Asset Delivery Group
Mechanical and Electrical Services Branch

WELDING AND JOINING SPECIFICATIONS

WS-2 THERMOPLASTICS

VERSION 1
REVISION 5
JUNE 2017
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 Principal Engineer Mechanical, Mechanical and Electrical Services Branch 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 / gas 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.

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

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

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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 of anything 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

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## 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 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/NZ ISO 9001 Quality management systems – Requirements;
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 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 12176-2  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 13956 Plastic 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;
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;
PMB07 Plastics, Rubber and Cablemaking Training Package;
POP003 Butt Fusion Jointing of PE Pipes and Fittings - Recommended Parameters;

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
S151 Prevention of Falls;
WC-OSH 108 Safe Working in Confined Spaces;
WC-OSH 125 Hot Work Adjacent to Gas Mains;
WC-OSH 126 Hot Work in Hazardous Areas
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/mirror 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;

**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/mirror and then brought together under pressure to form the weld;

**Hot gas welding** means a welding process which uses a stream of heated gas, usually 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.

**ITP** means the 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 Data Report;

NATA means National Association of Testing Authorities;

PE means Polyethylene;

Pilot Test Weld means the first 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 accredited by Australian National Training Authority (ANTA);

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;

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 / 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 / Parameter card depend on the application and criticality of the joint to be welded. A welding procedure / 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 Codes

#### 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 **VC-U, PVC-M, PVC-O & PVC-C Pressure Pipes**

Where specified, PVC-U pressure pipes and fittings suitable for solvent weld jointing, shall comply with AS/NZS 1477. 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).

Pipes and fittings shall be third-party certified by a JAS-ANZ accredited certifier under the Standards Mark or WaterMark schemes or acceptable equivalent.

PVC-U and PVC-M solvent welded jointing work shall comply with the requirements of AS/ NZS 2032 and this technical specification.  
Solvent cements for PVC-U and PVC-M shall be type P complying with AS / NZS 3879. For PVC-C, priming fluids and solvent cements shall comply with ASTM F493.

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 the 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.

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

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

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 gas 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

Polyethylene pressure pipe and fittings shall comply with SPS 125.

Pipes and fittings shall be third-party certified by a JAS-ANZ accredited certifier under the StandardsMark, or WaterMark schemes or equivalent. Jointing of PE pipe shall be in accordance with Table 2 below.

<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>Allowable Jointing Technique</th>
<th>Preferred Jointing Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ DN 90</td>
<td>Mechanical coupling, EFJ</td>
<td>Mechanical coupling</td>
</tr>
<tr>
<td>&gt; DN 90 ≤ DN 450</td>
<td>EFJ, BFJ</td>
<td>BFJ</td>
</tr>
<tr>
<td>&gt; DN 450</td>
<td>BFJ</td>
<td>BFJ</td>
</tr>
</tbody>
</table>

Table 2 JOINING TECHNIQUES FOR PE PIPE
As far as practicable the designer and the PWSP shall only use the BFJ welding process to join PE pipes. EFJ welding is least preferred and shall only be selected for pipe string tie-ins or tapping off takes.

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 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 intended for welding shall be transported and stored on site shielded from sunlight and from the weather and shall be maintained in their original sealed packaging until they are to be placed on the pipe. 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

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

<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>Allowable Jointing Technique</th>
<th>Preferred Jointing Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ DN 125</td>
<td>Socket Fusion, EFJ, BFJ</td>
<td>Socket Fusion, BFJ</td>
</tr>
<tr>
<td>&gt; DN 125 ≤ DN 250</td>
<td>EFJ, BFJ</td>
<td>BFJ</td>
</tr>
<tr>
<td>&gt; DN 250</td>
<td>BFJ</td>
<td>BFJ</td>
</tr>
</tbody>
</table>

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. EFJ welding is least preferred and shall only be selected for pipe string tie-ins, tapping off takes or where other jointing techniques are neither practicable nor available.

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 a JAS-ANZ 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 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 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% ± 0.25% by mass of carbon black to provide UV resistance.

