# Water Industry Guidance on Undertaking Gravity Sewer Rehabilitation

# Using Cured In Place Pipe (CIPP) Technology

| Revision Number | Description of Change | Author(s) | Approved By | Date of Approval |
|---|---|---|---|---|
| Draft 2.0 | Final Draft | SRCG | | |
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# Foreword

## General Purpose

This document describes the minimum standards to be achieved by those engaged in the design and implementation of solutions for the rehabilitation of gravity sewer assets using Cured In Place Pipe (CIPP) technology.

The document has been drafted by the Sewer Rehabilitation Contact Group, comprising of representatives of the UK Water and Sewerage Companies (WaSCs) for their own purposes. It is not a Water UK Information and Guidance Note (IGN), but the process for acceptance as an IGN has been initiated.

## General Scope

The document shall apply to all existing assets undergoing rehabilitation.

The guidance outlined in this document is the UK water industry's required practice and shall be followed unless there is a valid reason for deviating from it. Any deviation shall be notified in writing to the relevant Water and Sewerage Company (WaSC) and shall not be implemented without the prior written approval of the WaSC.

## Responsibility

If it is considered that adhering to any part of this document will result in an asset which is not fit for purpose for a particular project or situation, permission must be sought to modify the requirements of this document from the relevant WaSC through its appropriate derogations process.

## References

Where this document refers to external documentation (e.g. other standards and specifications, etc.) they are deemed to form part of this guidance document. It shall be the responsibility of the Designers and Contractors to obtain copies of all referenced external documentation where this is necessary to ensure compliance with the all relevant standards and specifications. The most recent version of all external documentation shall be used.

## Implementation of change

The UK WaSCs reserve the right to implement change at any time to this guidance document. Such changes may be required through a change in legislation, policy or strategic direction. Any changes to the guidance document will be notified to all appropriate stakeholders.

## Derogations from this guidance document

Whilst the minimum requirements of this guidance document shall be met (where applicable) this document is not intended to stifle innovation, or delay progress of any on site works. Should a derogation from any aspect of this guidance document be sought, a Derogation Application to the relevant WaSC must be submitted in advance of any proposed departure from the requirements of the guidance document. The submission of the application does not confer permission to proceed, and the application should be submitted allowing sufficient time for the WaSC to evaluate it. Works can only proceed based on the derogation once permission has been granted from the WaSC. The WaSC shall retain the right to reject the application in favour of compliance with the guidance document or any other reasons deemed appropriate by the WaSC.

## Glossary

| Term | Description |
|---|---|
| BS | British Standard, denotes a standard that applies in the UK |
| CCTV | Closed Circuit TV |
| CCTV Survey | Survey of the interior of a sewer |
| CESWI | Civil Engineering Specification for the Water Industry |
| CIP lateral connection repair | Cured in place repair of the connection between a sewer and a sewer lateral – see lateral connection repair |
| CIPP | Cured in Place Pipe |
| CIPP System | General term used in this guidance to include CIPP liners (full and part), cured in place repair and cured in place lateral repair |
| CIPP Technology | General term referring to all types of CIPP systems covered in this Guidance |
| CIPR | Cured in Place Repair |
| Cured in Place Repair (CIPR) | Short length of cured-in-place pipe (CIPP) used to effect a localised repair within a sewer (also referred to as local linings and patch repairs) or a repair to a lateral connection. |
| Cured In Place Pipe (CIPP) | Lining with a flexible tube impregnated with a thermosetting resin which produces a pipe after resin cure |
| Curing | The process of resin polymerisation, which may be initiated or accelerated using heat or ultraviolet light |
| Contractor | Any trading entity contracted to an employer to carry out any works covered by this guidance |

| Term | Description |
|---|---|
| Declared Value | Design value of a CIPP or CIPR material property which is declared in advance by the Supplier and substantiated by type testing |
| Derogation | A change from the guidance provided in this document |
| Derogation Application | Application to a WaSC for derogation from this guidance |
| EN | European Norm, denotes a standard that applies in the 34 European Countries covered by CEN (European Committee for Standardisation) |
| Full length liner | Lining a complete section of sewer between two access points |
| $H_2S$ | Hydrogen sulphide |
| IGN | Industry Guidance Note issued by Water UK |
| Installer | Company responsible for undertaking a CIPP or CIPR installation |
| ISO | International Organization for Standardization, denotes a worldwide standard |
| Lateral connection repair | In the context of this Guidance it is a repair made with CIPP technology to a damaged lateral connection, either stand alone or in conjunction with a full or part liner |
| Leak tight liner | Liner intended to prevent infiltration of groundwater to the sewer and/or exfiltration of sewage from the sewer |
| Liner | A flexible tube or folded sheet, consisting of a combination of carrier material, liquid resin system, and any other coatings and/or reinforcements |
| Local Repair | General term that in the context of this guidance includes all short length repairs using CIPP technology |
| Part Liner | A length of liner used in a long or large sewer where there are multiple defects close together instead of individual patches or a full-length liner |
| Patch Repair | Short length of cured-in-place pipe (CIPP); also referred to as a Cured-in-Place Repair (CIPR). |
| Re-Rounding | Use of techniques that can reshape pipes and displace surrounding ground |
| Resin system | A thermosetting resin including the curing agent(s) and any fillers or extenders |
| Site Quality Check | Quality checks required onsite before, during and following installation by the WaSC |
| SRCG | Sewer Rehab Contact Group, comprising representatives of each of the 13 WaSCs in UK and Ireland that meets to |

| Term | Description |
|---|---|
| | discuss issues of common interest concerning the rehabilitation of sewers |
| SRM | Sewer Risk Management by WRc Ltd |
| Type 1 Liner | The liner, grout and host sewer form a new rigid composite section that carries all ground and traffic loads |
| Type 2 Liner | The liner is designed as a flexible pipe to structurally stabilise the host sewer and the sewer fabric continues to carry the ground and traffic loads |
| Type Test | A single set of detailed tests to demonstrate that the proposed product can meet the declared values |
| WaSC | Water and Sewerage Company |
| WaSC Standard | Internal standard required by a WaSC for the performance of a specific activity |
| WIS | Water Industry Specification issued by Water UK |
| UK WaSCs | The 10 Water and Sewerage Companies (WaSCs) of England and Wales, Scottish Water, Northern Ireland Water |

# Table of Contents

# 1 Purpose

This Water Industry Guidance on Undertaking Gravity Sewer Rehabilitation using Cured In Place Pipe Technology has been drafted by the Sewer Rehabilitation Contact Group (SRCG), which comprises representatives from the 10 Water and Sewerage Companies (WaSCs) of England and Wales, Scottish Water, Northern Ireland Water (collectively referred to hereafter as the UK WaSCs) and Irish Water. Its purpose is to provide the UK WaSCs's specific baseline requirements with regard to gravity sewer rehabilitation using Cured In Place Pipe (CIPP) Lining. This guidance does not cover manhole, rising main or siphon rehabilitation or any rehabilitation method other than CIPP lining for gravity sewers. The Water Industry Guidance on Undertaking Gravity Sewer Rehabilitation using CIPP Technology shall hereafter be referred to as the guidance document. Renovation, renewal and rehabilitation works will be collectively known as sewer rehabilitation. This guidance document covers pre-rehabilitation requirements, design and material requirements, installation practice and test method requirements for sewer rehabilitation without excavation using CIPP methods. Service lateral pipes may also require rehabilitation using this guidance document.

While this guidance document is provided to convey the WaSCs' specific baseline requirements regarding sewer rehabilitation using CIPP, each design shall be carried out on a site-specific basis, accounting for all constraints and restrictions therein.

This guidance document shall be read in conjunction with the current editions of the Civil Engineering Specification for the Water Industry (CESWI) and WaSC's amendments to CESWI, the WRc Sewerage Risk Management (SRM) and other design standards outlined in this guidance document.

Where a conflict exists between a clause in this guidance document and CESWI, or SRM then this guidance document shall take precedence. Where a conflict exists between this document & a WaSCs internal standards or specifications then the WaSC internal standards or specifications shall take precedence.

It should be noted that CIPP technology is one of several trenchless techniques available for the rehabilitation or repair of gravity sewer pipes. Other suitable technologies should be considered by WaSCs when undertaking their solution selection process.

Trenchless gravity sewer rehabilitation techniques include:

- CIPP lining (included in this guidance)
- Lining with close-fit pipes (cross section reduced during installation then reverted)
- Slip lining with continuous pipe
- Lining with discrete pipes (sections of pipe jointed together)
- Lining with inserted hose
- Lining with pipe segments
- Reinforced cementitious lining

- Re-rounding then lining
- Spirally wound lining
- Lining with sprayed material (e.g. cement mortar, epoxy resin, polyurethane)

Trenchless gravity sewer repair techniques include:

- CIPP repair (included in this guidance)
- CIPP lateral connection repair (included in this guidance)
- Joint sealing (e.g. resin or grout injection)
- Mechanical props (expansion device to re-create circular cross-section)
- Robotic repair by remote control
- Stabilisation (e.g. pointing or chemical sealing against infiltration)

# 2 General

The proposed rehabilitation works are required to be designed, supplied, installed and tested in accordance with this guidance document and any design, classification and material standards referred to within it.

For guidance only, a selection matrix for CIPP Lining is included in the below table:

| | CIPP Liner |
|---|---|
| Any shape? | Yes |
| Large sewer suitability? | Yes (up to 2700mm circular) |
| Likely no-dig installation? | Yes |
| Construction feasible within a live water environment? | No |
| Curves/Bends permissible? | Yes (with limitation*) |
| Significant diameter reduction likely? | No |
| Is no-dig connection to laterals feasible? | Yes |

*Stipulated by lining manufacturer or assessed in design process

All works and materials required shall comply with the requirements of this guidance document and the standards referred to therein. Products and materials specified for use shall comply with this guidance document and all appropriate standards. The foregoing are necessary to confirm that the rehabilitation system is in accordance with the material specifications, structural and water tightness classifications and that the system is 'fit for purpose'. Evidence of compliance shall be provided where requested by the WaSC.

All materials shall be new unless explicitly requested otherwise by the WaSC.

The requirements of this guidance document relate to all sizes of both circular and non-circular sewer pipes.

Manhole rehabilitation works shall generally not commence until sewer rehabilitation works are completed and positively tested.

# 3 Sewerage Inspection Before Survey Works

## 3.1 Below Ground Asset Surveys

Prior to any rehabilitation works taking place along any section of sewer, below ground asset surveys shall be carried out to confirm the location, dimensions and condition of the assets. The sewers to be rehabilitated shall be surveyed to determine the position, size and angle of approach of all laterals, to an accuracy appropriate to the method of reconnection.

Manhole and sewer cleaning shall only be undertaken during these works where necessary to successfully complete the asset surveys. On completion of the surveys, drawings and reports of the survey and proposals for rehabilitation shall be prepared.

