
WATER INDUSTRY SPECIFICATION

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UK Water Industry

OPERATIONAL REQUIREMENTS: *IN SITU* RESIN LINING OF WATER MAINS

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This document has been prepared on behalf of the Water UK Standards Board. Technical queries should be addressed to the Standards Board c/o WRC, Frankland Road, Blagrove, Swindon, Wilts, SN5 8YF Tel: (01793) 865151 E-mail: wisign@wrcplc.co.uk. WIS 4-02-01 replaces the DWI publication Operational requirements: *In-situ* resin lining of water mains version 2.4 8 January 2007.

OR SECTION 1: GENERAL

OR 1.1: Scope

1. These Operational Requirements cover material selection, pipeline cleaning, application, curing, inspection and disinfection requirements needed to provide protective coatings for pipelines constructed of iron, steel, asbestos cement, or concrete using resin materials approved for *in situ* lining of potable water mains.
2. These resin materials are placed *in situ* by spray application to pipelines of 75mm diameter and above.
3. Compliance with these Operational Requirements is a legal requirement for the *in situ* application of resin coatings.
4. Additional information and advice is presented in the Code of Practice: *In Situ Resin Lining of Water Mains*⁽¹⁾.
5. Material-specific information and advice is presented in the Instructions for Use (IFU) document provided by the resin manufacturer.

OR 1.2: Implementation and Transitional Arrangements

1. These Operational Requirements shall apply from 1st April 2007.
2. Contractors holding a current approval to apply resin coatings shall be deemed '**Approved Contractors**' (as defined in OR 1.3 below), provided that, prior to 1st April 2007, they have:
 - provided to all personnel performing lining roles defined in Appendix B a written guide to and awareness training of the new Operational Requirements; and
 - satisfactorily demonstrated to a **Nominated Certifying Body** (as defined in OR 1.3 below) that their Quality Systems and working procedures meet the requirements of this document.

3. Lining rigs currently approved to apply resin coatings shall be deemed '**Approved Lining Rigs**' (as defined in OR 1.3 below), provided that, prior to 1st April 2007, it has been successfully demonstrated to a **Nominated Certifying Body** (as defined in OR 1.3 below) that they comply fully with the requirements of this document.

Transitional arrangements for training and certification of personnel are detailed in OR Sections 4 and 5 below.

OR 1.3: Definitions

For all aspects of *in situ* lining the following definitions apply:

Approved Contractor

The contracting company that has demonstrated its ability to apply a specified **Approved Coating Product** correctly in supervised lining trials (as described in Appendix A), has been certified by a **Nominated Certifying Body**, and are employed by a Water Undertaker to supply trained and appropriately certified personnel, approved products and machinery to apply resin coatings in accordance with these Operational Requirements.

The **Approved Contractor** is approved in respect of a stated resin and rig combination. A Contractor may be approved several times over for various combinations of resin and rig (see OR 3.2)

The **Approved Contractor** is responsible for ensuring that all aspects of the rehabilitation process can be monitored and inspected by the **Utility Representative**. This includes all components of the cleaning and lining process.

An **Approved Contractor** working as a sub-contractor on behalf of an unapproved Contractor as part of a rehabilitation contract is acceptable with the full permission of the appointed person responsible for the Water Undertaker contract.

Approved Contractors are listed in Appendix 3 of the Authorities' List of Approved Products.

Approved Coating Product

A resin material approved for use in the *in situ* lining of potable water mains.

Any construction product that is to be used in contact with public water supplies shall be used in accordance with Regulation 31 of the Water Supply (Water Quality) Regulations 2000⁽²⁾ in England, Regulation 31 of the Water Supply (Water Quality) Regulations 2001 in Wales, Regulation 27 of the Water Supply (Water Quality) (Scotland) Regulations and Regulation 30 of the Water Supply (Water Quality) Regulations (Northern Ireland) 2007, and any subsequent amendments.

As yet there are no harmonised European standards concerning fitness for use in contact with drinking water of *in situ* resin lining systems, nor are there any European Technical Approvals or equivalent national standards for these products. In the absence of European or national specifications, coating products shall be approved by the Authorities under the appropriate national regulation.