For both PVC and PE:
- 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 gas welding (PE and PVC) in accordance with DVS 2207-3, Hot gas welding of thermoplastic sheets and pipes and DVS 2207-3 (Supplement). Hot gas 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.

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 / parameter cards as defined in WELDING PROCEDURE / PARAMETER CARD.
- Pre-qualified procedures previously tested and proven shall be acceptable.
- For pipe welding, pre-qualified welding procedures for an equivalent pipe size and diameter shall be acceptable.
- Where pre-qualified procedures are not available, the welding procedure shall be verified by the preparation of test welds. Test welds shall be witnessed, produced and tested as required in Section 11;
- Equipment Maintenance and Calibration details including but not limited to pressure gauges;
- A detailed list of welder qualifications;
- PWSP Supervisor qualifications and documented statement of experience;
- 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 PWSP Organisational Responsibilities

The 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.

Test weld/s shall be witnessed by the PWSP’s supervisor prior to commencement of all works. Test weld/s shall be made using Welding Procedures as defined in Section 5. Test weld/s shall be carried out using all proposed site welding machines, by all welders involved in the work.

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 JAS/ANZ. 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 07 competencies for the specified work;
2. Documented welding and joining procedures specifications are in accordance with the welding standard specified;
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 B 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 is downloaded daily.

7.4 Welded Joint Traceability

The PWSP shall maintain traceability demonstrating the welder identification number performing the welding / jointing work corresponding with construction chainage as stipulated on the project plans.
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 Data Report

At the completion of a project the PWSP shall submit a Manufacturers Data Report (MDR) to the Corporation. The MDR shall be compiled concurrently during construction. 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 as applicable.

8 Qualification and Documentation of Welding and Joining Procedures

As required per section 7 Quality Assurance, the PWSP shall work to a welding procedure / parameter card for a given material and process. Welding / 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/parameter card shall be provided for each of the following welding techniques.

8.1 Butt Fusion Welding

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 proper melt temperature is achieved, bringing the ends together in a timely manner and allowing the joint to cool whilst maintaining the fusion faces under a predetermined force.

Records where the procedures were previously tested and proven for a given pipe size and SDR, shall be acceptable. Where prior records are not available a test piece shall be produced and tested to the mechanical requirements listed in Section 11.

The butt fusion procedure / parameter card shall have as a minimum the following information:
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;
7. Procedure unique identification;
8. Fusion machine type;
9. Fusion machine serial No;
10. Fusion parameters – Low / High / Dual;
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; and
23. Supervisor’s / PWSP endorsement

8.2 Electro Fusion Welding

The welding process requires the square ends of two pipes or fittings to be fitted into a 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.

The EFJ procedure at a minimum shall stipulate the following:

1. Brand name, type, size and pressure rating of 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;
7. Cooling time;
8. Type and brand of welding equipment / transformer to be used;
9. Control box details;
10. Documentation on maintenance, servicing and calibration of equipment; and
11. Clamp type / method.

8.3 Extrusion Welding

The welding process requires a 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:
8.4 **Hot Gas 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 gas, 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 gas welding procedure at a minimum shall stipulate the following:

1. Gas / air flow rate in litres/min;
2. Gas / 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 **Socket & Saddle Fusion Welding**

The welding process requires the outside surface of the pipe and the inside surface of the socket or saddle to be heated. After the mating surfaces are adequately plasticised the two components are joined by inserting one into the other and allowed to cool for a predetermined time under a predetermined pressure.

The socket and saddle welding procedure at a minimum shall stipulate the following:

1. Manufacturer name and date of manufacture, type, size and pressure rating of socket saddles/bands;
2. Ambient Temperature range;
3. Joint surface preparation;
4. Joint surface treatment / cleaning compounds;
5. Specialised tools and accessories;
6. Cooling time;
7. Type and brand of welding equipment / transformer to be used;
8. Control box details; and
8.6 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.

8.7 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

8.8 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.

8.9 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 gas welding.
8.10 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 10ºC 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.