During the survey it shall be noted if the pipework is consistent between manholes i.e. no significant changes in direction, material or diameter. Where the pipework is not consistent between manholes the designer/WaSC must be alerted prior to any rehabilitation works commencing. The WaSC shall be informed of any significant issues with regard the structure of the pipe e.g. corrosive substance damage (such as H2S damage), root ingress etc. as this will affect the preparation of the pipe(s) and cost of rehabilitation.

On completion of the rehabilitation works, final below ground asset surveys shall be completed to confirm that the works in each section have been carried out to the WaSC requirements.

## 3.2 Sewerage Inspection Survey Standards

The Contractor shall adhere to the WaSC's standards as appropriate when carrying out the works for below ground asset surveys. Other methods of inspection survey not covered by the WaSC's standards shall be submitted to the WaSC for approval.

## 3.3 Asset Database

The WaSC's asset database shall be updated in accordance with the requirements of the WaSC.

Information to update the WaSC's asset database shall be made available to the WaSC at the earliest convenience post completion of survey works.

This may be geospatially in that the asset is mapped in the wrong location, or regarding characteristics i.e. pipe diameter, material, depth etc. that are incorrect.

## 3.4 Site Quality Checks

Site Quality Checks shall be completed in accordance with Section 7 of this guidance and the requirements of the WaSC.

## 3.5 Uncharted Sewerage

Uncharted sewerage exists as a physical asset (sewers and/or manholes) but which does not have an associated digital record.

In the event of discovering uncharted sewers the WaSC shall be immediately informed. Uncharted sewers shall not be surveyed unless specifically instructed by the WaSC. When authorised, uncharted sewerage shall be surveyed in accordance with the WaSC requirements.

# 4 Sewerage Cleaning Works

Where required, prior to rehabilitation the sewer shall be cleaned by a method which is acceptable to the WaSC in accordance with their specifications and the Manual of Drain and Sewer Cleaning (WRc).

During all cleaning works, all upstream & downstream flows shall be managed, ensuring that there is no unplanned or unmanaged surcharging of upstream manholes and laterals during the cleaning and subsequent rehabilitation works. See also Section 7.9 on flow control during works.

Multiple cleaning equipment setups may be required. All supernatant liquid shall be decanted prior to the disposal of the material in accordance with Section 7.12 – Management of Waste Materials.

The WaSC shall be notified immediately if fresh soil, rocks, pieces of pipe, or other visible signs of potential problems occur during cleaning operations.

## 4.1 Pre-Survey Sewerage Cleaning

A sewer condition survey is required prior to commencing rehabilitation works to determine the rehabilitation method for the sewer length and to determine the enabling works required in order to carry out rehabilitation. Any cleaning of manholes and sewers necessary to facilitate the survey shall be instructed by the WaSC.

Operational information attributed to an asset is valuable information for a WaSC and shall be captured in accordance with any requirement of the WaSC prior to undertaking cleaning. Data captured may inform the decision-making process for future works.

## 4.2 Pre- Rehabilitation Works Cleaning

Pre-rehabilitation cleaning is required on the sewers and manholes where approval is given by the WaSC for rehabilitation works to proceed, following the initial manhole and CCTV survey. This cleaning shall consist of all necessary works to prepare the pipeline for rehabilitation and lateral repairs including but not limited to jetting, vacuuming, joint preparation and robotic cutting.

Manholes may need to be cleaned as part of the pre-rehabilitation works.

Sewers to be rehabilitated shall be prepared so that the installation and performance of the rehabilitation system is not impaired. The cleaning process and preparation shall not affect the stability of the existing sewer. Pre-rehabilitation cleaning works shall be carried out as per CESWI Section 9.3.

# 5 Sewer Rehabilitation Design

Refer to Appendix C: Sewer Rehabilitation Decision Process (included for guidance only).

Sewer rehabilitation shall be carried out using non-dig (or low-dig) methods where possible. Access will normally be via existing manholes and any special requirements for access shall be detailed in the method statement, should they be required. The following methods of sewer rehabilitation are discussed further in this guidance document.

- lining using cured-in-place-pipes (CIPP)
- local repairs
    - patch repair (CIPR)
    - Lateral connection repair (CIPR)
- stabilisation works

## 5.1 Design Requirements

The proposed sewer rehabilitation techniques shall comply with the design, classification and material standards as set out in this guidance document.

A design of the rehabilitation works shall be carried out in accordance with a recognised design standard, including, but not limited to:

- WRc (Water Research Centre) Sewerage Risk Management (SRM)
- DWA (German Association for Water, Wastewater and Waste) DWA-A143-2
- RERAU (REhabilitation des Réseaux d'Assainissement Urbains ) (2004)
- ASTEE (Association Scientifique et Technique pour l'Eau et l'Environnement) 3Rv2 (2017)
- ASTM (American Society for Testing and Materials) ASTM F1216-16

## 5.2 Lining Design

As stated above (Section 5.1) there are several available procedures for design. This guidance document does not preclude any applicable design standard, insofar as it satisfies the requirements for design parameters.

The current edition of WRc Sewerage Risk Management (SRM) has developed two structural design procedures – Type I and Type II. The Type I and Type II design procedures produce a structurally 'new' sewer that will carry all ground and traffic loads. They have two different underlying structural design philosophies:

- Type I liners - the liner, grout and host sewer form a new rigid composite section that carries all ground and traffic loads.
- Type II liners - the liner is designed as a flexible pipe to structurally stabilise the host sewer and the sewer fabric continues to carry the ground and traffic loads.

Generally, only Type II liners (or similar) shall be used for sewer rehabilitation, for both full length liners, part liners and localised repairs. Type I liners may be required to satisfy design criteria in some larger sewers.

Calculations for each proposed lining installation shall be prepared in accordance with procedures detailed in the adopted design standard. Due consideration shall be given to the following when preparing a design:

- Dead load (e.g. soil loads) (with particular regards to depth to cover)
- Live Load (e.g. traffic loads) (with particular regards to depth to cover)
- Groundwater Table and Hydrostatic Pressure Effects
- Groundwater and Soil Chemical Characteristics
- Floatation
- Hydraulic capacity requirements
- Sewage characteristics (Nature of material to be conveyed, chemical composition including any trade waste content or high temperature materials)
- Resistance to corrosive substances
- Host pipe condition, ovality, material & thickness
- Rehabilitation material physical properties
- Contractor's proposed method of installation
- Flow management requirements (in conjunction with the WaSC)
- Whole life cost of proposed solution.

The minimum design requirements are set out in Table 5.1 with WaSC specific values set out in Appendix D.

*Table 5-1 Minimum Design Requirements*

| Design Parameter | Minimum Value or Requirement * |
|---|---|
| Full Length Liner | Type II Liner; Type I may be applicable for larger sewers |
| Part Liner | Type II Liner; Type I may be applicable for larger sewers |
| Lateral Connection Repair | Type II Liner |
| Factor of Safety for Structural Loadings | 2.0 |
| Host Pipe Condition for Structural Liner | Fully (1) and Partially Deteriorated (2) |
| Soil Depth (mm) | Difference between ground level and pipe crown |
| External Grouting Pressure During Installation | Within the defined acceptable limits stated by the liner manufacturer |
| Lining Deformation Limitation | In accordance with *SRM* design or other recognised procedure |
| % of Internal Diameter | In accordance with *SRM* design or other recognised procedure) |
| Design Life for Rehabilitation Lining System | 50 years full liner and part liner (CIPP) |

For operational purposes, the ends of all repairs shall be tapered, as far as practicable, to form a smooth transition where they meet the internal surfaces of the host pipe. For "leak tight" liner installations the proposed local repair method shall demonstrably achieve a seal between the repair tube and the host pipe that will prevent infiltration and exfiltration. Where part length liners (CIPR) are installed over longitudinal defects, the length of the liner shall extend to the first length of undamaged pipework to minimise the need for further rehabilitation works.

The proposed liner shall adequately and demonstrably cure when in contact with the parent material given the high probability that the latter is wet.

The reduction in sewer capacity following rehabilitation shall be kept to a minimum.

The minimum value of the hydraulic capacity for each rehabilitation section shall be agreed with the WaSC prior to installation of any liner or repair. Calculations shall be submitted for each rehabilitation section to demonstrate that the proposed liner does not reduce the hydraulic capacity to less than the agreed value.

### 5.2.1 Structural Loading

The different national design procedures which are most frequently used are categorised in the table below by the type of structural design.

*Table 5-2 National design procedures. Note the comparison is for indicative purposes as the Types/Conditions/States are not directly comparable between the methods. The original documents should be consulted for the details of these.*

| Design Type | SRM | USA American Society for Testing Materials ASTM F1216-16 | Germany DWA-A143-2 | France ASTEE_3Rv2 | France RERAU (2004) |
|---|---|---|---|---|---|
| Rigid composite sewer | Type I | - | - | | |
| Flexible liner in structurally stable sewer | Type II | Partially Deteriorated | Condition I*, Condition II* | State I<br>State II (stable but further deterioration likely) | Equivalent of ASTEE State II** |
| Flexible liner in structurally unstable sewer | - | Fully Deteriorated | Condition III* | State III | |

* A translation of the DWA Condition categories is as follows:

- Host Pipe Condition I: Host pipe alone capable of bearing (e.g. leaks in pipe connections, walls have no cracks except hairline cracks)
- Host Pipe Condition II: Host pipe-soil system alone capable of bearing (e.g. longitudinal cracks with small pipe deformation with checked functional lateral bedding. Confirmed e.g. through long-term observation and/or penetrometry)
- Host Pipe Condition III: Pipe-soil system in the long-term no longer alone capable of bearing; significant deformation; compared with Host Pipe Condition II the liner is also stressed by earth and traffic loads

** A translation of the ASTEE States is as follows

- State I Stable, hydraulically compromised, superficial corrosion, designed to resist groundwater
- State II Stable but further deterioration likely, cracked deformations <10%, design to resist groundwater and further deformations.
- State III Unstable, likely to collapse, host pipe has lost its hoop and bending stiffness, design to resist groundwater and soil pressure

### 5.2.2 Water Table

Unless otherwise evidenced, the water table level shall be considered to be at ground level and its effects allowed for in the liner design calculations. It shall be noted that it is subject to variations, e.g. during rainfall events and high tides in coastal areas.

Design calculations shall demonstrate that the performance of sewer and manhole linings and localised repairs will be unimpaired due to water table pressure.

High saline concentrations can be expected in the groundwater in those areas adjacent to marine waters. The design shall demonstrate that there will be no negative impact on the long-term chemical, mechanical and physical performance of the lining material and any grouts or bonds due to the presence of saline groundwater.

### 5.2.3 Flotation and External Pressure

Design calculations with respect to flotation and pressure shall be submitted in accordance with the design standard being adopted.

Should the proposed rehabilitation method require annulus grouting, it is required to prevent flotation or deflection of the liner due to pressure induced by the grouting. The proposed method for pressure injection of grout fluid shall demonstrably be within the defined acceptable limits of the liner manufacturer. Should the lining not be capable of withstanding the proposed grout pressures, then the maximum pressure at the point of grout injection must be reduced or staged grouting must be employed.

