GRAVITY SEWER PIPE REHABILITAION

SLIP LINING – PERFORMANCE SPECIFICATION GUIDELINE

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Watercare

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More information

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DOCUMENT CONTROL

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Definitions

ASTM	American Society for Testing Materials
ASTT	Australasian Society for Trenchless Technology
CCTV	Closed Circuit Television – which includes cameras and displays to record and inspect pipelines.
Contractor	Main contractor engaged by Watercare, responsible for delivering the works
Defect	Any discontinuity, imperfection or inclusion arising from substandard materials, improper pipe preparation, or faulty manufacture, installation or workmanship which affects the hydraulic or structural performance of the lining
DN	Nominal Diameter
EF	Electrofusion
Engineer	A suitably qualified and experienced person to witness and sign-off on the quality and compliance of the work being audited.
Flow management plan (FMP)	Contractor plan(s) and methods to divert flows whilst preventing overflows or any adverse consequences whilst preparing the host pipe and installing the new liner. (wastewater)
IANZ	International Accreditation New Zealand
ISO	International Organisation for Standardisation
NCR	Non-conformance report
NDSRs	No-dig spot repairs
OD	Outside diameter
PIPA	Plastic Industry Pipe Association
Polyethylene (PE),	Thermoplastic material, which is produced by the polymerization of ethylene and pipes manufactured through an extrusion process
Project Specification	Project specific requirements specific by the design engineer which form part of the minimum requirements to be met during construction

Quality Control Plan	The Contractor's documentation that defines the procedures for delivering the level of construction quality required by the project.
SDR	Standard Dimension Ration. The SDR is calculated by dividing the outside diameter of the pipe by the wall thickness.
Slip lining	Involves inserting a new pipe into an existing rigid pipe. New pipe material can include polyethylene, GRP, PVC-u restrain, steel, concrete etc.
Specialist Contractor	Contractor carrying out the physical installation of the liner in accordance with the project specifications and manufacturer's recommendations.
Watercare	Watercare's representative responsible for managing the project.

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1. Scope

This Performance Specification includes the minimum requirements for the rehabilitation of pipelines using slip lining. Slip liners can be flexible polyethylene pipes, restrain PVC-u, GRP or any other pipe materials that are joined into a continuous length and inserted into existing rigid pipes.

This document shall be read in conjunction with *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*.

1.1 Overview

***Table 1**: Application of slip liner pipe*

Reference	Description
Liner material	Polyethylene (HDPE), GRP, PVC-U (SN16), Steel, Concrete [(a)]
Roughness coefficient	Refer to AS 2200: Design Charts for Water and Wastewater
Liner Classification	Class A – Fully-structural
Applications	Wastewater: Non-pressure and pressured
Pipe sizes	180mm OD – 900mm OD
Installation	Manhole to manhole or alternatively from shaft to shaft
Design life	Varies – depends on material selected - Minimum 50 years.

[(a)] Material selection based on design and construction methodology

Note: Slip lining of existing 150mm diameter sewers is not permitted.

2. Relevant Standards

***Table 2**: Standards applicable to slip lining*

Standards – General	Relevance
AS/NZS ISO 11295: Plastics piping systems used for the rehabilitation of pipelines - Classification and overview of strategic, tactical and operational activities	Planning and general
AS/NZS 2566.1: Buried Flexible Pipes - Part 1: Structural Design	Design
AS/ NZS2566.1 Supp1: Buried Flexible Pipelines Part 1: Structural Design - Commentary	Design
AS/ NZS2566.2: Buried Flexible Pipelines, Part 2	Installation and testing
Standards – Applicable to polyethylene pipe liner	**Relevance**
ISO 23818-1: Assessment of conformity of plastics piping systems for the rehabilitation of existing pipelines - Part 1: Polyethylene material	Material and testing
AS/NZS 2033: Installation of polyolefin pipe systems	Installation
ISO 12176-1: Plastics pipes and fittings – Equipment for fusion jointing polyethylene systems. Part 1: Butt fusion	Installation equipment
ISO 12176-2: Plastic pipes and fittings – Equipment for fusion jointing polyethylene systems. Part 2: Electrofusion.	Installation equipment
PIPA POP 003 Industry Guidelines - Butt fusion jointing of pe pipes and fittings - recommended parameters	Installation
PIPA POP 001 Industry Guidelines - EF jointing of PE pipes and fittings for pressure applications	Installation
ISO 21307 Plastics pipes and fittings — butt fusion jointing procedures	Installation
DVS 2207-1 German Welding Society Technical Code - Welding of Thermoplastics	Installation
ISO 13953 Polyethylene (PE) pipes and fittings — Determination of the tensile strength and failure mode of test pieces from a butt-fused joint	Material testing
ISO 21751 Plastics pipes and fittings — Decohesion test of EF assemblies – Strip-bend test	Material testing (if applicable)
PIPA POP 014 Industry Guidelines - Assessment of polyethylene welds	Installation / Assessment