Approved construction products are listed in the Authorities' List of Approved Products⁽⁵⁾, which is posted on the Drinking Water Inspectorate's website:

<http://www.dwi.gov.uk/cpp/pagea.shtm>.

Approved products shall be used in accordance with their conditions of approval, which are given in the Secretary of State's approval letter and in the List of Approved Products⁽⁵⁾.

Approved Lining Rig

A lining rig of a design that has been type tested in accordance with Appendix C and subsequently certified by a **Nominated Certifying Body** for the storage, heating, dispensing, mixing, and application of a specified **Approved Coating Product**.

New Contractor

A contracting company who wishes to undertake the supervised lining trials outlined in Appendix A so as to become an **Approved Contractor** and is required by the **Nominated Certifying Body** to undertake a full (at least three lining) assessment procedure.

New Contractors either hold no approvals for application of **Approved Coating Products** or the approvals they hold are for resin materials with significantly different properties or with different rehabilitation outcomes.

Nominated Certifying Body

From 1 April 2007 Water UK nominates Certifying Bodies.

A **Nominated Certifying Body** must be accredited by **UKAS** as a Conformity Assessment Body complying with these Operational Requirements (WIS 02 4-02-01) and with IGN 4-02-02 "Code of Practice: *In-situ* resin lining of water mains". Water UK and **UKAS** have each signed an Agreement to this effect.

Nominated Training Certifier

From 1 April 2007 Water UK nominates Training Certifiers.

A **Nominated Training Certifier** must be accredited by **UKAS** as a Conformity Assessment Body complying with these Operational Requirements (WIS 02 4-02-01) and with IGN 4-02-02 "Code of Practice: *In-situ* resin lining of water mains". Water UK and **UKAS** have each signed an Agreement to this effect.

UKAS (The United Kingdom Accreditation Service)

The sole national accreditation body in the UK recognised by the Department of Trade and Industry, on behalf of Government as a whole, by means of a Memorandum of Understanding dated 1 August 1995.

Utility Representative

A person certified by a **Nominated Training Certifier** and appointed by the Water Undertaker as their representative.

The **Utility Representative** may or may not be a direct employee of the Water Undertaker but shall not be an employee of the **Approved Contractor** or any organisation associated with the **Approved Contractor** (whether parent

company, subsidiary company, or affiliated company).

Responsibility	OR
General duty to inspect all materials and work undertaken	OR 1.5
Review resin manufacturer's Instruction For Use (IFU) documents	OR 2.1
Require the Approved Contractor to demonstrate on a weekly basis that monitoring and alarm systems are operating in accordance with the Operational Requirements <u>and</u> rig type test conditions	OR 3.2
Inspect maintenance and calibration records of rig and components	OR 3.3
Be present at rig performance audits	OR 3.3
Monitor the Approved Contractor and take responsibility on behalf of the Water Undertaker for the quality of all linings	OR 4.1
Where emergency circumstances require, consider return of main to service prior to lining and specify in writing the appropriate disinfection, flushing and customer care requirements to be carried out by the Approved Contractor	OR 6.1
Be present at spin-up determination tests	OR 6.6
Consider need for spin-up test as a result of weather conditions	OR 6.6
Assess any rectification works linked to aborted linings prior to restoration of supplies to customers	OR 6.8
Review mix-ratios recorded by the monitoring system	OR 6.8
Examine CCTV inspection and the lining print out and ensure that linings meet the Operational Requirements before return to service	OR 6.11
Assess rectification of lining defects	OR 6.12
Assess suitability for return of main to service, having regard to risk of contamination and where necessary consider appropriate action	OR 6.13
Inspect pipe samples for lining quality and coating thickness	OR 6.14
Sign all documentation and retain copies	OR 7

The **Utility Representative** is responsible for ensuring all linings and work undertaken by the **Approved Contractor** are carried out in compliance with and to the quality outlined in the Operational Requirements. For reference,

the responsibilities of the **Utility Representative** are tabulated below together with the relevant section of these Operational Requirements:

Recognised Fitter

A person formally trained by rig suppliers or rig manufacturers and who has provided acceptable evidence of their competence, training, and experience to a **Nominated Certifying Body**.