8.11 Planning for successful fusion welding

To ensure the integrity of the welds the following procedures should 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 –
   - Pre-qualified welding procedures being proposed for the project and the welding machines which will be used and destructive weld testing data can be considered;
   - Carry out trial welds on the actual 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;
   - Assessment of weld bead (for butt fusion welding).
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 a RTO to PMB 07 Competency Standards. The RTO shall be accredited by State/Territory Training Authorities under the Australian National Training Authority (ANTA) guidelines and complying with PMB 07 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 301B and PMBWELD 305B (Installation);
2. Electrofusion Welding (PE) - PMBWELD 302B and PMBWELD 305B (Installation);
3. Training needs to be complemented with a minimum field experience (two continuous years) in either butt fusion or electrofusion welding or both if the skills and processes are required in construction. Where personnel do not meet this criteria but have successfully completed the training requirements, they shall work under direct supervision of a competent welder at all times; and
4. Regular updating of certification by an RTO (tickets and stamps) or evidence by way of log sheets of successful welded joints on previous projects. In particular welding of pipe larger than 315mm is specialised.

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 laying program 0605 through the Challenger TAFE, Fremantle, WA or a Solvent Cement Jointing program delivered by XLT Institute of Welding, Engineering & Technology, Bibra Lake, WA 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 or 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 309B (Extrusion Welding); and
2. Minimum of 6 months experience in welding of thermoplastic membrane / linings and sheeting as applicable. Where personnel do not meet these criteria they shall be supervised by a competent person at all times during the execution of work.

9.4 Hot Gas Welding
Personnel engaged in hot gas welding of PVC or PE membrane / linings or sheet shall have the following minimum qualification and experience:

1. Successfully completed the Plastiline® membrane/ lining course through the Central Institute of Technology, Perth Campus, WA;
2. Successfully completed and certified to PMBPROD287, Weld Plastic Materials; and
3. Minimum of 6 months experience in welding of thermoplastic membrane / linings and sheeting as applicable. Where personnel do not meet these criteria they shall be supervised by a competent person at all times.
9.5 Membrane Welding

All membrane welding is to be undertaken by qualified welders who have been trained in each of the welding techniques to be used on the project. The IAGI International Association of Geosynthetic Installers provides examiners (proctors) to provide training of Certified Welding technician (C.W.T.) or master seamer.

The welder shall have installed a minimum of 10 projects and seamed a minimum of 500,000 sq. metres of material. Where personnel do not meet these criteria they shall be supervised by a competent person at all times.

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 attending the entire course through a RTO or by the producing a welded test piece and submitting the same for testing as per the destructive testing criteria stated in Section 11.

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, at the start of pipe jointing work.

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 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 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.

Care shall be taken to prevent sand and other material from entering the pipes during installation.

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

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 shall be used for lifting pipes 6 metres in length or longer. Slings for handling the pipeline shall be positioned away from butt fused joint positions. Pipes and fittings shall be loaded and unloaded by lifting (by hand or hydraulic hoist), 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 - not 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

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, discarded and the remaining pipe – but not pipe fitting - ends 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 and has a clear potential to initiate failure.

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 – including referral to the pipe manufacturer as necessary - by the Corporation.
10.1.6 Pipe Assembly

If space permits, pipe shall be welded / fused together in one length. Pipe shall be placed on 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. 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 approximately 0.4 mm of the outer oxidized pipe skin be removed to ensure adequate bonding of the pipe.

Hand scrapers shall not be permissible except for the surface preparation prior to the welding of fittings such as electrofusion tapping saddles.

The use of clamps to restrain electrofusion fittings shall be required 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. 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 15 - 20 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 as far as practicable alternatively EFJ coupling joints shall be used.

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.

EFJ shall be carried out to comply with the requirements of ISO 11413 and ISO 12176-2.

Extrusion welding for joining of Polyethylene (PE 100 or PE 80) pipe ends for pressure applications shall not be permissible.