Standards – Applicable to polyethylene pipe liner	Relevance
AS/NZS ISO 11296.1: Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks, Part 1: General	General
AS/NZS ISO 11296.2: Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks, Part 2: Lining with continuous pipes	General
AS/NZS 5065: Polyethylene and polypropylene pipes and fittings for drainage and sewerage applications	Material manufacture
AS/NZS 4129: Fittings for Polyethylene (PE) pipes for Pressure Applications	Material manufacture
AS/NZS 4130: Polyethylene (PE) Pipes for Pressure Applications	Material manufacture
AS/NZS 4131: Polyethylene (PE) Compounds for Pressure Pipes and Fittings	Material manufacture
PIPA POP 007: Flanged joints for Polyethylene (PE) Pipe	Installation
Standards – Applicable to PVC-U restrained pipe liner	**Relevance**
AS/NZS 1260: PVC-U pipes and fittings for drain, waste and vent applications	Material manufacture
Standards – Applicable to GRP pipe liner	**Relevance**
ISO 25780: Plastics piping systems for pressure and non-pressure water supply, irrigation, drainage or sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin — Pipes with flexible joints intended to be installed using jacking techniques.	Material manufacture
ASTM D3262: Standard Specification for "Fiberglass" (Glass-Fibre- Reinforced Thermosetting- Resin) sewer pipe	Material and testing
ASTM D3567: Standard Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings	Determining the physical dimensions of fiberglass pipe and fittings
ASTM D790: Standard Test Method for Flexural Properties of Plastics	Material and Testing
ASTM D2583: **S**tandard Test Method for Indentation Hardness by Means of Barcol Impresse**r**	Material and Testing
ASTM D638: Standard Test Method for Tensile Properties of Plastics	Material and Testing
ASTM D695:Standard Test Method for Compressive Properties of Rigid Plastics	Material and Testing
ASTM D4161: Standard Specification for "Fiberglass" (Glass-Fiber reinforced Thermosetting-Resin) Pipe Joints Using Elastomeric Seals	Standard Specification
ISO 16611: Plastics piping systems for drainage and sewerage without pressure –non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) – Dimensions, requirements and tests.	Material and testing
ASTM F477: Standard Specification for Elastomeric Seals (Gaskets) for Jointing Plastic pipe	Material and testing (Joint testing)
ASTM D5365: Standard Test Method for Long-Term Ring-Bending Strain of Fiberglass (Glass-Fibre-Reinforced Thermosetting-Resin) Pipe	Material and testing (Long term Stiffness – Material creep & Long term ring bending strain test)
ASTM D3681: Standard Test Method for Chemical Resistance of "Fiberglass" (Glass–Fiber–Reinforced Thermosetting-Resin) Pipe in a Deflected Condition	Material and testing (Chemical resistance of pipe in a deflected condition)
ASTM D2105: Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Tube	Material and testing (Axial tensile strength)
ASTM D2290: Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe	Material and testing (Hoop tensile strength)
ASTM D2412: Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading	Material and testing Stiffness & flexural modulus
Standards – Applicable to steel pipe liner	**Relevance**
AS 1579: Arc-welded steel pipes and fittings for water and wastewater	Material and testing

Standards – Applicable to steel pipe liner	Relevance
NZS 4442: Welded steel pipes and fittings for water, sewage and medium pressure gas	Material and testing
AS/NZS 3678: Structural steel - Hot-rolled plates, floorplates and slabs	Material
AS/NZS 1594: Hot-rolled steel flat products	Material
AWWA C210: Liquid/Epoxy Coatings and Linings for Steel Water Pipe and Fittings	Material – Coating
WSA TN-06: Guidelines for the use of cement mortar linings in sewerage applications	Material
AS 4321: Fusion-bonded medium-density polyethylene coating and lining for pipes and fittings	Material – Coating
ISO 4200: Plain end steel tubes, welded and seamless — General tables of dimensions and masses per unit length	Material
ESF-600-STD-701: General Mechanical Construction Standard	Installation
Standards – Applicable to concrete pipe liner	**Relevance**
AS/NZS 4058: Precast concrete pipes (pressure and non-pressure)	Material
AS 1646: Elastomeric seals for waterworks purposes	Material
ASTM C361: Standard Specification for Reinforced Concrete Low-Head Pressure Pipe	Material
ASTM C1417: Standard Specification for Manufacture of Reinforced Concrete Sewer, Storm Drain, and Culvert Pipe for Direct Design	Material
ASTM C443: Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets	Material
ASTM F477: Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe	Material
AS/NZS 3725: Design for installation of buried concrete pipes	Design
CG: General Civil Construction Standard	Installation