As noted in Appendix B, the **Recognised Fitter** is responsible for ensuring that lining rigs are set up in accordance with the conditions (alarm conditions, set-points, etc.) used when rig approvals were granted, and that rigs can perform in accordance with the Operational Requirements.

OR 1.4: Reference Documents

1. The following documents or any revisions thereof referred to in this document form an integral part of the specification.

- BS EN ISO 9001⁽³⁾

OR 1.5: Inspection

1. The **Utility Representative** shall, at all times, have access to all parts of the site during the entire course of the cleaning and lining process.
2. The **Approved Contractor** shall provide reasonable assistance to the **Utility Representative** for the inspection of materials, workmanship, and quality.

OR 1.6: Workmanship

1. All work shall be performed in a thorough and workmanlike manner by trained and, where required by this document, appropriately certified personnel.

OR SECTION 2: MATERIALS

OR 2.1: General

1. The resin material used for *in situ* lining shall be:
 - i) an **Approved Coating Product**,
 - ii) supplied with a copy of the resin manufacturer's Instruction For Use (IFU) documents, which shall be made available in all instances to the **Utility Representative**.

The IFU, which has been approved by the Authorities, shall contain all additional information required to allow the **Approved Contractor** to apply the **Approved Coating Product** in accordance with these Operational Requirements, including:

- Temperature parameters for resin components and rig heating system (OR 3.2);
- Whether a heated umbilical is required (OR 3.4);
- The correct solvent for cleaning the in-line mixer and spinner head (see OR 3.5 and OR 3.6);

- Any procedures to be followed when pre-conditioning and transferring resin components to the tanks of a rig (see OR 6.3);
- The minimum air-cure time from completion of application before CCTV inspection can commence (see OR 6.10);
- The minimum air-cure period before the main can be considered for return to service (see OR 6.11); and
- Restrictions on disinfectant concentrations (see OR 6.13)

OR 2.2: Manufacture

1. In addition to the requirements of OR 2.1, the resin materials shall be:
 - i) manufactured under an approved ISO 9001⁽³⁾ Quality System;
 - ii) formulated from a base and activator that shall be manufactured in two distinct different colours and shall give a third distinct colour when mixed in the correct ratio; and
 - iii) supplied in clearly marked containers indicating the following:
 - mix-ratio (by weight and volume);
 - maximum and minimum heating requirements;
 - batch numbers;
 - date of manufacture;
 - shelf life or expiry date;
 - storage instructions;
 - handling instructions;
 - basic health and safety instructions compliant with current legislation.

OR SECTION 3: LINING EQUIPMENT

OR 3.1: General

1. The equipment used to apply resin materials shall be suitable for storage, heating, dispensing, mixing and application in accordance with the resin manufacturer's

Instructions For Use and these Operational Requirements.

2. Suitable safety equipment to allow high-pressure working and minimise material discharges shall be incorporated into any design.

OR 3.2: Lining Rigs

1. The rig used to line potable water mains with resin materials shall be certified by a **Nominated Certifying Body**.
2. The **Approved Contractor** shall obtain separate approvals for each generic lining rig/resin combination that is to be used.

Note: Appendix C details the test procedure and pass criteria for the approval of lining rigs.

3. Documentary evidence of these approvals shall be available.
4. The equipment shall be designed to permit the operatives to obtain results described in these Operational Requirements and the associated Code of Practice⁽¹⁾.
5. The **Approved Contractor** shall notify the **Nominated Certifying Body** of any proposed lining rig modifications relating to the following key functions:
 - Monitoring system (and associated components);
 - Pumping system;
 - Alarms (and associated set points);
 - In-line mixers; and
 - Umbilical (hose diameter/configuration).

The **Nominated Certifying Body** shall then consider the need for further formal assessment. Modified lining rigs shall not be used without prior consent of the **Nominated Certifying Body**.

Failure to comply with the requirement to inform the **Nominated Certifying Body** of rig modifications or use of alternative rig designs shall result in the suspension of the contractor's certification until such approvals are obtained.