### 5.2.4 Leak Tightness

Leak tight liners shall be used for ground water infiltration or sewage exfiltration reduction and the supplier shall provide suitable evidence of expected performance.

Reference shall be made to CESWI Cause 9.17.

Reference shall be made to Table 8.1.1 for water/leak tightness testing requirements.

### 5.2.5 Resistance to Corrosive Substances & Contaminated Wastes

The survey results and the environment in which rehabilitation products will be installed shall be considered prior to selecting the rehabilitation method. This includes consideration of areas with direct contact with acidic sewage, high saline content groundwater near marine areas, corrosive industrial waste and other contamination sources.

A solution (installation material and technique) shall be selected that is suitable for this environment and the proposed rehabilitation solution shall demonstrably have adequate chemical resistance properties. The proposed products shall be resistant to microbiological and other forms of attack.

## 5.3 Material Specification

Table 5.3 sets out the permitted materials to be utilised alongside the relevant specifications. All materials used shall be resistant to chemical attack, microbiological attack and abrasion for suitable use in a municipal sewage application and in an underground sewerage environment.

*Table 5-3 Material Specifications*

| Lining Type | Specification | Title |
|---|---|---|
| Lining with cured in place pipe method – materials | *EN ISO 11296-4:2018* | *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks. Part 4: Lining with cured-in-place pipes.* |
| Localised Repairs | *WIS 4-34-06* | *Specification for localised sewer repairs using cured-in-place systems with or without re-rounding.* |

Note: only the most recent and up to date versions of the standards and specifications shall be used and prevail (i.e. the standards and specifications listed in the above table may be revised after the issue of this Specification)

The composition of all components, which make up the finished pipe shall be submitted to the WaSC for approval prior to its installation.

Material classes shall be as set out in EN ISO 11296 – 4:2018 Clause 5.1 Table 1.

### 5.3.1 Resin Liners

Any proposed resin-based solution shall meet the minimum requirements set out in table 6.1.

*Table 6-4 Liner Type Minimum Requirements*

| Characteristic | Minimum Requirement |
|---|---|
| Flexural stress at rupture | 50 MPa |
| Modulus of elasticity | 2,000 MPa |
| Tensile stress | 25 MPa, Elongation 0.5% |
| Creep Modulus [after– 20 years] | 1500 MPa in air<br>800 MPa in water |

### 5.3.2 Material Characteristics

The manufacturer's declaration shall be provided as part of the design. This shall detail the material composition and wall structure and thickness of the pipe product. The installed pipe provided shall meet this declaration.

A cut section of the CIPP wall shall be examined visually, with magnification as necessary, to confirm that the thickness and relative position of each component layer are within the tolerances declared.

The wall thickness of the installed pipe shall comply with the requirements indicated in Table 4 of EN 11296-4:2018.

## 5.4 Mechanical Characteristics

The mechanical characteristics of pipe samples taken from actual installations shall comply with the requirements set out in Table 5 of EN 11296-4:2018.

## 5.5 Geometric Characteristics of Liners

Details shall be prepared for each design to demonstrate that the design has considered and achieved the minimum requirements in respect of the required liner geometric characteristics.

### 5.5.1 Liner Wall Thickness

The design of any proposed liner wall shall include calculations on (but not limited to) the following design parameters:

- Thickness (total and composite) and relative positions of each component layer.
- Tolerances.

### 5.5.2 Liner Dimensions

The wall thickness and length of the proposed liner shall have sufficient tolerance so that any longitudinal or circumferential stretch that occurs during installation can be accommodated without any degradation to the performance of the liner.

The outside diameter of the liner shall be selected so that it forms a close fit to the existing sewer wall when installed.

## 5.6 Whole Life Cost

Whole life cost solutions consider the cost of the product from design through to disposal or the end of product design life. Where multiple patch repairs (CIPR) are to be used within a 30m section or between manholes, a full or part liner (CIPP) may be a more cost-effective solution. Design solutions shall follow the WaSC specific requirements on calculating the whole life cost for the proposed solution. Refer to the WaSC specific requirements in Appendix D.

# 6 CIPP Rehabilitation and Repair Techniques

This section addresses the use of and requirements for both CIPP lining and Cured in Place Repairs (CIPR) to sewers and lateral connections. There are several configurations for installing CIPP liners or CIPR. These are full length CIPP liners, part liners (CIPP), and repairs (CIPR) which include patches and lateral connection repairs.

Full length "manhole to manhole" CIPP lining uses CIPP technology to create a new pipe within the existing sewer length to be rehabilitated as shown in figures 1 & 2 below.

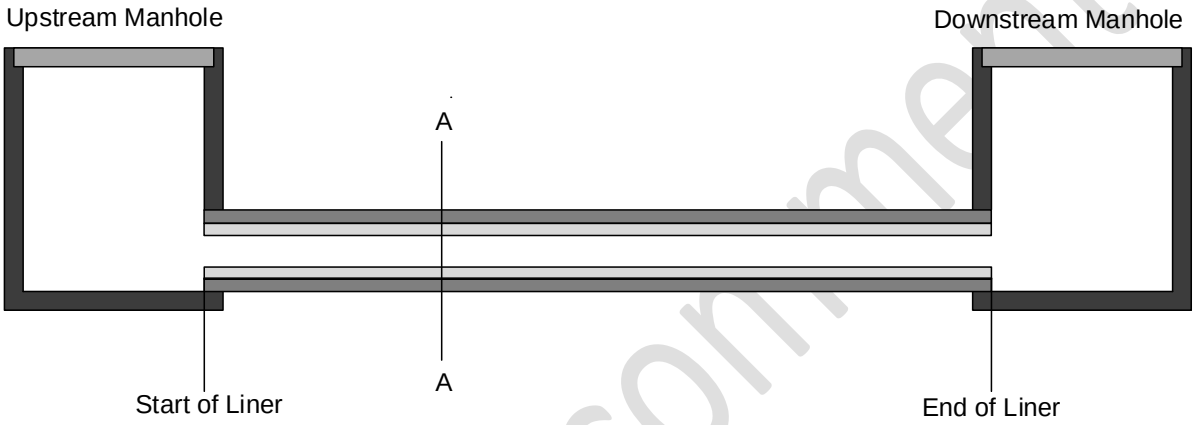



*Figure 1 Full Length "manhole to manhole" CIPP liner*

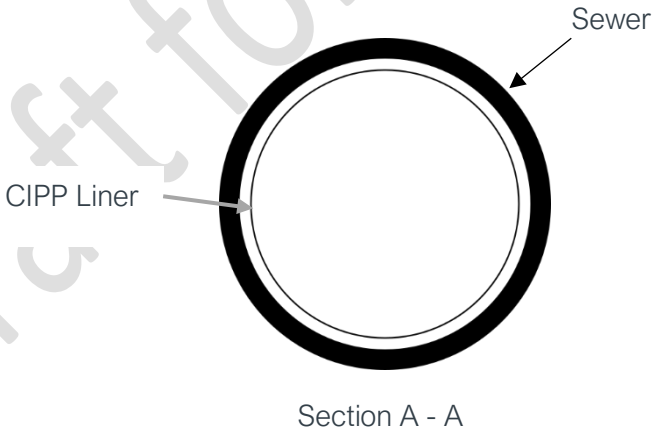



*Figure 2 Cross section of CIPP lined sewer*

Part length CIPP liners are similar to a full length CIPP liner, however only traverse part way along a sewer length. The cross section is the same as that of a full length CIPP liner (figure 2). Figures 3, 4, & 5 show example configurations of part liners.