3. Design

Design of the lining system shall meet all the relevant requirements of *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*.

4. Material requirements

4.1 Material properties

The Contractor shall submit test data to substantiate that the values for material properties nominated in the design calculations can be achieved by the materials supplied for the pipeline installation.

Where material properties under load vary with time, material properties of the lining at the end of the design life shall be used in design calculations.

The material properties of the lining material used in the rehabilitation of the pipeline shall be consistent with the design properties. These properties shall have the same values as those nominated by the Designer.

4.2 Chemical, temperature and abrasion resistance

Refer to *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*, Section 4.3 for general requirements.

5. Construction

For all general construction requirements refer to *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*.

5.1 Installation

5.1.1 Liner installation

The liner shall be fitted neatly inside the host pipe, with the liner pipe being in contact with the invert of the host pipe.

Pipes can be inserted using four techniques:

- Winching
- Pushing machine
- Pulling/Pushing attachment fitted to an excavator.
- Manually.

For general installation requirements refer to:

- CG: General Civil Construction Standard
- ESF-600-STD-701: General Mechanical Construction Standard

5.1.2 Polyethylene pipe installation

In addition to the installation requirements listed above, polyethylene pipe installations shall consider the following requirements.

5.1.2.1 Jointing of PE pipe

Jointing of PE pipe, except where otherwise instructed, shall be achieved by butt-welding of the material. Electrofusion welding shall only be accepted where it is demonstrated that butt welding cannot be achieved, or butt weld test samples are retrieved from the installation. The Contactor shall confirm that the use of electrofusion joints shall not restrict the polyethylene pipes' passage through the host pipe, or adversely impact the grouting procedure around the annulus, should these be required and approved by Watercare.

The strength of the weld must be comparable to that of the parent material.

Joints between sections of pipeline or with adjacent facilities shall not be stressed until sufficient time has elapsed for the pipe joints have cooled and attained full strength.

5.1.2.2 Relevant standards

The liner installation shall be in accordance with the following standards and shall be installed as per the liner manufacturer's specification:

- **AS/NZS 2033**: Installation of polyolefin pipe systems
- **AS/NZS 2566.2**: Buried flexible pipelines - Installation
- **PIPA POP 003** Industry Guidelines - Butt fusion jointing of pe pipes and fittings - recommended parameters

- **ISO 21307** Plastics pipes and fittings — butt fusion jointing procedures
- **PIPA POP 001** Industry Guidelines - EF jointing of PE pipes and fittings for pressure applications
- **DVS 2207-1** German Welding Society Technical Code - Welding of Thermoplastics
- **PIPA POP 014** Industry Guidelines - Assessment of polyethylene welds
- **AS/NZS ISO 11296-2**: Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks. Part 2: Lining with continuous pipe.
- **AS/NZS ISO 11297-2**: Plastics piping systems for renovation of underground drainage and sewerage networks under pressure. Part 2: Lining with continuous pipe.
- **AS/NZS ISO 11298-2**: Plastics piping systems for renovation of underground water supply networks. Part 2: Lining with continuous pipe.

There shall be no defects or discontinuities that could adversely affect the hydraulic performance or long-term life of the lining.

5.1.2.3 Welding environment

The Contractor shall take the necessary measures to ensure that site conditions does not affect the quality of welds. Appropriate shelter or shielding shall be established to negate any adverse site conditions such as wind, rain and dust.

5.1.3 Butt fusion jointing of PE pipes

5.1.3.1 General

All butt-fusion welding of PE pipes shall be in accordance with PIPA POP 003 (directly adopted from ISO 21307) or DVS 2207-1 the German Welding Society (DVS) Technical Code.

The heat soak pressure must be equal to the drag pressure and the weld cooling time in the clamps must be in accordance with DVS 2207-1.