Use of fast fusion machines 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 external and internal beads post welding using BFJ shall be as specified by the designer, this requirement shall be project specific. Removal of welding beads shall be only considered where there is a potential for process flows to be affected. 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. Cleanliness of joints and the work site is critical;
2. Isopropanol 70% concentration weld wipes shall be used for the preparation of weld joints. The use of methylated spirit and acetone is not permitted. Cleaning with Isopropanol 70% concentrate spray pack / bottle with a lint free rag is also acceptable;
3. Provide a shelter to achieve adequate protection of the pipe and fitting during the weld cycle, this includes blanking the pipe ends (to prevent the pipe acting as a venturi and allowing the draft so produced to cool the weld surface prior to joining);
4. Protect against contamination such as dust, sand and rain;
5. 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;
6. No tapping of saddles should occur or movement of the pipe until the required cooling times has elapsed (refer Section 10.1.8.1);
7. Weld map, traceability of welding joints to welders correlating to the chainage on construction drawing shall be maintained;
8. Welding procedure documentation including manufacturer’s instructions, shall be available on site;
9. Welder identification number to be embedded on all weld joints completed in the case of butt fusion welded joints;
10. Welder identification number to be written in white permanent marker on the completed electro fusion welded coupling;
11. 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;
12. A pilot weld for each welding machine, pipe diameter, wall thickness and material type with a record of the parameter values for each weld shall be made. Pilot welds shall be destructively tested to the testing requirements; and
13. Certification for shop fabricated / vendor purchased fittings is available.

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:

- minimum cooling time out of the machine (referred to as t6 in ISO 21307, clause 5.1, figure 1 for single low-pressure fusion jointing procedure) shall be adhered to in WS-2 as the minimum cooling time IN the machine without pressure. (The exception to this rule is for pipe end welds inclusive of fittings where the t6 cooling period 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 out of 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 15º 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;
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. 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 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 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
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 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 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

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.

<table>
<thead>
<tr>
<th>Procedure Qualification Test Diameter</th>
<th>Type of joining process</th>
<th>Qualifies for sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any ≤ DN 200</td>
<td>Butt Weld</td>
<td>Any ≤ DN200</td>
</tr>
<tr>
<td>Any ≥ DN 200 to DN 450</td>
<td>Butt Weld</td>
<td>Any ≥ DN 200 to DN 450</td>
</tr>
<tr>
<td>Any ≥ DN 450 to DN 800</td>
<td>Butt Weld</td>
<td>Any ≥ DN 315 to DN 800</td>
</tr>
<tr>
<td>Any ≥ DN 800</td>
<td>Butt Weld</td>
<td>Any ≥ DN 800</td>
</tr>
<tr>
<td>Any ≤ DN 200</td>
<td>Electrofusion Weld Other Than a EF Saddle Weld</td>
<td>Any ≤ DN 200</td>
</tr>
<tr>
<td>Any ≥ DN 200 to DN 450</td>
<td>Electrofusion Weld Other Than a EF Saddle Weld</td>
<td>Any ≥ DN 200 to DN 450</td>
</tr>
<tr>
<td>Any ≤ DN 200 (carrier pipe)</td>
<td>Electrofusion Saddle Weld</td>
<td>Any ≤ DN 200 (carrier pipe)</td>
</tr>
<tr>
<td>Any ≥ DN 200 to DN 450 (carrier pipe)</td>
<td>Electrofusion Saddle Weld</td>
<td>Any ≥ DN 200 to DN 450 (carrier pipe)</td>
</tr>
</tbody>
</table>

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 the same. Weld beads shall be uniform and symmetrical without sharp notches and shall comply with the requirements of DVS2202-1, evaluation group 2. Pipe joints deemed by the Corporation not to meet these criteria shall be re-welded.

11.2.2 Mechanical / Destructive Tests - BFJ
The PWSP shall provide samples of BFJ for destructive weld evaluation testing as follows:

1. Joint Test weld joint in accordance with table 4;
2. 1 joint in the first 500 metres following testing of the test pilot weld;
3. 1 joint in every 50 pipe joints maximum for remainder of the pipeline after the testing of the first 500 metres as prescribed above; and
4. where testing reveals defects as determined by the test requirements, the previous weld to 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, bend testing to BS EN 12814 Part 1 and tensile fracture testing to ISO 13953. Bend testing is only required where the wall thickness of the pipe ≥ 30mm. The PWSP shall pay for all testing and associated costs and shall provide the Corporation with the test results immediately as they are available.