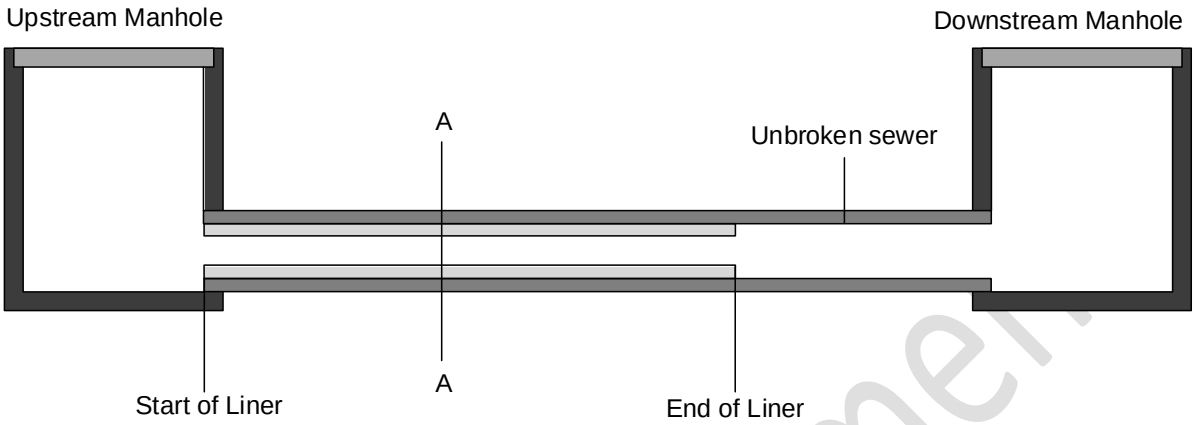



*Figure 3 Part liner starting at upstream manhole*

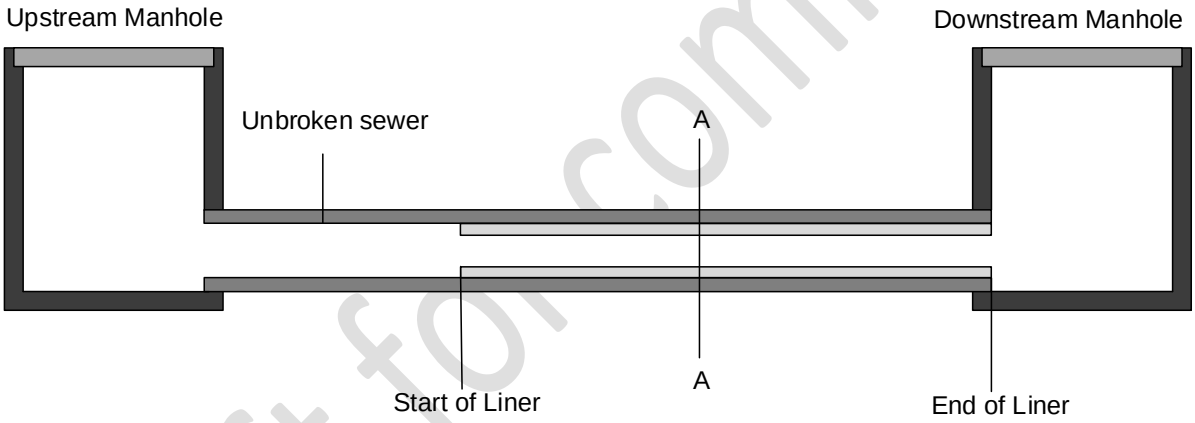



*Figure 4 Part liner terminating at downstream manhole*

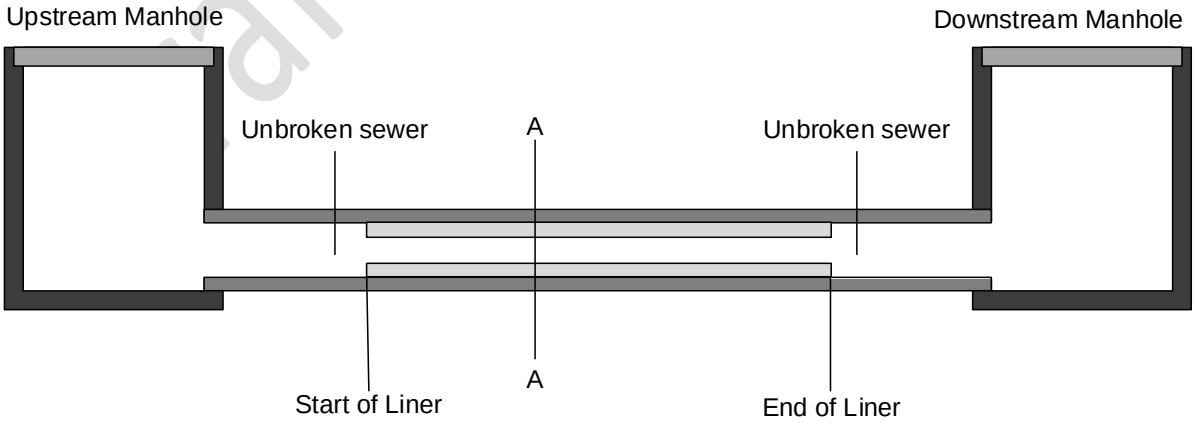



*Figure 5 Part liner starting and terminating within sewer pipe*

Cured in Place Repairs (CIPR) are local repairs (CIPR) and include patch repairs and lateral connection repairs.

A patch repair (CIPR) forms a repair over a short defect length as shown in figures 6 & 7.

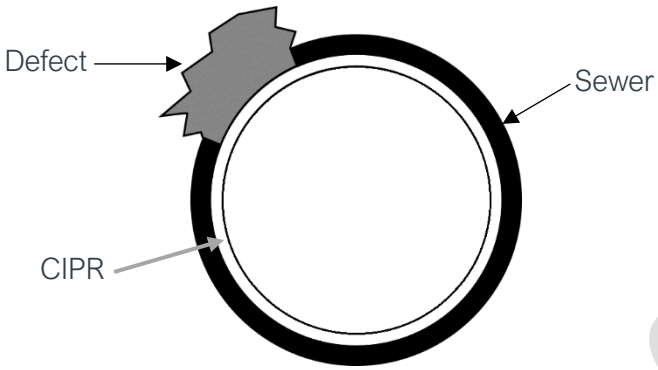



*Figure 6 Section B-B Cross section of CIPR*

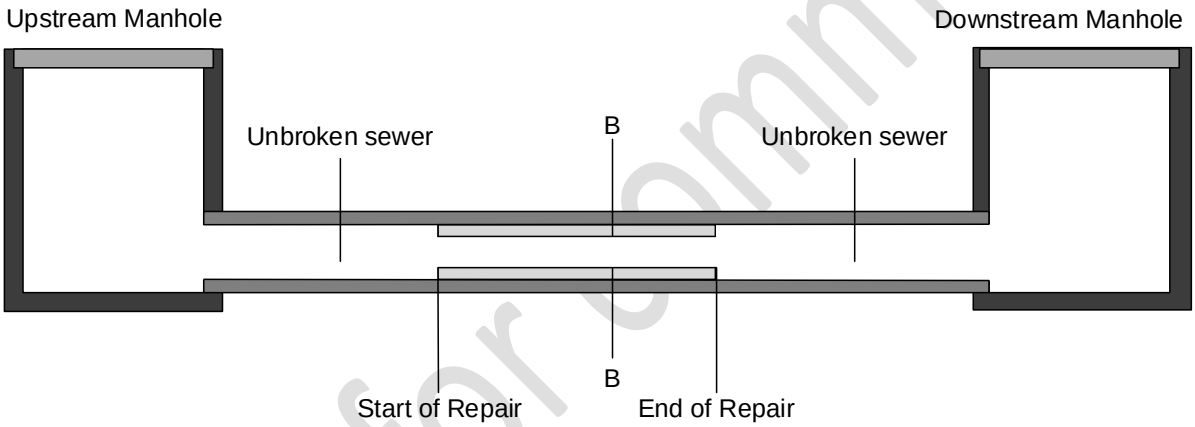



*Figure 7 CIPR within a pipe length.*

Lateral connection repairs are localised repairs on an incoming connection. This may be a structural repair to a connection or part of a leak tight lining solution. More information on lateral connection repairs can be found in Section 6.2.2

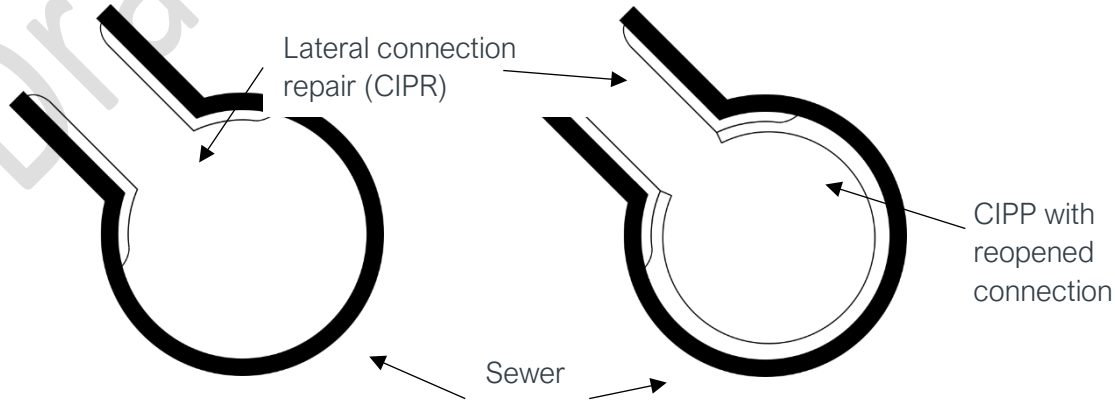



*Figure 8 Cross section of lateral connection repair*

Refer to Appendix A: Selection Matrix of Sewer Rehabilitation Techniques and Appendix C: Sewer Rehabilitation Decision Process (included for guidance only).

## 6.1 Full Length Liners and Part Liners for Sewers

Where multiple defects along a sewer length are highlighted following the pre-rehabilitation CCTV survey full length (manhole to manhole) liners might be proposed. These will require full design, prior to supply. The minimum design requirements are outlined in Section 5 Sewer Rehabilitation Design.

Approval for use of a full-length liner is required from the WaSC where multiple structural defects, which would otherwise merit patch repairs (CIPR), need repair. Part liners may be used where full lining (manhole to manhole) is not deemed necessary by the WaSC, but where several patch repairs (CIPR) would otherwise be required over its length. Full length cost and whole life cost calculations shall be used to determine the suitability of the proposed liner solution. Refer to Appendix C: Sewer Rehabilitation Decision Process and Appendix D WaSC Requirements.

All necessary survey work and cleaning of the pipeline run between manholes, as detailed in sections 3 & 4, shall be undertaken as part of the lining works.

In some instances, it may be necessary to undertake a local repair to prepare the pipeline for the installation of a full-length liner. This local repair shall be designed and installed allowing enough time for it to achieve full strength before the full-length liner is installed.

Pipe diameter and continuity of pipe diameter along the sewer to be lined must be proven prior to rehabilitation works starting on site.

Where deformities are present, investigation shall be completed to confirm the extent of the deformity.

A pre-lining condition survey (such as CCTV) shall be carried out immediately prior to installation to ensure that the lining can be successfully installed and to establish the locations of any connections (live & disused) and bends.

The installed liner shall be continuous over the entire length of a sewer line section and be free from visual defects such as foreign inclusions, dry spots, pinholes, major wrinkles or fins and de-lamination. The lining shall, as far as reasonably practicable, be impervious, free of any leakage, and serviceable. The liner shall be installed in accordance with EN ISO 11296-4 Clause 8.2. It is accepted that a degree of wrinkling will generally occur at bends and at irregularities in the host pipe, including stepped joints.

### 6.1.1 Reconnecting to existing manholes & laterals

To prevent water migration between the CIPP system and the existing pipe, the CIPP liner shall achieve a tight fit against the existing pipe. The liner and existing host pipe shall be sealed at the manhole exit and entry locations in accordance with EN ISO 11296-4 Clause 9.7 – Reconnections to the existing pipeline system.

## 6.2 Local Repairs (CIPR)

### 6.2.1 Patch Repairs

Local repairs using short lengths of liner are to be carried out in accordance with CESWI Clause 9.19 and WIS 4-34-06.

Where multiple patch repairs (CIPR) are to be used within a 30m section or between manholes a full-length liner or part liner (CIPP) may be a more effective solution. Refer to the WaSC specific requirements in Appendix D.

Local repairs are required to resist exterior hydrostatic pressure at the installation location without ballooning, assuming that the water table is at the ground level at all locations.

It is required to ensure water tightness is achieved at each local repair. Local repairs shall be a minimum length to meet the requirements as set out in CESWI Clause 9.19.

All necessary CCTV survey and cleaning work shall be carried out as part of the patch repair installation work.

The entire localised repair process shall be continuously monitored by CCTV camera within the pipe from confirming positioning of the defect to successful completion of the repair. Regardless of the technique employed, in the case of leak tight liners the rehabilitation technique must be capable of being installed under infiltration flows and sealing the defect to prevent continued infiltration flow between the repair and the sewer.

### 6.2.2 Lateral Connection Repairs

Prior to lining a sewer, repairs at defective lateral connections, including laterals causing infiltration, shall be carried out. All users of lateral connections that are to be temporarily 'blocked off' during relining operations shall be notified in advance. Flows from these laterals shall be managed to ensure minimum disruption to the user.

All lateral and branch connections shall be re-opened on pipeline sections following the installation and, where applicable, pressure testing of liners.

All necessary CCTV survey work and robotic cutting shall be carried out where required as part of the lateral repair.

Lateral connection repairs shall extend into the lateral pipe for a length in accordance with ISO 11296-4 based on the class of the repair, or as stipulated by the WaSC, and ensuring that the transition between the collar and pipe is smooth.

#### 6.2.2.1 Reopening of Sewer Lateral Connections

Re-opening of sewer connections shall be carried out in accordance with CESWI Clause 9.5.

In advance of undertaking repair works the exact distance and orientation at which lateral connections connect to the main sewer shall be recorded, using CCTV monitoring and an accurate method of distance measurement. Lateral connections shall be surveyed to confirm if they are open or capped off, allowing for the design to accommodate any lateral connections deemed to be abandoned.