Note: The weld cooling time under pressure in DVS 2207-1 is the minimum, not a “target” value. The cooling time must be increased for ambient temperatures greater than 15ºC.

5.1.3.2 Welding personnel

The Contractor shall appoint a lead welder (or welding supervisor) in the Contractor’s Work Method Statement and Quality Control Plan to take responsibility for all site welding decisions and be responsible for the visual examination and acceptance of all welds in accordance with practical experience, NZS 2033, DVS 2207-1 and PIPA POP 014 Assessment of Polyethylene Welds.

All butt welding shall be carried out by competent and experienced operatives who hold a current New Zealand NZS 2033 requirement endorsement Polyethylene fusion qualification or similar approved. The Contract shall not change welding operatives during the Contract without the written approval of the Engineer. Replacement welders must have equivalent experience to the welder they replace.

The Contractor shall provide the following details for welding operatives:

- The name/s of all welding operatives

- The relevant experience of the named operatives, including their experience with the proposed welding machines and the welding method to be used
- A current NZS 2033 Polyethylene fusion certificate for each named operative
- The name, qualifications and experience of the lead welder (and welding supervisor).

5.1.3.3 Welding machinery maintenance, service and calibration.

Butt welding equipment shall conform to ISO 12176-1: Plastics pipes and fittings – Equipment for fusion jointing polyethylene systems. Part 1: Butt fusion.

The Contractor's nominated lead welder or welding supervisor is responsible for ensuring that all PE pipe welding equipment is well maintained, kept in serviceable condition and has been calibrated within the last 12 months. The Contractor shall provide a calibration certificate for each machine prior to pre-construction welds.

Welding machinery should generally be serviced twice a year (and more often if they are used heavily). The contractor shall provide evidence of service records for the machinery to be used during the welding process.

Failure to adequately maintain and calibrate the welding equipment may result in welds being rejected.

Only semi-automatic or automatic welding machines shall be used by the Contractor. Dual low-pressure or high-pressure butt-fusion jointing is not permitted.

It is important that the Contractor follows the parameters specified for the welding method selected.

5.1.3.4 Cleanliness

The contractor shall ensure that the exposed surface of the pipe to be welded is free of dust and any contaminants that may otherwise result in weak bond.

Isopropyl Alcohol (IPA) having a concentration of 95% or greater shall be used for pipe cleaning prior to welding. IPA wipes specifically for PE electrofusion welding or IPA liquid with lint free cotton cloth is accepted. Acetone is not allowed.

5.1.3.5 Pre-construction welds

Before commencing installation of any pipes, each welding operative must have completed two pre-construction test welds under "normal" site conditions on the size of pipe to be used. This shall pass the acceptance criteria of ISO 13953 for tensile strength and failure mode (using the designated welding equipment and approved WMS).
The acceptance criteria are:

- The tensile strength of each weld specimen tested must be greater than 95% of that observed for a sample of the pipe with no weld (a "parent" pipe specimen).
- All test specimens (number as required in ISO 13953) must exhibit fully ductile fracture. If even one test specimen fails in a brittle or mixed brittle/ductile mode will constitute a weld failure.

Construction shall not commence until the welding operative have produced two consecutive welds that comply with the acceptance criteria. If satisfactory test results prove difficult to achieve, the Contractor shall provide the Engineer with a report on the cause of the problem and any revisions to the WMS or other precautions that are needed to achieve satisfactory welds.

During construction, tests on selected welds (at the agreed frequency) must also pass the above acceptance criteria.

The welding operative must carefully inspect each weld as it is made for consistency and confirm conformance with PIPA POP 014 (assessment of Polyethylene Welds) which covers quantifiable criteria for butt weld visual examination. The visual defects identified are mainly derived from DVS Technical Code DVS 2202.1:2008. and must be been signed off by the lead welder or welding supervisor (refer to the site butt fusion welding record).

5.1.3.6 Lab testing

Tensile testing of butt-fusion welds must be carried out by an IANZ-accredited laboratory in accordance with ISO 13953 or an approved alternative.

The Contractor must send a copy of all weld acceptance test results to the Engineer as they are received. The test results must include a graphical plot of the load-extension response of the test specimens. Include a copy of the site butt-fusion weld record, weld photograph/s and the welding machine printout for each test weld for the Engineer's review.

5.1.3.7 Failed welds

If a weld fails during installation of the pipe or during pressure acceptance testing, the lead welder or supervisor must review the site butt-fusion welding record, the welding machine print-out, any photographs and the welding parameters. The lead welder and the welding operative may be able to determine the likely cause of the failure.