The acceptance criteria for tested weld samples shall be separation in a ductile mode, at an average effective stress of equal to 100% of that of the parent material, with the lowest single value ≥ 85% of the parent material. 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 remade welds shall be inspected by the PWSP and shall be to the acceptance of the Corporation.

11.3 Electrofusion Pipe Butt Joints - EFJ

11.3.1 Visual Examinations
Pipe joints made by EFJ shall be visually inspected by the PWSP’s supervisor prior to requesting the Corporation’s representative to audit and provide acceptance of the same. Couplings and saddles that indicate error readings, short circuiting, exposed wires, failure of coupling melt indicators and or melt outside the weld zone shall be cut out and re-welded. All welded joints shall meet the requirements of DVS 2202-1, evaluation group 2. Pipe joints deemed by the Corporation not to meet these criteria shall be re-welded.

11.3.2 Mechanical / Destructive Tests – EFJ
The PWSP shall provide samples of EFJ for destructive weld evaluation testing as follows:
1. Pilot weld joint shall be carried out in accordance with table 4
2. 1 joint in the first 500 metres following testing of the pilot weld;
3. 1 joint in every 50 pipe joints maximum for remainder of the pipeline after the testing of the first 500 metres as prescribed above meets the testing requirements; and
4. where testing reveals defects as determined by the test requirements, the previous weld to 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 above testing criteria shall only apply to pipelines with a working pressure $\geq$ 800 kPa. For working pressure less than 800 kPa including gravity mains, the pilot weld only shall be tested.

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. Butt welds shall be tested for Peel de-cohesion test in accordance with requirements ISO 13954, saddle joints shall be tested in accordance to ISO 13956. The PWSP shall pay for all testing and associated costs and shall provide the Corporation with test results immediately as they are available.

The acceptance criteria for tested weld samples for electro fusion shall not present a brittle failure zone longer than 25% of the fusion zone in the longitudinal axis.

## 11.4 Hydrostatic testing of welded pipelines

### 11.4.1 Pipeline testing requirements

Typical pipeline installation, construction and testing requirements are specified in project documents including technical workmanship specifications.

Each PE pipeline shall be hydrostatically tested in accordance with Section 7 AS/NZS 2033 to verify structural integrity and leak-tightness and to determine its acceptability for service. The method of test for pressure PE pipelines shall be the General Pressure Test (Technical). The method of test for non-pressure PE pipelines shall be either Method 1-Hydrostatic test or Method 2-Low pressure air test.

Field test pressures shall be determined by reference to AS/NZS 2033 Sub-clause 7.4.2 and to the maximum PE pipeline system design and site test baseline pressures (at a pipe wall temperature of 20°C) nominated by the system designer on project drawings.

Mean PE pipe wall and test water temperatures shall be measured to derive the safe (or de-rated baseline) pressure values to be applied to a PE pipeline during field pressure testing, where pipe wall temperatures during are likely to exceed 20°C. De-rating shall be in accordance with values given in AS/NZS 2033 Clause 3.7 for elevated (>20°C) PE pipe wall temperatures. Field pressure testing of a PE pipeline where its wall temperature exceeds 55°C shall not be permissible.

High pressure air testing shall not be permissible.

**Notes:**

1. The General Pressure Test (Technical) is also known as the **Constant Pressure (water loss) test** method. It is the accepted industry reference test method for PE pressure pipelines because it is a more...
accurate indicator of the interactive hydraulic and structural performance of a visco elastic pipeline than other test methods, being independent of pipeline soil support effects and constraints;

2. Disinfected water should be used for hydrostatic pressure testing where the intended service is required for conveyance of drinking water, this shall be disposed of in accordance with the project requirements.

11.5 Hot Gas Welding and Extrusion Welding

11.5.1 Visual Examination

Pipe joints made by hot gas 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 required 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 for lamination by prodding with a sharp knife or scraper.

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. The test voltage shall be determined in accordance with AS 3894.1 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 Cress Meter. The Cress meter shall be calibrated at a frequency of no greater than two years.