6. Except where separate provisions have been made for alternative monitoring technologies assessed according to the process detailed in Appendix F, all lining rigs shall conform to the following requirements:

- i) use a positive displacement pump to dispense base and activator separately at the resin manufacturer's specified mix-ratio $\pm 5\%$;
- ii) be fitted with in-line flow monitoring equipment with ancillary pressure monitoring, calibrated at prescribed maintenance periods. Calibration records (or copies thereof as long as the copies are certified and controlled in accordance with the requirements of the contractor's quality system) shall be retained on site for inspection at any time;
- iii) give appropriate audible-alarm and abort responses if the mix-ratio is out of specification (as detailed in Appendix C);
- iv) store the base and activator separately and maintain resin component temperatures in accordance with the resin material manufacturer's Instructions for Use (IFU) document throughout the rig;
- v) have re-circulation facilities from the storage reservoirs through the hoses and return to storage;
- vi) be fitted with a facility to continuously record the volume of resin materials passing through flow meters between calibration; and
- vii) provide continuous numerical visual display and a minimum of 2 copies of a printout showing:
 - spin-up data (duration* and mix-ratio by volume);
 - flow rate;
 - mix-ratio by volume;

- base output pressure;
- activator output pressure;
- lining speed in metres per minute;
- coating thickness in mm (with a resolution of 0.01mm);
- mix-ratio alarms;
- elapsed time from start of lining;
- date and real time;
- percentage of acceptable mix-ratios recorded by the monitoring system;
- percentage of acceptable coating thickness recorded by the monitoring system; and
- lining rig identification number.

** The spin-up duration is defined as the period of time from when pumping of the resin commences on the rig to when the winching-in mechanism of the hoses is activated.*

7. Lining variables (flow rate, mix-ratio, output pressures, lining speed, thickness, and elapsed time) shall be printed at a maximum interval of 30 seconds.
8. Monitoring systems shall meet the alarm response time criteria specified in Appendix C.
9. The **Approved Contractor** shall demonstrate to the **Utility Representative** on a weekly basis that monitoring and alarm systems are operating in accordance with the Operational Requirements and rig type test conditions. (This can be demonstrated either by explicit testing of the response times in accordance with Appendix C, or through review of the monitoring system parameters.)
10. Durable paper and ink shall be used in the printing device such that the printout is still legible after the required retention period of the paperwork (see OR Section 7).
11. The monitoring system shall have the capability of storing the data from the last lining carried out and printing these data at a later time, if required.

OR 3.3: Calibration and Rig Audits

1. All lining rigs shall be calibrated in accordance with the rig/equipment manufacturer's instructions after a specified volume of resin components has been pumped (as specified in the **Approved Contractor's** Quality System), at a maximum interval of 12 months, or following replacement of any component that affects its calibration.
2. Flow monitoring systems shall be calibrated after a specified volume of resin components has been pumped (as specified in the **Approved Contractor's** Quality System), at a maximum interval of 6 months, or following replacement or repair of any component that could affect mix-ratio or monitoring thereof.
3. The rig manufacturer/supplier or **Recognised Fitter** shall undertake the calibration of rigs and flow meters.
4. Documentary evidence (original or copies thereof as long as the copies are certified and controlled in accordance with the requirements of the contractor's quality system) of calibration shall be kept with the lining rig and be available for inspection by the **Utility Representative** and/or any authorised auditor. This documentation shall include serial numbers or identifiers to ensure correct identification of components. The lining rig shall not be operated if this documentation is not in place.
5. Each rig shall be shown to be operating in accordance with these Operational Requirements before being used on lining contracts. To demonstrate this, the rig shall be subjected to a performance audit undertaken by a **Nominated Certifying Body** and **Recognised Fitter** in the presence of a **Utility Representative**, requiring the application of a coating to pipes laid above ground. A minimum pipe length of 20 metres shall be lined.

OR 3.4: Lining Hoses

1. Suitable pressure rated hoses shall be mounted on a drum with a precise winching system that can ensure smooth withdrawal.
2. When specified by the resin material manufacturer in the Instructions for Use (IFU) document, heated umbilical hoses shall be used.
3. The umbilical and hoses shall be maintained in clean condition and in good repair.
4. All umbilicals shall be used only with food grade oil or water containing a food grade anti-freezing agent. The utility representative should ensure that any release of heating fluid does not affect the lining.