The Contractor shall submit a Non-conformance Report (NCR) to the Engineer. The NCR must include copies of the relevant weld records (site and machine print-outs), photos and proposed corrective actions. Subsequent corrective actions needed to resolve the weld failure shall be agreed with the Engineer.

The investigation may, (at the Engineers discretion) require cutting out the joints made immediately before and after the failed weld for testing (if the cause of failure is not readily obvious). If these joints pass the ISO 13953 test and no other potential problems have been identified, the failed joint may be assumed to be a one-off event.
If either of these adjacent butt-fusion welds fail the tensile test, provide a fully detailed report to the Engineer. It may be necessary for the Contractor to engage an independent expert in PE welding (acceptable to the Engineer) to review the failure in detail and observe some test welds so that an acceptable resolution to the problem can be achieved and a remedial action strategy agreed.

Repair any cut-out butt-fusion weld sections using a new butt weld (pre-installation) or two EF couplers and a length of PE pipe of the same DN and PN or SN as the adjacent pipes. The EF coupler welds must comply with PIPA POP 001 Industry Guidelines - EF jointing of PE pipes and fittings for pressure applications. Make one test EF weld at the same time as the repair using two

sections of the actual pipe used for the repair and send the test joint to an IANZ-accredited laboratory for testing in accordance with ISO 21751 Plastics pipes and fittings — Decohesion test of EF assemblies – Strip-bend test. Send a copy of the EF welding site record, the EF controller printout and the results of each EF weld test to the Engineer.

The Contractor shall outline any specific repair or replacement procedures for potential defects that may occur during the installation. Repair/ replacement procedures, if any, shall be as per the manufacturer's recommendation.

Note: Repairing a cut-out butt weld with two EF couplers may introduce significant risk and the possibility that the repaired pipe may not pass through the hose pipe where annular gaps are restrictive. In addition, the introduction of EF couplers may limit the passage when grouting the annular gap. It is recommended that failed butt welds are avoided by critical attention and consistency when carrying out the weld process.

5.1.4 Electrofusion jointing of PE pipes

5.1.4.1 General

The Contractor shall minimise the number of EF joints required and to ensure all fittings and equipment needed are on site to minimise joint assembly time. an appropriate welding shelter and clean the pipe ends (by washing and drying if necessary).

All EF jointing shall be in accordance with PIPA POP 001: Electrofusion Jointing of PE Pipes and Fittings, 2003, for Pressure Applications.

All EF saddle welds must only be made by a single welding operative who has experience and has been endorsed by the lead welder or supervisor.

5.1.4.2 Welding personnel

All electrofusion welding shall be carried out by competent and experienced operatives who hold a current New Zealand NZS 2033 Polyethylene fusion qualification or similar approved. The Contract shall not change welding operatives during the Contract without the written approval of the Engineer. Replacement welders must have equivalent experience to the welder they replace.

The Contractor shall provide the following details for welding operatives:

- The name/s of all welding operatives
- The relevant experience of the named operatives, including their experience with the proposed welding machines and the welding method to be used
- A current Polyethylene fusion certificate for each named operative
- The name, qualifications and experience of the lead welder (and welding supervisor).

5.1.4.3 Cleanliness

The contractor shall ensure that the exposed surface of the pipe to be welded is free of dust and any contaminants that may otherwise result in weak bond.

Isopropyl Alcohol (IPA) having a concentration of 95% or greater shall be used for pipe cleaning prior to welding. IPA wipes specifically for PE electrofusion welding or IPA liquid with lint free cotton cloth is accepted. Acetone is not allowed.

5.1.4.4 Welding machinery maintenance, service and calibration.

Electrofusion control boxes shall conform to ISO 12176-2: Plastic pipes and fittings – Equipment for fusion jointing polyethylene systems. Part 2: Electrofusion.

The Contractor's nominated lead welder or welding supervisor is responsible for ensuring that all PE pipe welding equipment is well maintained, kept in serviceable condition and has been calibrated within the last 12 months. The Contractor shall provide a calibration certificate for each machine prior to pre-construction welds.

Welding machinery should generally be serviced twice a year (and more often if they are used heavily). The contractor shall provide evidence of service records for the machinery to be used during the welding process.

Failure to adequately maintain and calibrate the welding equipment may result in welds being rejected.

5.1.4.5 Pre-construction welds

Before commencing installation of any EF coupler, each welding operative must have completed pre-construction test joints (using the designated welding equipment and the approved WMS) that pass the acceptance criteria of ISO 21751 (strip-Bend test) or ISO 13954 (Peel-decohesion test) for tensile strength and failure mode.