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;
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;
- 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

<table>
<thead>
<tr>
<th>Geomembrane Thickness</th>
<th>Minimum Pressure</th>
<th>Maximum Pressure</th>
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<tbody>
<tr>
<td>(mm)</td>
<td>(kPa)</td>
<td>(psi)</td>
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<tr>
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<td></td>
<td>275</td>
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**TABLE 5. AIR CHANNEL TEST PRESSURES FOR HDPE GEOMEMBRANES**

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

<table>
<thead>
<tr>
<th>Geomembrane Thickness</th>
<th>Maximum Pressure Drop</th>
</tr>
</thead>
<tbody>
<tr>
<td>(mm)</td>
<td>(kPa)</td>
</tr>
<tr>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td>1/5</td>
<td>21</td>
</tr>
<tr>
<td>2.0</td>
<td>14</td>
</tr>
</tbody>
</table>

**TABLE 6. ALLOWABLE PRESSURE LOSS IN AIR CHANNEL TEST**
• Remove the needle or other approved pressure-feed device and seal the hole using extrusion welding or an approved process.

Note that a decrease in the geomembrane temperature (e.g. due to clouds/overcast 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 3894.1 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 3894.1 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. 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.
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 or delegate will 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.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Criteria</th>
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<tbody>
<tr>
<td>Peel Strength</td>
<td>Fusion seam &gt; 70%</td>
</tr>
<tr>
<td></td>
<td>Extrusion seam &gt; 65%</td>
</tr>
<tr>
<td></td>
<td>Minimum specified* geomembrane yield strength</td>
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<tr>
<td>Seam Separation</td>
<td>Zero</td>
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<tr>
<td>Shear Strength</td>
<td>&gt; 95% minimum specified* geomembrane yield strength</td>
</tr>
<tr>
<td>Elongation</td>
<td>&gt; 100% of distance between edge of seam and nearer grip</td>
</tr>
<tr>
<td>Location of Failure</td>
<td>Outside the weld</td>
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</table>

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:

- Reconstruct the seam between the nearest passing destructive test locations on each side of the failed sample; or
- 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

Iso-propanol impregnated pipe-wipe shall be used to clean fittings and pipe ends to be joined by welding.

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 six months. Equipment servicing and calibration periods can be extended to no more than 12 months where it can be demonstrated the equipment has had low utilisation; has not been altered, modified or damaged. 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 to but not limited to the heater plate, the hydraulic or pneumatic unit, the frame / clamp unit, trimming tools, electro-fusion welding generator and pressure gauges.

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

13.1 General

The 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 WC-OSH 134 'Undertaking 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

Exemptions for certain works to be undertaken during a Total Fire Ban are obtained in advance by Service Delivery Branch, on behalf of the Water Corporation and its contractors. Intention to apply the exemption for work to proceed still requires:
- notification on the day to FESA or the Local Bush Fire Authority (local authority), and
- compliance with the conditions of exemption.

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 – WC OSH 108.

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 S131.

13.6 Working Hours and Fatigue Management
All personnel undertaking work shall be aware and adhere to the Water Corporation 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.

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 Gas 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

### Specificaiton WS-2: Installation, Welding and Joining Thermoplastics

### 1.0 QUALITY ASSURANCE SYSTEM

#### Quality Assurance Systems Allowed

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</tr>
<tr>
<td>AS/NZS ISO 3834.3</td>
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<td>Other International System</td>
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#### Clause Item Submission Precondition WC Approval/Outcome Plan/Actual Dates

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#### Sub-Contractor to be used

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#### Intent to use Alternative Processes

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<th>Item Description</th>
<th>Submission</th>
<th>Precondition</th>
<th>WC Approval/Outcome</th>
<th>Plan/Actual Dates</th>
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<tbody>
<tr>
<td>8</td>
<td>Welding Process/s</td>
<td>Intent to use alternative processes.</td>
<td>Before development of welding procedure.</td>
<td>Accept/Reject Within 10 working days</td>
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### 10 Days Prior to Planned Commencement of Works.

