any seam unless it can be shown that this procedure will not reduce the stress rupture resistance of the seam below 75% of that of the parent geomembrane.

Only seams bounded by two locations from which samples passing laboratory destructive tests have been taken shall be considered acceptable. An additional destructive test sample shall be taken from repair seams when the length of a reconstructed seam exceeds 50 m. This sample must pass destructive testing or the procedure outlined in this section must be repeated. The PWSP shall document all actions taken in conjunction with destructive test failures.

11.7.3 Plastic Lining – Reinforced Concrete Pipe

Testing of weld joints and repair of PVC or PE liners in reinforced concrete pipes shall comply with WSA 113.

12 Consumables, Maintenance, Servicing and Calibration

Surfaces prepared for assembly and welding, including welding equipment shall be wiped with an isopropanol solution having a minimum concentration of 90% and a lint free cloth. Use of methylated spirits, acetone, methyl ethyl ketone (MEK) or other solvents is not permitted.

All equipment shall be well maintained and kept in a clean condition both in stores and all times at site. Equipment shall be serviced and calibrated regularly. The frequency at which this is carried out shall be different for individual items of equipment and will depend on usage but shall be at least once every twelve (12) months.

Equipment that has been repaired resulting from damage or modification shall be serviced and calibrated on completion of repair or modifications regardless of the last calibration date. Servicing shall be carried out but not limited to the heater plate, the hydraulic or pneumatic unit, the frame / clamp unit, trimming tools, electro-fusion welding generator, pressure gauges and data loggers. Welding machines and associated equipment shall always be in good working order. Frequent breakdowns are unacceptable with the particular machinery being quarantined and removed from site.

Pressure gauge calibration shall be certified by a NATA laboratory or NATA traced master gauge. Electronic or written records of appropriate servicing and calibration reports shall be kept and made available on request.

Infrared non-contact thermometers shall be calibrated by comparison to a Certified (NATA Endorsed Test Report) test thermometer sensor, using a black body source. Checking interval against a reference device at the temperature of use shall be every 6 months. Electronic or written records of appropriate servicing and calibration shall be kept and made available on request.

13 Welding Safety

13.1 General

The Contractor / PWSP shall ensure that all employees have completed the relevant induction process for working on Water Corporation sites. A Job Safety Analysis (JSA) shall be in place for every task.

The Water Corporation strongly supports the use of *WTIA Tech Note 7- Health and Safety in Welding*.

13.2 Portable and Handheld Tools

All portable or handheld electrical tools that are intended to be moved when in operation shall be protected by an RCD (Residual Current Device).

The RCD shall be:

- In-built to a generator set; or
- Built into the construction site switchboard; or
- Built into the switchboard or the power outlet of an established premises; or
- A portable RCD that is plugged directly into the power socket outlet.
- Inspected and tagged quarterly by a competent person.
- Protective guards shall not be removed during use of the hand tool.

All electrical tools shall have the quarterly electrical test tags.

13.3 Hot Work

Plastic welding of the type described in this Specification is deemed 'Hot Work', and shall be carried out in accordance with

- the Water Corporation's procedure HSEAA-P-134 "Hot Work" (and applying the associated Hot Work Permit where there is a credible fire risk); and
- AS1674.1- Part 1 Fire Precautions; and
- the West Australian Bush Fire Act 1954 and FESA Act 1998

Hot work MUST not proceed when a Total Fire Ban (TFB) is in place. If the work is considered essential and must be undertaken on a TFB day, the Supervisor must notify the Operations Manager who must enact a Total Fire Ban exemption in order to conduct hot work. Refer to Section 7.6 of the HSEAA-P-134 "Hot Work" procedure for further guidance.

13.4 Working in a Confined Space

Where work is intended to be carried out in a confined space, all personnel carrying out the activity shall be suitably trained and qualified to work in a confined space and shall comply with the Water Corporation Safe Working in Confined Space Procedure – HSEAA-P-124 'Confined Space' procedure.

13.5 Safe Working with Coatings and Wrapping

When replacing existing steel pipes with PE pipes and there is a requirement to cut out the old section of pipe, personnel need to be aware that some older pipe coatings as described below may present a health risk.

Some bitumen based pipe wrapping materials have been found to contain asbestos fibres. These fibres are physically stable but may present a risk to health if disturbed during the process of removal of the coating or handling.