Test results to ISO 21751 (strip-bend test) that satisfy the acceptance requirements below will mean that the ISO 13954 (Peel-decohesion test) is not required. Tests to ISO 13954 will be acceptable and may be used (at the Engineers discretion) to resolve any doubts about strip-bend tests.

The acceptance criteria are:

- The length of brittle decohesion must not be more than 33% of the fusion length and must include any voids in the pipe and coupler interface (for either the ISO 21751 or ISO 13954 test methods.
- Successfully complete the number of pre-construction test welds under normal site conditions as shown in Table 3.

***Table 3**: Minimum number of test specimens for peel-decohesion or strip bend test*

Pipe DN (OD) Range (mm)	Number of test specimens
160 - 280	4
315 – 506	6
630 and larger	8

Where EF saddles are used for lateral repairs, the Contractor shall prepare four (4) strip-bend test specimens for testing prior to undertaking any works.

5.1.4.6 Lab testing

Tensile testing of electro-fusion welds must be carried out by an IANZ-accredited laboratory in accordance with ISO 21751 (strip-Bend test) or ISO 13953 or an approved alternative. Advise the testing laboratory of the welding methodology used, the welding operatives name, the pipe manufacturer, the Pipe DN and PN and the date of manufacture of the pipes for completeness of the laboratory test report.

The Contractor must send a copy of all weld acceptance test results to the Engineer as they are received. The test results must include a graphical plot of the load-extension response of the test specimens. Include a copy of the site weld record, weld photograph/s and the welding machine printout for each test weld for the Engineer's review.

5.1.4.7 Failed EF welds

If an EF weld fails during installation of the pipeline or during pressure acceptance testing, the lead welder or supervisor must review the relevant site jointing log sheet and the EF controller printout with the operative.

The Contractor shall submit an NCR to the Engineer that identifies the likely cause of the failure. The NCR must include all the relevant site records, photographs and proposed corrective actions.

The Contractor shall cut out the failed coupler and replace it with two EF couplers of the appropriate SDR and a section of PE pipe of the same PN as the adjacent pipes. Make one test EF weld at the same time as the repair, using two sections of the pipe used for the repair and the same make and PN of EF coupler and send that test weld for testing as described in section 5.2.5.7. Send a copy of the EF welding site record, a photograph of the EF coupler and the results of the test results to the Engineer.

5.1.5 Grouting of the annulus, as applicable and appropriate

A cementitious low carbon grouting mix strength may be specified in the *Project Specification*.

Where required and specified in the *Project Specification*, the whole of the void between the liner pipe and the existing sewer is to be filled with a cementitious grout. The grout material shall provide protection for the concrete and reinforcing steel of the existing pipes, to prevent further or ongoing corrosion and further loss of strength. The grouting material and the methodology shall be approved by the Engineer before any grouting of the liner commences.

The grouting process shall ensure that the liner pipe resides in the invert of the host pipe and that the pipeline gradient is maintained without any backfall. The Contractor shall demonstrate that complete filling of the void has been achieved.

5.1.6 Lateral connections

Lateral connections shall be cut in to the new line by means of electrofusion jointing, and shall be in installed in compliance with PIPA POP 001 Industry Guidelines - EF jointing of PE pipes and fittings for pressure applications

Unless it can be clearly established that the connections have been abandoned, provision shall be made for reopening them on completion of the lining operation.

5.1.7 Defects

Liners shall be assessed for defects as per the relevant requirements of Section 5.2.10 of *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*.

The following are common examples of defects that are considered unacceptable and must be remediated:

- Refer to PIPA POP 014 (Assessment of Polyethylene Welds) which covers quantifiable criteria for butt weld visual examination.
- Weld defects as identified by the welding inspector (steel pipes)
- Pipes with differing wall thicknesses and outside diameters.
- Popped rubber ring joints
- Leak test does not comply with this specification (non-pressure).
- Pressure test does not comply with this specification (pressure)
- Poor quality cut outs
- Inadequate sealing at manholes (non-pressure)
- Pipe material not meeting the specified design.

Note: The defects listed above are not intended to be an exhaustive list. Installed liners will be assessed to confirm they meet the functional requirements over the design life of the lining system.