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<th>Plan/Actual Dates</th>
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<td>7</td>
<td>Quality Plan</td>
<td>As detailed</td>
<td>Approved</td>
<td>Yes/No</td>
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<td>7</td>
<td>Qualification of Welding Procedures</td>
<td>Schedule of qualified procedures</td>
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<td>Accept/Reject</td>
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<tr>
<td>8</td>
<td>Welding Procedure Sheet (WPS)</td>
<td>All major parameters/essential variables and as per 7.2 advise copies held available to workplace.</td>
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<td>Accept/Reject</td>
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<td>Submission</td>
<td>Precondition</td>
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<td>Plan/Actual Dates</td>
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<td>8</td>
<td>PWSP</td>
<td>Nominate qualified person responsible.</td>
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<td>9</td>
<td>PWSP details</td>
<td>Qualification/ certification and experience, records.</td>
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<td>Welding Inspector</td>
<td>Qualification, certification and experience.</td>
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<tr>
<td>9</td>
<td>Welder qualified to Qualified Welding procedures</td>
<td>Details for each welder</td>
<td>Acceptance</td>
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<td>9</td>
<td>Welder qualification, certification, etc.</td>
<td>As detailed</td>
<td>Acceptance</td>
<td>Yes/No</td>
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<tr>
<td>11</td>
<td>Inspection/Test Plan</td>
<td>Inspection + Test Plans (ITP's)</td>
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<td>Accept/Reject</td>
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**Before Welding Commences**

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<th>Precondition</th>
<th>WC Approval/Outcome</th>
<th>Plan/Actual Dates</th>
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<td>6</td>
<td>Commencement</td>
<td>Request approval to commence</td>
<td>All Pre conditions met</td>
<td>Yes/No</td>
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**Identification and Traceability after Welding Done**

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<th>Plan/Actual Dates</th>
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<tbody>
<tr>
<td>7.4</td>
<td>Identification of welders to welds.</td>
<td>Records</td>
<td>Work Done</td>
<td>Accept/Reject</td>
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</table>

**Testing**

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<th>Item</th>
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<th>Precondition</th>
<th>WC Approval/Outcome</th>
<th>Plan/Actual Dates</th>
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</thead>
<tbody>
<tr>
<td>11</td>
<td>Testing</td>
<td>Test Certificates (destructive or non-destructive)</td>
<td>Work Done NATA Acquitted. Lab.</td>
<td>Accept/Reject Compliance</td>
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<tr>
<td>11 &amp; 7.5</td>
<td>Pilot weld testing</td>
<td>Test Results</td>
<td>Work Done</td>
<td>Witness and Accept/Reject</td>
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<tr>
<td>11</td>
<td>Testing records</td>
<td>Supply as part of MDR</td>
<td>Work &amp; Tests done</td>
<td>Accept/Reject Compliance</td>
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**Requalification when Essential Variables fall outside Standard/Code Limits**

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<th>Clause</th>
<th>Item</th>
<th>Submission</th>
<th>Precondition</th>
<th>WC Approval/Outcome</th>
<th>Plan/Actual Dates</th>
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</thead>
</table>
Appendix B - Polyethylene (PE) Butt Welding Record Sheet

Note: There are 3 recognised welding procedures for butt welding PE:

a) Single Pressure – Low Fusion Jointing
b) Dual Pressure – Low Fusion Jointing
c) Single Pressure – High Fusion Jointing

A further procedure for Fast Fusion Welding is currently being evaluated by PIPA

<table>
<thead>
<tr>
<th>Project:</th>
<th>Welding Machine:</th>
<th>Pipe Size:</th>
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<tbody>
<tr>
<td>Project No:</td>
<td>Serial No:</td>
<td>SDR:</td>
</tr>
<tr>
<td>Task Description &amp; Location:</td>
<td>Gauge Calibration Date:</td>
<td>Thickness:</td>
</tr>
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<td>Task Start/ Finish Dates:</td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Weld Number</th>
<th>Time</th>
<th>Ambient Temp</th>
<th>Heater Plate Temperature</th>
<th>Drag Pressure</th>
<th>Bead Up Pressure</th>
<th>Bead Size</th>
<th>Head Soak Pressure</th>
<th>Heat Soak Time</th>
<th>Change Over Time</th>
<th>Welding Pressure</th>
<th>Cooling Time</th>
<th>Comments</th>
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Welder Signature: ________________
Supervisor Name: ________________
Works Inspector (Client): ________________
**Daily Butt Welded Joint Register (Dual Pressure)**