The external coatings of all buried steel pipe coated in coal tar enamel or other bitumen based material manufactured prior to 1985 shall be treated as containing asbestos and procedures for safe removal, handling and disposal shall accordingly apply.

This and other work that involves asbestos containing materials shall be carried out in accordance with the Water Corporation Safety Procedure HSEAA-P-131 'Working with Asbestos'.

13.6 Working Hours and Fatigue Management

All personnel undertaking work shall be aware and adhere to the Water Corporation Fatigue Management & Working Hours Standard S333 and Western Australia legislative acts.

13.7 Working at Heights

All personnel undertaking work shall be aware and adhere to the Water Corporation Prevention of Falls Standard S151 and procedure HSEAA-P-143 'Falls'.

13.8 Solvents and Fire Hazard

All personnel undertaking work shall be aware and adhere to the manufacturer's recommendations and the Material Safety Data Sheets (MSDS) in the handling and use of solvents. MSDS's for all solvents or chemicals used in the welding processes shall be kept onsite and available at all times. Whilst handling solvents the appropriate PPE as determined by the JSA shall be used.

Thermoplastic faces to be joined by welding shall be thoroughly cleaned of any solvent residue prior to the joint being assembled as remnant solvent could have the potential to start a fire especially in EFJ joints.

13.9 Inhalation and Fumes

The PWSP shall ensure adequate ventilation during welding of thermoplastics. When using Hot Air welding the welder shall at a minimum use a P2 flame retardant respirator.

13.10 Specific Risk Related to Thermoplastics

All thermoplastics are flammable. The temperature at which they ignite and the ferocity with which they burn varies, but all release toxic fumes as they decompose. Never leave material on or near a combustible heat source such as open fires of any kind. Store thermoplastics away from work areas where possible. Always keep fire extinguishers or at least a bucket of sand in the workshop/ work area.

Many thermoplastics release fumes when overheated during machining. Use of an appropriate coolant will help to avoid this.

13.11 Handling and Disposal of Solvents

Solvents and adhesives can also produce potentially dangerous fumes which require exhausting. Fumes can cause nausea, irritability, drowsiness or in extreme cases, coma.

Solvents need to be stored away from any source of combustion. Machining acrylic results in high dust levels. Liquid coolant helps absorb dust in certain processes, but grinding, sanding, filing or hand shaving / sawing, must be done in well-ventilated area with appropriate protective equipment.

Any excess or unused solvents shall be removed from site and disposed of at a registered chemical disposal site.

13.12 Disposable of Thermoplastic Waste

All swarf, shavings and offcuts produced during the welding and/or fabrication process shall be collected and disposed of to a registered plastics recycler.

Burial of waste thermoplastic materials is not permitted.

Appendix A - Welding Documentation Requirements

SPECIFICATION WS-2: Installation, Welding and Jointing Thermoplastics

1.0 QUALITY ASSURANCE SYSTEM

Quality Assurance Systems Allowed:

- | | | |
|--------------------------------|--------------------------|--|
| | Yes/No | |
| 1.1 AS/NZS ISO 9001 | <input type="checkbox"/> | |
| 1.2 AS/NZS ISO 3834.3 | <input type="checkbox"/> | |
| 1.3 Other International System | <input type="checkbox"/> | |

Clause	Item	Submission	Precondition	WC Approval/Outcome	Plan/Actual Dates
7	Detailed Welding management system	Details for assessment	Type of system	Accept/Reject Within 10 working days	

Sub-Contractor to be used: Yes No

Clause	Item	Submission	Precondition	WC Approval/Outcome	Plan/Actual Dates
7	Sub-Contractor full Details	Details for assessment	Sub-Contractors to be used.	Accept/Reject Within 10 working days	

Intent to use Alternative Processes Yes No

Clause	Item	Submission	Precondition	WC Approval/Outcome	Plan/Actual Dates
8	Welding Process/s	Intent to use alternative processes.	Before development of welding procedure.	Accept/Reject Within 10 working days	

10 Days Prior to Planned Commencement of Works.

Clause	Item	Submission	Precondition	WC Approval/Outcome	Plan/Actual Dates
7	Quality Plan	As detailed	Approved	Yes/No	
7	Qualification of Welding Procedures	Schedule of qualified procedures		Accept/Reject	
8	Welding Procedure Sheet (WPS)	All major parameters/essential variables and as per 7.2 advise copies held available to workplace.		Accept/Reject	