Where liners have been installed over existing lateral connections and branches, the connection(s) shall be reinstated using non-dig techniques unless they are designated and proved to be abandoned.

The required lateral connections shall be reopened using an appropriate method ensuring all sharp edges are ground away leaving a smooth transition to the existing lateral pipework. Each finished connection shall be made flush with the lining and shall provide a smooth transition.

A sealing system shall be employed at each lateral, and branch along sections of sewer which have been relined, in order to prevent ingress of infiltration at the opening. The sealing system shall prevent any infiltration entering the sewer at the location of the connections via the annulus between the original sewer and the liner, ensuring flush finishes.

Laterals deemed to be live shall be reopened immediately after the liner has been cured, or following pressure testing, where applicable, in accordance with manufacturer's procedures. It must be ensured that the surcharging of laterals does not occur.

The procedure of reopening of sewer lateral connections shall be completed under constant CCTV monitoring.

# 7 Installation

## 7.1 Method Statement & Installation Manual.

A method statement which details the proposed method of installation and the procedures for site handling, insertion, cure, end finishing and lateral reopening shall be prepared as part of the design works. For CIPP, the method of curing shall be included in the method statement. Ambient cure methods shall not be used, except by prior written agreement with the WaSC. The manufacturer's installation manual may provide much of this information and shall be referenced as required.

## 7.2 Health & Safety

Designers, installers and all those involved in the rehabilitation works in conjunction with their teams must identify hazards associated with the activities being undertaken. This includes ensuring those involved with the works are provided with the necessary information, resources and training to perform their tasks. The relevant key procedures and risk assessment guidelines shall be identified prior to works starting on site. Consultation with the relevant WaSC is required to ensure all appropriate health & safety procedures are followed and recorded as per statutory and WaSC requirements.

## 7.3 Working Area and Site Enabling.

The working area shall, where reasonably practicable, be kept clean and surface coverings installed to prevent debris on the liner whilst being laid out. Any requirements for water / power / traffic management shall also be identified prior to, and managed as part of, the onsite works.

## 7.4 Installation of Cured in Place Pipe Lining (CIPP)

CIPP linings shall be designed, manufactured, installed, tested, inspected and certified in accordance with EN ISO 11296.

Details of the proposed method of insertion shall be compiled and provided before any works commence.

CIPP liners shall be of composite construction and shall compromise at least the following material components:

- Resin system;
- Carrier material.

Plus, optionally:

- Reinforcement;
- Internal membrane;
- External membrane.

Measures shall be put in place to ensure that any liquid resin shall not contaminate the environment and that no hot processing fluids shall be released into the sewer network. Any lubricant used to reduce friction during inversion shall be declared and approved by the WaSC. Details of all lubricants and their associated Material Safety Data sheets intended for use on the

project shall be submitted with the design in advance of any works commencing. The lubricant shall not have a detrimental effect on as installed performance the cured in place pipe or the environment.

For short, local repairs (typically 0.5m to 3m in length) a cured-in-place repair (CIPR) may be permitted. The bonding to the host pipe via resin adherence requires extensive pipe preparatory works. Refer to WIS 4-34-06 - Localised sewer repairs using cured-in-place systems with or without re-rounding.

## 7.5 Winching

Where winching is the proposed installation method, a detailed method statement shall be prepared as part of the design.

When on site, the winching forces for each pull shall be recorded, including the forces at the start of every pull and for every increment of 20m winching distance. Where the pull is temporarily stopped, the restart winching force shall be recorded. These records shall be made available as part of the (daily/weekly/final) job report(s).

## 7.6 Styrene Emissions

Water UK has issued a The Styrene Protocol for WaSCs to apply when styrene is used in sewer rehabilitation and individual WaSCs may have additional guidance of their own.

Where the lining material used comprises of styrene, the contractor shall be aware of the relevant legal requirements, water industry guidance and any specific requirements of the WaSC, in order to protect staff, the public and the environment.

Where the lining material system to be installed comprises of styrene, the contractor shall ensure that the WaSC is aware.

A risk assessment and method statement detailing measures to mitigate styrene emissions shall be provided prior to works starting on site. This shall include those emissions causing nuisance odours during works and within the environs of the apparatus and equipment. As a minimum, adequate ventilation shall be provided with a mechanical (forced) ventilation system on standby.

Considerations for minimising the release of styrene include: ensuring that sufficient energy is delivered in hot cure (water /steam) to maximise the cross polymerisation; and the use of pre liners.

Lateral connections from the sewer to properties provide a particular migration route for styrene between installation sites and the occupiers. As per CESWI Clause 9.20: *"the Contractor shall take all precautions to prevent styrene fumes from cured-in-place linings or patch repairs entering the properties via their laterals. A suitable monitor to measure the styrene fumes level shall also be available on site".*

The method statement shall provide details about how styrene levels will be monitored and recorded.

Where members of the public may be at risk of exposure to styrene odours, guidance from the WaSC's H&S team must shall be sought prior to commencing work. The possibility of styrene

migration should be made aware to customers prior to installation, particularly those on a health vulnerability register.

The WaSC's control room shall be made aware of the location of work prior to installation, so it can be prepared for any emergency call or to answer questions from the public.

Any styrene contaminated curing water shall be removed in a safe manner and in accordance with the requirements of the WaSC, ensuring no release to the environment.

## 7.7 Lining Termination

Upon completion of the installation and curing of the liner, manhole access to sewers shall be re-established by trimming the liner without compromising the integrity of the connection to the manhole. Precautions to avoid damage to the manhole structure (e.g. delamination and spalling) shall be detailed within the method statement for the works. Linings shall be cut in accordance with the manufacturer's instructions. For CIPP liners, the use of approved Leak Tight liners or provision of end seals is essential where groundwater infiltration or sewage exfiltration is a factor.

At intermediate manholes, the lining of the channel shall be left in place to provide continuity between adjacent renovated pipe lengths. The lining soffit shall be cut out and edges shall be sealed, and the benching made good with a mortar compatible with the chemical resistance of the lining material. Where the liner is installed to address groundwater infiltration care shall be taken to ensure the joint between cut liner edges and the manhole structure are adequately sealed.

At the upstream end of any rehabilitated sewers that are lined and where the thickness of the liner exceeds 12.0mm, the original invert shall be broken out and regraded with a suitable mortar bed so that inverts of the lining and the host pipe have a smooth transition. (Refer to CESWI Clause 9.15.)

## 7.8 Flow Control During Works

Upstream flows shall be maintained during the works. Flows may be managed by the following methods;

- temporarily stopping flows for limited periods,
- over-pumping/diverting flows,
- or use of vacuum tankers.

Flows shall be managed without affecting the performance of the upstream sewer or service provided to upstream properties.

Prior to works starting, expected flow rates shall be determined and agreement shall be sought with the WaSC if temporary flow management – including stopping of flows, use of vacuum tankers, over-pumping or off-peak hours work will be required to successfully rehabilitate the sewer. Early consultation with the WaSC regarding flow control measures is recommended.

Where circumstances are such that the temporary stopping of flows could be detrimental to the performance of the network, allowance shall be made for over-pumping of manholes and sewer lines in order to carry out the works.

Detriment to network performance might be in terms of internal and external property flooding or negative environmental impact such as unplanned discharge of sewage to watercourses or land.

Approval shall be sought from the WaSC for over pumping operations, detailing the following;

- Reasons for over pumping requirement;
- Over pumping location in network;
- Estimated flow rates and proposed pumping regime
- Estimated number of over pumping days required.

A method statement outlining the proposed flow control operations shall be submitted as part of the design.

## 7.9 Interface with Manholes

Where a manhole must be altered to facilitate installation of a liner, this shall be identified on completion of the pre-surveys.

In cases where it is proposed to remove manhole cover slabs to provide suitable access, the process for removing the cover slabs without damaging the remainder of the manhole structure or without detriment to the structural integrity shall be included as part of the method statement. The method statement shall also detail how the proposed method will avoid the system being inundated with surface water in the event of rainfall.

The manhole shall be modified and reinstated such that installed liners do not form irregularities around the edges of the liners or differences in level which may cause accumulation of solids (i.e. debris, silt, rags, etc.) in the sewer or manhole.

The ends of the lining shall be sealed once they have been trimmed to match the face of the manhole. The materials used and the method of sealing shall be determined and detailed in the design & method statement.

## 7.10 New or Extended Manholes

If a new or extended manhole is required to facilitate access to rehabilitation works prior approval shall be sought as part of the design in accordance with WaSC specifications.

## 7.11 Management of Waste Materials

The management and disposal of all waste materials produced during survey cleaning works, pre-rehabilitation cleaning and preparation works, and the rehabilitation works shall be in accordance with all waste management legislation applicable to the WaSC's jurisdiction.

Materials generated from construction, refurbishment or demolition activities shall be reused or recycled wherever practicable. The Designer shall take all practicable steps within the design to maximise the use of suitable reused or recycled materials and to minimise waste.

## 7.12 Data Collection on CIPP Installation

It is expected that the installer will record the details of each CIPP installation, samples taken, and quality control measures carried out for future reference and for their own quality assurance

purposes. The WaSC may require provision of such data for its records and quality control purposes. Such requirements shall be agreed with the WaSC prior to installation. WaSC specific data requirements can be collated using the table within Appendix D.

# 8 Quality Assurance and Control

When a CIPP system (CIPP liner, CIP Repair or CIP lateral connection repair) is installed for the purpose of renewing a deteriorated sewer pipe, the asset owner has expectations that it will perform in a manner similar to that of a new pipe. This means that it should:

- Have a known set of material properties,
- Have a minimum expected life,
- Not suffer any premature failure,
- Not contain any defects that might affect its subsequent performance and/or serviceability of the sewer.

The nature of the CIPP process, where effectively a new pipe is manufactured within the sewer on the day of installation, means that the performance of the installed liner is a function of both the installation process undertaken and the materials used on the day installation.

To ensure a CIPP system will perform for its specific purpose and for the expected lifetime it has to: be appropriate for the task, have evidence that supports its ability to meet the expected performance criteria and then be installed correctly so the finished product meets those criteria.

Fundamental to this is the application of an appropriate quality control system, from the point of manufacture to the completed installation, applied by the relevant stakeholders, and supported by awareness of the standards, specifications and guidance relevant to the CIPP system.

The stakeholders involved in the delivery of an installed CIPP rehabilitation of a pipe include: material manufacturers/suppliers, rehabilitation system manufacturers/suppliers, their national agents/suppliers, transport and storage contractors, installation contractors/sub-contractors, the sewer network owners and their contractors/framework partners involved in planning, investment, design, procurement and delivery.

The WaSCs expect that stakeholders involved with a CIPP System have in place, and to adhere to, a Quality Control system that is compliant with ISO 9001 and that takes account of the relevant industry, national and international guidance, specifications, standards and legislation. A WaSC may require detail of the Quality Control system and evidence to support its application at pre-qualification, tendering, selection, installation and post-installation.