(Butt Fusion Weld Procedures in accordance with: PIPA Guideline POP 003)

<table>
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<tr>
<th>Date:</th>
<th>Project:</th>
<th>PWSP:</th>
<th>Weather (X)</th>
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<td></td>
<td></td>
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<td>Raining</td>
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**Welder Name/Number:**

**Welding Machine:**

- Serial No :
- Hydraulic Cyl Area:

**Primary Fusion Pressure =**

- Annulus x 150 kPa
- Hydraulic Cyl Area
- Secondary Fusion/Cool Pressure =
- Primary Fusion Pressure

**Material & Pipe:** Polyethylene

**Ambient Temp:**

**Welding Parameters** (pressure in kPa, time in minutes & seconds, temperature in Celsius, pipe wall thickness (t) in mm)

<p>| Weld No | Heater Plate Temp (230 +10 -5C) | Drag Pressure kPa | Bead Size 0.1t + 0.5 (Max: 6mm) | Soak Time (0.1t + 4) | Soak Time (10t + 60) | Heater Removal Time (0.1t + 4) | Fusion Pressure (Primary) | Fusion Time (10 sec) | Secondary Pressure (Primary) | 6 | Cooling Time Under Pressure (Per ISO 21307, Table A2) | Cooling Time Out of machine (Per ISO 21307, Table A2)* | Welder | Inspector |
|---------|---------------------------------|-------------------|-------------------------------|---------------------|---------------------|-------------------------------|-------------------------|---------------------|-------------------------------|   |                                |                               |        |           |</p>
<table>
<thead>
<tr>
<th>Weld No</th>
<th>Heater Plate Temp (230 +10 -5C)</th>
<th>Drag Pressure kPa</th>
<th>Bead Size 0.1t + 0.5 (Max: 6mm)</th>
<th>Soak Press (Drag Only)</th>
<th>Soak Time (10t + 60)</th>
<th>Heater Removal Time (0.1t + 4)</th>
<th>Fusion Pressure (Primary)</th>
<th>Fusion Time (10 sec)</th>
<th>Secondary Pressure (Primary)</th>
<th>6</th>
<th>Cooling Time Under Pressure (Per ISO 21307, Table A2)</th>
<th>Cooling Time Out of machine (Per ISO 21307, Table A2)*</th>
<th>Welder</th>
<th>Inspector</th>
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* Refer to Clause 10.1.3.1 of WS-2 for additional advice.
Appendix C - Inspection Release Form

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<th>DESCRIPTION</th>
<th>COMPONENT CODE</th>
<th>HEAT / BATCH / CAST No.</th>
<th>TEST CERTIFICATE NUMBER</th>
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## Inspection Release Form

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<th>QUANTITY RELEASED</th>
<th>DESCRIPTION</th>
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<th>HEAT / BATCH / CAST No.</th>
<th>TEST CERTIFICATE NUMBER</th>
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**TQ’s, NCR’s, PUNCHLISTS ETC** ……………………………………………

**DESTINATION OF MATERIALS** ……………………………………………

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<th>MATERIALS COMPLETE</th>
<th>CERTIFICATION REQUIRED</th>
<th>CERTIFICATION REVIEWED</th>
<th>CERTIFICATION ATTACHED</th>
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<th>DESTINATION CORRECT</th>
<th>MSDS SUPPLIED</th>
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<td>Y ☐</td>
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<td>Y ☐</td>
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</tr>
</tbody>
</table>

**THIS CERTIFICATE IS A CLEARANCE FOR SHIPMENT ONLY AND DOES NOT RELIEVE THE SUPPLIER OF ITS CONTRACTURAL OBLIGATIONS.**

**COMPANY SIGNATURE**

**DATE**

**CLIENT SIGNATURE**

**DATE**

---

*Inspection Release Form*  
WS2 – Welding &Joining Specification (Thermoplastics)*
END OF DOCUMENT