6. Acceptance Control

Acceptance control of slip lining shall be as per the relevant items described in:

- Section 6 of *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems* including the process of assessment of defects
- CG: General Civil Construction Standard (as applicable)
- ESF-600-STD-701: General Mechanical Construction Standard (as applicable)

6.1 Butt-fusion welding records

The Contractor shall maintain a site record for all butt-fusion welds. This may be in the form of the site butt-fusion welding record in Appendix B or the Contractor's own record form. If the Contractor's own site record form is used, it must contain the information on the appended form and be submitted to the Engineer for review at least ten (10) working days before commencing pre-construction welding.

The Contractor shall take a focussed photograph of each butt-fusion weld before the end of the weld time while the pipe is still clamped. The photograph must clearly show the weld bead and the unique weld identifier. These photographs will become part of the weld records, along with the welding machine printouts and the site butt-fusion welding record. Make the photos available to the Engineer on request and submit them prior to Practical Completion.

Photographs must be able to be easily cross-referenced with the weld. To enable this, ensure the following:

1) Image files are renamed to match the weld number.
2) When taking photographs, ensure that the device's location services are turned on to enable the image to be geotagged and the photograph location saved in the image EXIF data. Alternatively, provide GPS locations of each weld on the site record sheet.
3) Include weld numbers in at least one photograph. Photographs showing the welding operative and/or lead welder can be useful.

6.2 EF welding records

The Contractor shall maintain a site record for all EF welds. This may be in the form of EF welding record in Appendix C or the Contractors own record form. If the Contractor's own site record form is used, it must contain the information on the appended form and be submitted to the Engineer for review at least ten (10) working days before commencing pre-construction welding.

The lead welder or welding supervisor must verify on the site record form that all EF welds have been made in accordance with the WMS and that the information on the record form is correct.

The Contractor shall take a focussed photograph of each EF weld before the EF fitting is buried. The photograph/s must clearly show the unique weld identifier, the EF fitting's make, size and PN.

The photographs, site records and EF controller printouts shall be made available on request and handed over prior to Practical Completion.

Photographs must be able to be easily cross referenced with the weld. To enable this, ensure the following:

1) Image files are renamed to match the weld number.
2) When taking photographs, ensure that the device's location services are turned on to enable the image to be geotagged and the photograph location saved in the image EXIF data. Alternatively, provide GPS locations of each weld on the site record sheet.

6.3 Testing

6.3.1 Leak testing – non-pressure

Refer to *ESF-600-STD-206: Gravity sewer pipe rehabilitation – General requirements for the installation of lining systems*.

Appendix A: Example Inspection and Test Plan

Contractor Name	ABC Limited	**To be completed, submitted, and approved before works can commence**	**Complete Watercare's Health and Safety induction**	*Yes*	*Date*
Project Reference	(Project Name)		**Control of Work documentation submitted (AA, JSA, Work Permits etc.)**	*Yes*	*Date*
Contractor Representative			**Work Method Statement**	*Yes*	*Date*
			Flow management plan	*Yes*	*Date*
			Quality Control Plan	*Yes*	*Date*

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Upstream Structure (e.g. MH 01)	Downstream Structure (e.g. MH 02)	Pipe Cleaned (Yes / No)	Flow Management in place (Yes/No)	CCTV Inspection (Reference Report No.)	Confirm Pipe Size (ID) (mm)	Confirm Liner Size (OD) (mm)	Liner Material and Certificates	Confirm location of laterals	Pipeline preparation after cleaning (e.g. repairs)	Installed liner - no defects	Site welding record	Grouting around liner anulus (if required)	Liner termination and epoxy around manholes	Post-installation CCTV	Testing and sampling of pipeline	Remediate all defects	Contractor's Representative
MH-01	*MH-02*	*Yes*	*Yes - in place (17/04/2024)*	*Yes: Report No. 1234 (18/04/2024)*	*300 mm*	*285 mm*	*Polyethylene / Yes*	*Yes*	*Repairs completed (21/04/2024)*	*Yes*	*Weld No.'s*	*Not required, only at terminations*	*Yes (25/04/2024)*	*Yes: Report No. 9876 (26/04/2024)*	*Pass (30/04/2024)*	*Completed (02/05/2024)*	*Signed and Date*