Clause	Item	Submission	Precondition	WC Approval/Outcome	Plan/ Actual Dates
8	PWSP	Nominate qualified person responsible.		Accept/Reject	
9	PWSP details	Qualification/ certification and experience, records.		Yes/No	
8	Welding Inspector	Qualification, certification and experience.		Yes/No	
9	Welding Supervisor	Qualification, certification and 2 years relevant experience.	Acceptance	Yes/No	
9	Welder qualified to Qualified Welding procedures	Details for each welder	Acceptance	Yes/No	
9	Welder qualification, certification, etc.	Qualification/ certification and experience, records.	Acceptance.	Yes/No	
11	Inspection/Test Plan	Inspection + Test Plans (ITP's)		Accept/Reject	

Before Welding Commences

Clause	Item	Submission	Precondition	WC Approval/Outcome	Plan/ Actual Dates
6	Commencement	Request approval to commence	All Pre conditions met	Yes/No	

Identification and Traceability after Welding Done

Clause	Item	Submission	Precondition	WC Approval/Outcome	Plan/ Actual Dates
7.4	Identification of welders to welds.	Records	Work Done	Accept/Reject	

Testing

Clause	Item	Submission	Precondition	WC Approval/Outcome	Plan/ Actual Dates
11	Testing	Test Certificates (destructive or non-destructive)	Work Done NATA Acquitted. Lab.	Accept/Reject Compliance	
11	Pilot weld testing	Test Results	Work Done	Witness and Accept/Reject	
7.5 & 11	Testing records	Supply as part of MDR	Work & Tests done	Accept/Reject Compliance	

Requalification when Essential Variables fall outside Standard/Code Limits

Clause	Item	Submission	Precondition	WC Approval/Outcome	Plan/Actual Dates
8.11	New Procedure	Qualification of New Welding Procedure	Change after work commences	Accept/Reject Review/Release Hold Pt.	

Appendix B: Butt Welding Traceability Report/Register

(as per ISO 21307:2017 and WS2)

Project Number:		Project Name:						Sheet No: of					
HDPE Welding Panel Company:		Butt Welding Procedure:		Single Low Fusion		High Fusion Pressure							
Welding Operator /ID number:													
PWSP/Supervisor:													
Welding Machine:		Serial Number:		Temperature gun S/N / calibration date:									
Cylinder Area: (mm ²)		Welding Machine calibration date:				Cleaning Fluid Manufacture / Date /MSDS:							
		Pipe Manufacture / Date Manufactured:											
Pipe Material		Pipe Size DN		SDR		PN		Average Wall Thickness: mm					
Welding Parameters (pressure in bar, time in minutes & seconds, temperature in Celsius)													
Pipe Weld Number and Date Welded	Ambient Temp (deg C)	Cleaning Wipes / Fluid Batch No.	Axial mis-alignment weld joint (mm)	Welding Machine ID / No.	Heater Plate Temp all welds (deg C)	Weld Location / Chainage	Weld Soak Pressure and Time (Bar) (Minutes / Seconds)	Bead Size (mm)	Heater Plate removal time (Secs)	Welding Fusion Pressure + Drag (Bar)	T5 Weld cool time in clamps under pressure (Mins)	T6 Weld cool time in clamp without pressure. (Mins)	Pipe Wall Thickness (mm)
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Welding Technician Signature / Date: _____

PWSP QA/QC Signature / Date: _____

Template WS-2



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Appendix C - Inspection Release Form

IRC No.

SHEET OF

INSPECTION ASSIGNMENT No.

INSPECTOR'S NAME PROJECT No.

PROJECT

SUPPLIER

SUBCONTRACT/ORDER No.REV

SUBSUPPLIER

SCOPE OF WORK

ADDRESS

MATERIALS RELEASED

P.O. ITEM No.	QTY ORDERED	QTY RELEASED	DESCRIPTION	ITEM CODE	HEAT / BATCH / CAST No.	TEST CERT No.

<p style="text-align: center;">TQ's, NCR's, PUNCHLISTS ETC</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p>	<p>COMPANY SIGNATURE</p>	<p>DATE</p>
<p style="text-align: center;">DESTINATION OF MATERIALS</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p> <p style="text-align: center;">.....</p>	<p>CLIENT SIGNATURE</p>	<p>DATE</p>
<p>THIS CERTIFICATE IS A CLEARANCE FOR SHIPMENT ONLY AND DOES NOT RELIEVE THE SUPPLIER OF ITS CONTRACTURAL OBLIGATIONS.</p>		

End of Document