Within the overall quality control system for a CIPP System are measures that apply to:

- Demonstrating its expected performance
- Correct selection and/or design
- Quality assurance during manufacture, distribution and storage before arrival at site
- Quality assurance during installation
- Procedures for checking and acceptance post-installation.

### 8.1.1 Applying Quality Assurance

The key opportunities for the WaSC to ensure quality control is applied for CIPP System installation are:

- Ensuring that WaSC staff and those working on their behalf involved in all stages of the use of CIPP Systems in the sewer network are aware of this guidance and other relevant requirements and understand how they must apply them.
- Inclusion of quality assurance requirements for the supplier/contractor in pre-qualification to tender requirements.
- Inclusion of quality assurance requirements for the supplier/contractor at the tender drafting stage
- Appropriate evaluation of quality assurance elements within bids
- Ensuring that quality assurance supervision is applied on-site
- Undertaking post-installation checks and evaluation of the findings
- Warranty period acceptance checks.

## 8.2 Quality Assurance to Demonstrate Expected Performance of a Rehabilitation System

Providing evidence to support claims concerning the expected performance of a CIPP System is normally the responsibility of the manufacturer/supplier.

The methods by which the expected performance of a rehabilitation system can be demonstrated are by physical testing or other activities that determine its characteristics and/or whether it complies with any existing requirements in an industry, national or international specification or technical standard, or a contract. Such testing is commonly referred to as type-testing as once performed, the same results should be expected of any subsequent product of the same type, if correctly manufactured and installed in the case of CIPP systems. To support achieving the expected performance characteristics, an installation manual must be provided and applied.

Where a WaSC specifies non-standard design or use of a novel product for which specifications/standards do not exist, the WaSC may need to work with the manufacture/supplier to produce the necessary evidence of expected performance and any specific installation instructions necessary to achieve it.

### 8.2.1 Evidence of Performance – Type Testing, Test Reports & Product Approvals

The evidence to support the declared performance of a product can be presented by a manufacturer/supplier in several ways. They can provide a declaration of their compliance, copies of the relevant test reports, an approval certificate and/or other information.

Tests for determining short-term and long-term mechanical characteristics, geometric characteristics, and additional characteristics of CIPP liners and CIP repairs are listed in Table 8.1.

An approval for a CIPP system may be available from a relevant national or industry body to confirm that it has independently assessed the available evidence and has concluded that the system is compliant with a given set of requirements, specifications or standards. Approvals may include consideration of the quality of the installation manual.

An end user should check that the scope of any evidence provided to them to support claims concerning the performance of a CIPP system cover the performance parameters that are relevant to the application that they are considering for the CIPP system.

#### 8.2.1.1 Type Testing

Type-testing generates values for performance that can be 'declared' by the manufacturer/supplier, against which the quality of subsequent installations can be measured if required by the installation contractor or WaSC as part of their post-installation Quality Assurance.

Specifications, standards and contracts usually state minimum performance values to be achieved by a CIPP System. However, the values achieved and declared may exceed these.

Specifications and standards may not exist for novel products and in such cases appropriate tests may need to be devised by the manufacturer or end user to demonstrate performance, and evidence of performance and declared values generated.

Type testing should be undertaken or witnessed by independent third parties. If not, the end user needs to satisfy themselves concerning the accuracy of performance claims made.

Type testing requirements for CIPP liners are set out in ISO 11296-4 and for CIP repairs in WIS 4-34-06.

### 8.2.2 Evidence of Performance for CIPP Systems

#### 8.2.2.1 CIPP Liner

Evidence from an independent third party is required to show the liner system has undergone type testing performed in accordance with relevant specifications/standards that substantiates the manufacturer's/supplier's declared values and to demonstrate conformity with minimum required values.

#### 8.2.2.2 CIP Repair

Evidence from an independent third party is required to show that the CIPR has undergone type testing performed in accordance with WIS 4-34-06 that substantiates the Supplier's declared values and to demonstrate conformity with minimum required values.

#### 8.2.2.3 CIP Lateral Connection Repair

Evidence from an independent third party is required to show the liner system has undergone type testing performed in accordance with relevant specifications/standards that substantiates the manufacturer's/supplier's declared values and to demonstrate conformity with minimum required values.

### 8.2.3 Installation Manual

An installation manual is required for each CIPP liner and CIPR system. This must be of sufficient detail to ensure that, if correctly followed before, during and after installation, the installed CIPP system can achieve the declared values, and conform with any minimum required values.

Drafting the installation manual is usually the responsibility of the manufacturer/supplier of a rehabilitation system. Relevant stakeholders must be fully aware of the requirements in the installation manual and their responsibilities.

## 8.3 Quality Assurance in Selection and/or Design

The selection of the CIPP system is part of the Quality Control system and is the responsibility of the WaSC or its delegated partner/contractor. Performance characteristics of the selected CIPP System must be suitable for the rehabilitation task.

A selected CIPP System may be an off the shelf product or a specifically designed solution. An off the shelf product is used where its performance characteristics are considered suitable for the rehabilitation task and reliance is made on the existing installation manual to achieve declared values/minimum requirements. For a designed solution the expected performance will determine the minimum performance requirements and values to be achieved and may require bespoke installation instructions and quality control measures.

For bespoke designs a specific Quality Control plan should be completed as part of the design.

## 8.4 Quality Assurance during Manufacture, Transport and Storage before Delivery to Site

The production of a CIPP system required Quality Control for the manufacture, transport and storage of raw materials used to make components, the components that make up the CIPP System and the finished CIPP system before delivery to site. The latter may include the factory wetting out of the resin into the carrier in the factory prior to delivery to site.

This is the responsibility of the manufacturer(s) of the raw materials, components and system, and those responsible for their custody during transport, storage.

### 8.4.1 Quality Assurance in Manufacture

The manufacture of the raw materials, the components (e.g. resin, felts and installation equipment) and the final CIPP System are factory activities and factory Quality Control processes must be applied to ensure consistent quality. These will include:

- Record keeping
- Maintaining appropriate environmental conditions in manufacture and storage
- Testing of batches to confirm properties in accordance with the design and specifications.

A WaSC may require access to evidence concerning Quality Control in manufacture, including a factory visit.

### 8.4.2 Quality Assurance in Transport and Storage

The quality control system must ensure the correct transport and storage of raw materials, components and completed CIPP Systems. This must prevent accidental damage, including adherence to any environmental conditions stipulated by the supplier, and ensure any damage is identified up to delivery to site. Stakeholders must be aware of any shelf-life expiry.

## 8.5 Quality Assurance for Installation

Quality assurance at installation includes any final preparation of the CIPP System that is undertaken off-site immediately prior to installation (such as wetting out), in preparing the site and sewer in accordance with the installation manual and undertaking the installation.

### 8.5.1 Qualification of Contractor

It is the responsibility of the installing company to ensure that is qualified to install the system and that individual staff have received the necessary training/qualifications.

The WaSC may require evidence to demonstrate that the company and installation staff are qualified and may undertake onsite supervision during installation.

### 8.5.2 Site Supervision

The WaSC may require that its own staff are in attendance to manage or observe Quality Control onsite, or delegate it to contractors or the installer.

Site supervision should include:

- Checking the qualifications of installation staff.
- Checking that an installation manual is available.
- Checking that the products supplied (i.e. the combination of resins and felt, and other system components) are as ordered and have not been substituted.
- Checking that cleaning and other preparations of the host pipe are in accordance with the rehabilitation system manufacturer's/supplier's instructions.
- Ensuring that the installation team follows the methodology required in the installation manual, particularly with regard to preparation of the components (including onsite wetting out), correct functioning of installation and monitoring equipment, handling of the liner, correct application of the curing method, sealing of liner ends to sewer/manhole, where necessary.
- Recording the data required on the installation process (e.g. evidence of cure).
- Undertaking post-installation checks.

## 8.6 Quality Assurance Post Installation

It is expected that the installer will undertake checks of the CIPP System post-installation as required by its own internal quality control system, the CIPP system manufacturer/supplier, and any specific requirements of the WaSC. The extent of these should be agreed between the installer and the WaSC prior to the installation.

The required checks must be planned into the installation work programme and the necessary resources and equipment made available to undertake them.

Post-installation checks will normally be undertaken as soon as is possible post installation.

Where a CIPP System has been installed specifically to address infiltration of groundwater, but the water table was below the sewer at the time of installation, the WaSC may require an additional inspection when the groundwater has returned to expected levels.

Where a warranty period is stipulated in the contract, end of warranty checks may be required by the WaSC.

### 8.6.1 Visual Inspection

A visual inspection will be undertaken during installation (if required in the installation manual) and immediately post-installation to check for abnormalities or defects.

This may be in person in man entry situations, by CCTV or other remote method, if stipulated.

The abnormalities/defects to be checked for may be stated in the installation manual, in a specification/standard (e.g. WIS 4-34-06 for CIP Repairs) or as directed by the WaSC. The WaSC is to be notified of any derogations.

The WaSC may wish to make an overall assessment of serviceability of the sewer (i.e. has flow been affected or could the installed rehabilitation affect likelihood of future blockages).

### 8.6.2 Pressure Testing

Where specified by the WaSC, an installed liner system shall be pressure tested using air or water, in accordance CESWI Clause 9.11. (Clause 13 of EN 1610:2015). This shall be carried out on liners with no connections or prior to reopening connections. Open ends shall be stopped with plugs, caps or blank flanges, properly jointed. Results of the testing should be provided to the WASC and any failed inspections rectified and retested.

### 8.6.3 Sampling CIPP Systems Post-installation for Laboratory Testing to check Conformity with declared/expected Performance Criteria

Whilst it is expected that a contractor will include taking samples from installed liners for short-term testing to verify the installed liner meets its performance requirements as part of their own internal QA system, to monitor their own performance, a WaSC may also require that samples are taken from installed liners for testing and reporting to them.

It is impractical to obtain a sample from CIP repairs and lateral connection repairs as the location is usually remote and the installation too small for a sample to be taken in situ. In these cases, the WaSC may require that the installer demonstrates that its equipment is correctly functioning, and installation procedures are being correctly followed, by undertaking an installation into a section of pipe set up above ground from which a sample can be obtained for this purpose.

#### 8.6.3.1 Post-installation Sampling of Full-length Liners

**Location of Sample Extraction**

A sample of the liner shall be taken from an intermediate manhole or extension into an end manhole or from the installed liner within the host pipe.

The exact location of samples to be tested shall be agreed with the WaSC prior to rehabilitation.

Where the sample is taken from within the sewer, the lining shall be made good after the sample has been taken.

**Dimensions of Samples**

The dimensions of samples vary with pipe diameter and the range of tests that are required to be undertaken using the sample. The advice of the independent third-party laboratory undertaking the tests can be sought.

### Frequency of Sampling

The frequency of sampling required by a WaSC is at its own discretion, depending on its internal requirements QA requirements.