Appendix B: Site Butt Fusion Welding Record Example

Site Butt Welding Record Example

Sheet No.		of (No. of sheets)		Watercare An Auckland Council Organisation

Project	Contractor (Company)		Welding Supervisor		Welding Machine Details		Pipe Details		Weather Code	1 - Sunny	Weld Protection	1 - None	Weld Method		Welding Supervisor Sign-off:	
			Name:		Make:		PE			2 - Dry		2 - Poly tent	POP 003 5.1			
Location	Welder's Details		Welding qualification:		Type:		DN			3 - Rain		3 - welding shelter	DVS 2207.1			
	Name				Machine No.		PN			4 - Hail		4 - Heating for low temp	Other (State)			
Contract No.	Welding qualification:		Welding ID No.		Manufacture date		Manufacturer			5 - Frost			Additional Comments			
	Welding ID No.				Calibration date		Manufacturing Standard			6 - Wind						
Pipe Installed									For multiple responses under the Code No's columns below, specify the numbers in the same sequence as above (e.g. 3,4 = rain & wind, or 1,2 = sunny & dry and 2 = poly tent)							
Open Trench	Trenchless															

Weld No.	Date/Time	Average Pipe OD / thickness (1) [mm]	Measured heating plate temperature (2)		Drag pressure [bar]	Jointing Pressure Settings (3)			Heat Soak time (4) [s]	Change-overtime (4) [s]	Weld pressure build-up time (4) [s]	Cooling time under pressure (4) [minutes]	Ambient temp.[°C]	Bead width / height (4) (mm)	Maximum Misalign.(4) (mm)	Code No's.		Photo taken (Y/N)	Welding operatives' visual inspection comments
			Minimum [°C]	Maximum [°C]		Bead-up [bar]	Heat Soak [bar]	Welding [bar]								Weather	Weld Protection		

Signature of Welder:	Date:		Any other comments or explanations

Notes:
1) For pipes >DN225, measure pipes OD's with a diameter tape & wall thicknesses at 4 equally spaced points around the pipe. For pipes ≤DN225, use the average pipe OD and wall thickness from AS/NZS 4130 for setting the weld pressures
2) Measure the plate temp for each weld at 12, 3, 6 & 9 o'clock using a calibrated temp. probe
3) According to the welding method used. (Note that the Soak pressure must equal the drag pressure for all welding methods)
4) The actual values must be entered
5) Include geotag in image EXIF data. Rename image file to match weld number Signature

Appendix C: EF Fusion Welding Record Example

EF Welding Record Example

Sheet No.		of (No. of sheets)		Watercare An Auckland Council Organisation

Project	Contractor (Company)		Welding Supervisor		Welding Machine Details		Pipe Details		Weather Code		Weld Protection		Generator Set Details		Welding Supervisor Sign-off:	
			Name:		Make:		PE			1 - Sunny		1 - None				
Location	Welder's Details		Welding qualification:		Type:		DN			2 - Dry		2 - Poly tent	Make/Model			
	Name				Machine No.		PN			3 - Rain		3 - welding shelter	Power (kVa)			
Contract No.	Welding qualification:		Welding ID No.		Manufacture date		Manufacturer			4 - Hail		4 - Heating for low temp	Manufacture date			
	Welding ID No.				Calibration date		Manufacturing Standard			5 - Frost			Calibration date			
										6 - Wind						

Pipe Installed	
Open Trench	Trenchless

For multiple responses under the Code No's columns below, specify the numbers in the same sequence as above (e.g. 3,4 = rain & wind, or 1,2 = sunny & dry and 2 = poly tent)

Additional Comments

1) If Ovality % is greater than allowed in POP 001 use re-rounding clamps. (Ovality % = (Max. OD-Min.OD) x100/ mean OD. For pipes <DN315, 1.5% allowed. For pipes DN315 and larger, 1% allowed.
2) Cut off end reversion (barrelling) if the peeled pipe OD is less than the min. allowed in POP 001.
3) Peel depth is given in Table 2 POP 001 - it may require several peels to allow Coupler to fit.
4) Include geotag in image EXIF data. Rename image file to match weld number Photo.

Site Details					Pipe Details			Fitting Details			Pre-weld details				Post Weld Details						
Weld No.	Date/Time	Weather Code	Weld Protection Code	Ambient Temp [°C]	Pipe (DN/PN)	Min. pipe OD (50mm from end)	Measured ovality [1] Max. / Min diameter	Type	Make	SDR	Minimum Reversion Dia at End [2]	Peel.[3] Thickness (mm)	Pipe OD/s (peeled)	Are Both Pipe OD's ≥POP 001 Min?	Pre-heat Y/N	Start Weld Time	End Weld Time	Weld Time (on fitting)	End Cool Time	Photo taken Y/N	Indicator Pins Popped Y/N

Signature of Welder:	Date:	Any other comments or explanations