A suggested minimum requirement for a WaSC to consider is sampling rates of between 1 in 10 installed liners to as high as 100% for liners in sewers deemed critical/complex by the WaSC.

Any deviation from a required test frequency shall be agreed with the WaSC, for example in cases where obtaining a sample is not feasible.

A WaSC may require that a sample is taken and retained for future testing should that become necessary (e.g. for investigating a subsequent failure of the liner).

### Witnessing Sampling and Chain of Custody

Responsibility for witnessing the extraction of a sample and verifying its authenticity in the chain of custody to delivery to the test laboratory will be determined by the WaSC.

### Sample Data Sheet

A sample data sheet shall be provided with each sample submitted for testing, that provides the information necessary for the testing to be undertaken and reported. Typical data requirements for a CIPP liner sample data sheet is shown in Appendix A.

### Testing

Testing shall be carried out by an independent laboratory that is accredited to undertake the required tests.

### Tests

The normal requirements for post installation testing of an installed liner are short-term testing for:

- short term flexural modulus;
- flexural stress at first break;
- mean wall thickness;
- water tightness.

Further details of these tests are given in Table 8.1

A WaSC may require additional tests to be undertaken on a sample.

### Pass/fail Criteria

The pass/fail criteria for each test is determined by whether the result meets the declared value provided by the CIPP System manufacturer/supplier, the required values set for a bespoke design, or any other minimum value stipulated by the WaSC, prior to installation.

#### Communication of Results

The WaSC may require the test report to be communicated directly or via the installer.

#### Interpretation of Results

Where the rehabilitation does not meet the pass value, the results shall be discussed with the WaSC to determine whether the installation is fit for purpose.

The WaSC may require a second sample to be obtained from within the lined pipe for testing to verify the results of the first test.

The WaSC may require additional tests (e.g. long-term tests) to be undertaken on a sample to determine other performance characteristics including long-term tests.

### 8.6.3.2 Post-installation Sampling CIP Repairs and CIP Lateral Connection Repairs

It is impractical to take a sample from an installed CIP repair or lateral connection repair, because of their remote location and size. However, the WaSC may require the installer to undertake quality control tests using alternative means to demonstrate that its equipment is correctly functioning, and installation procedures are being followed. This can be achieved by setting up an arrangement of pipe or a split mould above ground into which the CIP repair is installed so that a sample can be obtained.

Laboratory tests for CIP repairs are listed in Table 8.1 and WIS 4-34-06.

For sample dimensions, chain of custody, sample data sheet, pass/fail criteria, communication and interpretation of results see section 7.6.4.1.

## 8.7 Rectification

Following post-installation checks the WaSC will determine whether the installed CIPP System meets required performance values and is serviceable (i.e. will not affect the function of the sewer).

Where required by the WaSC, the works shall be rectified to ensure compliance with performance requirements and any further checks, required by the WaSC, carried out.

## 8.8 Data Collection on CIPP Installation

It is expected that installers will record relevant information on each CIPP installation for their own quality assurance purposes, and provide the WaSC with such information as it may require. For guidance a list of data requirements is presented in Appendix E.

*Table 8-1 Cured-in-place-pipe (CIPP) & Cured-in-place-repair (CIPR): Sampling and Testing Requirements*

Note 1: Where requirements are specified in Table 8.1.as declared values, these declarations shall be documented for each CIPP product, with supporting test data or references to such data, in the installation manual for that product.

| Rehabilitation Type | Sampling Frequency for Laboratory Test | Laboratory | | | |
|---|---|---|---|---|---|
| | | Test | | Standard | Pass Value |
| Full Length CIPP Liner | As per WaSC | Short-term mechanical characteristics of pipes (Ref: Table 5 of EN ISO 11296-4) | Initial specific ring stiffness | *EN ISO 11296-4* *ISO 7685* | Declared value, but not less than 0,25 kPa* |
| | | | Short-term flexural modulus | *EN ISO 11296-4* *EN ISO 178* | Declared value in MPa* |
| | | | Flexural stress at first break | *EN ISO 11296-4* *EN ISO 178* | Declared value in MPa* |
| | | | Flexural strain at first break | *EN ISO 11296-4* *EN ISO 178* | Declared value but not less than 0,75 %* |
| | | | Ultimate longitudinal tensile stress | *EN ISO 11296-4* *BS ISO 8513* | Declared value in MPa* |
| | | | Ultimate elongation | *EN ISO 11296-4* *BS ISO 8513* | Declared value but not less than 0,5 %* |
| | | | **Declared values refer to the mean value of each characteristic as determined from the results of tests on a set of the specified number of test pieces* | | |

| | | | | | |
|---|---|---|---|---|---|
| | | Long-term mechanical characteristics of pipes (Ref: Table 6 of EN ISO 11296-4) | Dry creep factor* | *ISO 11296-4* *ISO 7684* *ISO 10468* | Declared value but not less than (0,125 kPa) / Long term (50 years) specific ring stiffness |
| | | | Long-term flexural modulus under dry conditions* | *EN ISO 11296-4* | Declared value in MPa |
| | | | Wet creep factor* | *EN ISO 11296-4* | Declared value but not less than (0,125 kPa) / l Long term specific ring stiffness |
| | | | Long-term flexural modulus under wet conditions* | *EN ISO 11296-4* | Declared value in MPa |
| | | | Long-term flexural strength under dry conditions** | *EN ISO 11296-4* | Declared value in MPa at 50 years |
| | | | Long-term flexural strength under wet conditions** | *EN ISO 11296-4* | Declared value in MPa at 50 years |

| | | | | | |
|---|---|---|---|---|---|
| | | | **It is expected that only one of these methods of creep testing (dry or wet) will be applied, according to contract requirements*<br>***It is expected that only one of these methods of long-term strength testing (dry or wet or in acid) will be applied, according to contract requirements. Required for design of non-circular liners* | | |
| | | Geometric characteristics (Ref: Table 4 of EN ISO 11296-4) | Mean Wall Thickness of composite layer | *EN ISO 11296-4* | Not less than the design thickness (plus, the thickness of any abrasion layer) |
| | | | Minimum wall thickness of composite layer | *EN ISO 11296-4* | Not less than 80 % of the design thickness (plus the thickness of any abrasion layer), or 3 mm, whichever is greater |
| | | Additional characteristics (Ref: Table 7 of EN ISO 11296-4) | Resistance to chemical attack in a deflected condition* | *EN ISO 11296-4*<br>*ISO 10952* | Minimum extrapolated failure strain at 50 years: declared value but not less than 0,45 % |
| | | | Long-term flexural strength under acid conditions* | *EN ISO 11296-4* | Declared value in MPa at 50 years |
| | | | ** The relevance of these tests depends on the liner design conditions, but it would normally be expected that only one or the other is carried out.* | | |

| | | | | |
|---|---|---|---|---|
| | | Water Tightness (Leak tightness) | *DWA-A 143-3 (Ref Cl. 7.2.9)* | No leakage over test period (30 minutes) |
| Cured in Place Patch Repair (CIPR) | As per WaSC | Short Term Flexural Modulus | *WIS 4-34-06* *EN ISO 11296-4* | Declared value but not less than 1500 MPa. |
| | | Flexural Stress at first break | *WIS 4-34-06* *EN ISO 11296-4* | Declared value, but not less than 25 MPa |
| | | Flexural Strain at first break | *WIS 4-34-06* *EN ISO 11296-4* | Declared value, but not less than 0.75% |
| | | Wall Thickness | *WIS 4-34-06* | Design thickness (except as provided n clause 4.3.2 of *WIS 4-34-06*) |
| | | 50-year failure strain in bending in acid environment (glass reinforced plastic only) | *WIS 4-34-06* | Declared value but not less than: 0.75% in type A fluid 0.45% in type B fluid |
| | | Leak tightness (Water tightness) | *WIS 4-34-06* | 0.5 litres per metre of internal sewer diameter per patch repair over a 30-minute period |
| Lateral connection repair | In-situ tests only – CCTV or visual inspection. (Clause 8.5.2 of ISO 11296-4 states: "*The extensions into the lateral pipe of Class A and B lateral connection collars as defined in Table 3 shall be considered as pipes*". | | | |

# APPENDIX A TYPICAL SAMPLE DATA SHEET INFORMATION REQUIREMENT FOR A POST-INSTALLATION TEST SAMPLE

### A) Information on the taking of the sample:

- Unique identification number for the sample
- Date of sampling
- Company responsible for obtaining sample - signature
- WaSC representative - signature
- Indication of whether the sample is a first test or a repeat test
- Location of the liner being tested
- Weather conditions/temperature?
- Photo of installed liner & manhole reference

### B) The following is a list of typical sample identification data:

- Liner material ID
- WaSC (client)
- Company responsible for installation
- Date of installation
- Liner manufacturer
- Length of liner
- Host pipe identification
- Sample identification
- Extraction location
- Extraction position
- Resin type
- Base material
- Pipe geometry
- Liner coating

### C) Sample Dimensions

If the sample dimensions do not meet those required for conducting the tests selected and note of the reason for this.

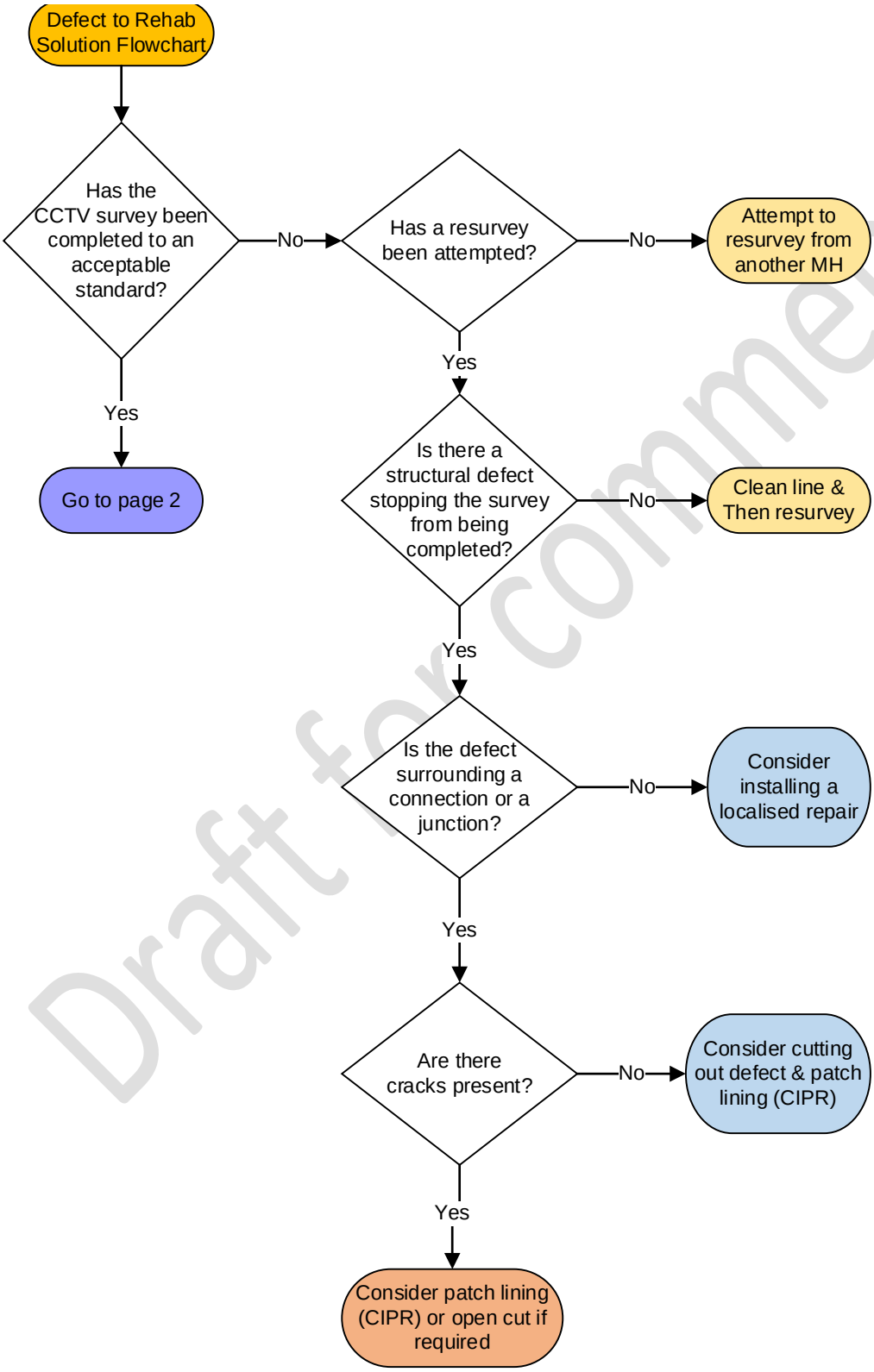
### D) Sample Tests (to be selected by the WaSC)

- 3-point deflection test in radial direction (standard test) for determination of:
  - E modulus
  - Bending stress
- Wall thickness
- 3-point deflection test in axial direction
- Apex pressure test for determination of the E modulus
- Water tightness test (standard test)
- Inspection of the curing of the laminate if the E modulus or bending stress is too low:
- Determination of the trace styrene content (for UP resins)
- Thermal analysis (DSC measurement) (for epoxy resins)
- Inspection of the long-term behaviour when the E modulus or bending stress is too low:
- 24-hour creep tendency 3-point

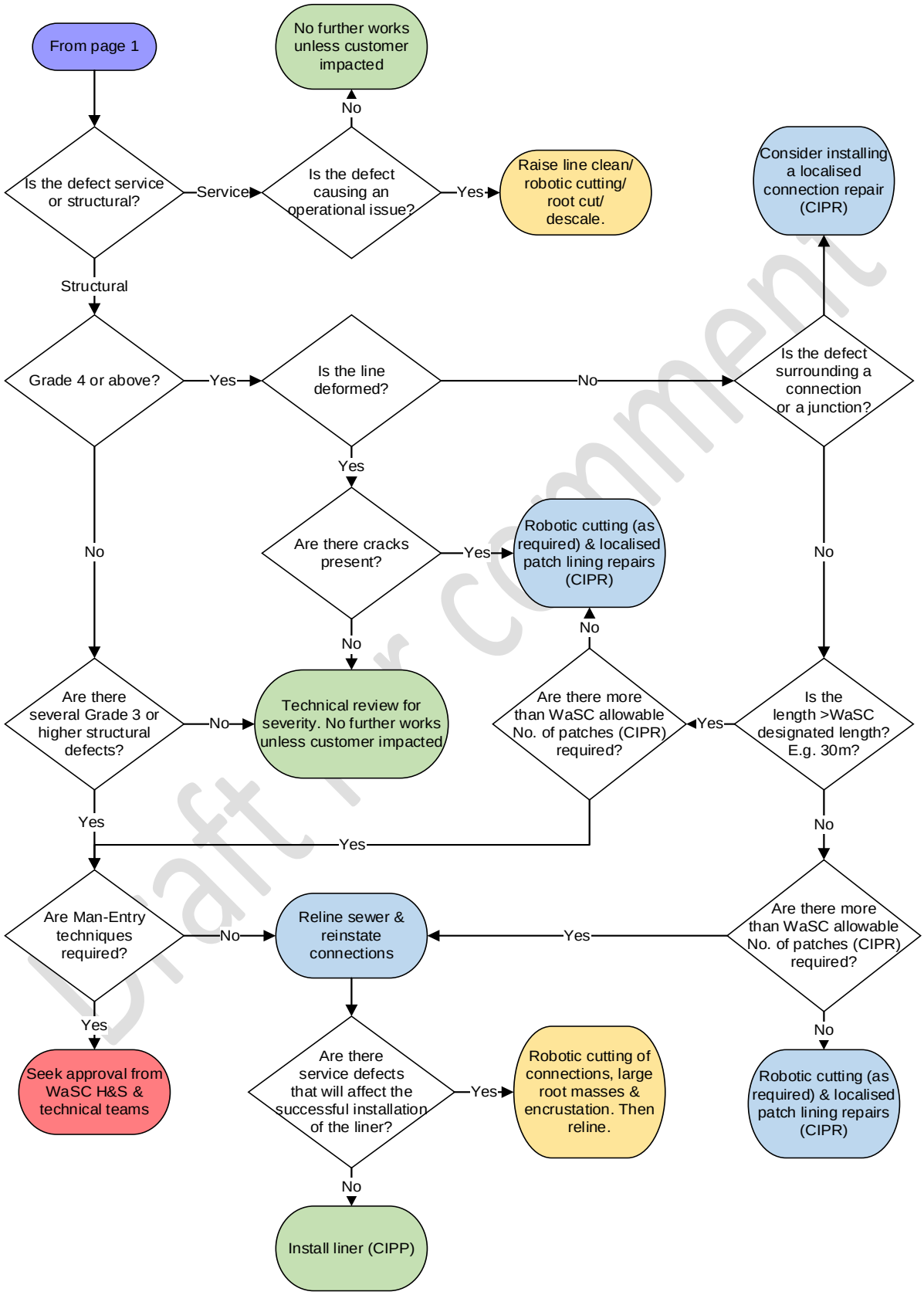
- 24-hour creep tendency apex pressure
- Material identification:
    - Spectral analysis
    - Calcination method
    - Density measurement

# APPENDIX B SEWER REHABILITATION DECISION PROCESS

(1/2) (included for Guidance only)



## APPENDIX B SEWER REHABILITATION DECISION PROCESS (2/2)



# APPENDIX C LIST OF REFERENCES

| Document name or Standard No. | Title |
|---|---|
| ASTEE 3Rv2 | (Association Scientifique et Technique pour l'Eau et l'Environnement) (2017) |
| ASTM F1216-16 | Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube. |
| SRM 5th edition | WRc Sewerage Risk Management (SRM). Online based. |
| CESWI 7th Edition | Civil Engineering Specification for the Water Industry. |
| DWA-A 143-2 | Sanierung von Entwässerungssystemen außerhalb von Gebäuden - Teil 3: Vor Ort härtende Schlauchliner. English translation: Rehabilitation of drainage systems outside buildings Part 2: Static calculation for the rehabilitation of sewage pipes and sewers with lining and assembly methods |
| DWA-A 143-3 | Sanierung von Entwässerungssystemen außerhalb von Gebäuden - Teil 3: Vor Ort härtende Schlauchliner. English Translation: "Rehabilitation of drainage systems outside buildings - Part 3: Field hardening liners |
| EN 1610:2015 | Construction and testing of drains and sewers. |
| Manual of Drain and Sewer Cleaning 1st Edition | Manual of Drain and Sewer Cleaning (WRc). |
| ISO 7684:1997 | Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the creep factor under dry conditions |
| ISO 10468:2018 | Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the ring creep properties under wet or dry conditions |
| | |
| ISO 10952:2008 | Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Determination of the resistance to chemical attack for the inside of a section in a deflected condition |
| ISO 11296-4:2018 | Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks. Part 4: Lining with cured-in-place pipes. |
| RERAU | REhabilitation des Réseaux d'Assainissement Urbains . French National Research Programme: Rehabilitation of Urban Sewer Networks (2004) |
| The Styrene Protocol | The Styrene Protocol – issued by Water UK for use by WaSCs |
| WIS 4-34-06 | Specification for localised sewer repairs using cured-in-place systems with or without re-rounding. |

# APPENDIX D WASC REQUIREMENTS CHECKLIST.

To be completed by the WaSC as part of contractual negotiations / design negotiations.

| Design Parameter | Requirement | WaSC Specific Value |
|---|---|---|
| Preferred Design Method | An appropriate design method e.g.<br>SRM (WRc)<br>DWA-A143-2<br>RERAU (2004)<br>ASTEE 3Rv2 (2017)<br>ASTM F1216-16 | |
| Loading Conditions for Structural Liner | Site dependent - Dead and Live Loading Condition as per site conditions | |
| Minimum Thickness for Pipeline Liner | At WaSC discretion subject to fulfilling hydraulic conditions | |
| Maximum Thickness for Pipeline Liner | At WaSC discretion subject to fulfilling hydraulic conditions | |
| Water Table Level | Ground Level unless identified or otherwise by WASC as evidenced and agreed with the WaSC | |
| Hydrogen Sulphide Level | System dependent (*WaSC*) | |
| Maximum number of permissible defects in one sewer length (30m or manhole to manhole) for patch repair (CIPR). | | |
| Minimum number of defects in one sewer length (30m or manhole to manhole) to consider full length lining | | |
| Frequency of testing (when deviating from the frequencies laid out within this document) | | |
| Pressure testing | Air or Water<br>Frequency | |
| Quality Assurance Requirements | | |
| Distance lateral repairs should extend into lateral | According to ISO or WaSC's requirement. | |

# APPENDIX E DATA COLLECTION PARAMETERS

Data collection parameters as detailed within UKWIR Club Project (copied with permission)

- Job reference.
- Asset ID.
- Location.
- Date.
- Delivery team/Installer.
- Technique type.
- Installed product (e.g. Tradename).
- Product details:
    - outer diameter
    - wall thickness
    - length.
- Details of any defect period/warranty.
- Planned versus reactive activity.
- Pre-installation details:
    - how long between CCTV and installation?
    - cover depth
    - why technique was selected
    - defects present
    - previous failures/maintenance
    - structural design type
    - surrounding environment e.g. groundwater depth, soil/concrete.
- Installation details, full records:
    - pre-work
    - installation process (e.g. UV CIPP cure protocol)
    - winch loads
    - internal pressure
    - cure type
    - cure temperature/duration/speed, as appropriate
    - sewage flow rate
    - overflow details
    - already lined.
- Post-installation QA checks:
    - CCTV survey
    - pressure test
    - laboratory test results.
- Costs:
    - process
    - labour
    - add-ons
    - schedule of rates
    - out-turn.