OR 3.5: In-Line Mixer

1. In-line mixers shall be approved by a **Nominated Certifying Body** for use with the resin material being applied. Documentary evidence of satisfactory mixing in the in line mixer shall be available.
2. Documentary evidence of the approval shall be available.
3. Approved in-line mixers shall be clearly and indelibly marked with a unique reference that provides an audit trail to this approval.
4. Facilities for cleaning the in-line mixer shall be provided. These shall include the correct solvent as specified by the resin material manufacturer in the Instructions for Use (IFU) document. Suitable health and safety precautions shall be implemented.

OR 3.6: Lining Application Head

1. Lining application heads shall incorporate rear-venting exhausts and shall allow a coating of the required thickness to be applied without causing significant pin-holing or ridging.
2. Prior to each lining, the lining application head shall be operated by the **Approved Contractor** to ensure the head spins without malfunction.

3. Lining application heads shall be cleaned and inspected after every lining operation by a suitably trained lining operative. Any faults observed shall be rectified or the lining head replaced.
4. Facilities for cleaning the lining application head shall be provided. These shall include the correct solvent as specified by the resin material manufacturer in the Instructions for Use (IFU) document. Suitable health and safety precautions shall be implemented.

OR 3.7: CCTV Equipment

1. Colour CCTV equipment shall be used for internal pipeline inspection purposes. Such equipment and its operation shall be specified as follows:
 - i) provide suitable VHS video or digital recording and storage with freeze frame facility and frame-by-frame advance;
 - ii) be properly maintained to ensure reliability and with suitable illumination to provide a clear, focused image;
 - iii) provide the following on-screen details at the start of the recording:
 - unique identifier;
 - date cleaned/lined as appropriate;
 - date CCTV surveyed;
 - location – street and town;
 - excavation numbers;
 - pipe diameter; and
 - pipe material.
 - iv) provide the following on-screen details during the inspection:
 - excavation reference numbers;
 - metres travelled from launch; and
 - date.
2. The speed of travel of the camera through the main shall be at a rate that ensures the entire pipe bore can be properly inspected.

OR 3.8: Compressed Air

1. Any compressor or blowing device that is used in the rehabilitation process shall incorporate a minimum of three suitable and

properly maintained filtering devices and/or after-coolers to prevent contamination from water, oil, or particulates.

2. The filter sizes shall be matched to the compressor size and pressure.

OR SECTION 4: UTILITY REPRESENTATIVE

OR 4.1: Requirements

1. The **Utility Representative** is required to monitor the **Approved Contractor** and take responsibility on behalf of the Water Undertaker for the quality of all linings.
2. Such quality control shall only be carried out by personnel who meet the following criteria:
 - i) have achieved formal certification from a **Nominated Training Certifier** in the theory and site practice elements of the process as set out in Appendix B;
 - ii) resubmit for certification at three yearly intervals; and
 - iii) comply with all other requirements specified by the Water Undertaker.

OR 4.2: Implementation and Transitional Arrangements

1. Certification in full accordance with clause OR 4.1 shall be required with effect 1st April 2007.
2. **Utility Representatives** who gain formal certification in the theory and site practice elements in accordance with Appendix B in the period 1st April 2006 to 31st March 2007 shall be deemed to be certificated from 1st April 2007.

OR SECTION 5 : CONTRACTOR

OR 5.1: Requirements

1. Resin linings shall only be applied by **Approved Contractors** who comply with the following:
 - i) have gained certification in a supervised trial as outlined in Appendix A (separate approvals are required for each

Approved Coating Product/Approved Lining Rig combination);

- ii) resubmit for certification at five-yearly intervals;
- iii) operate a current ISO 9001⁽³⁾ Quality System that explicitly includes resin lining methods and is certified by a third party certification body accredited to ISO/IEC Guide 62/ISO/IEC 17021 by UKAS (United Kingdom Accreditation Service).

The scope of the Quality System shall cover each *in situ* lining system for which approval is held. Hence, the scope shall cover 'epoxy', 'rapid set', 'semi-structural', etc. as appropriate (not each **Approved Coating Product/Approved Lining Rig** combination);

- iv) ensure any personnel involved with the actual lining process are direct employees of the certified contracting company; and
- v) ensure sufficient personnel have achieved formal certification from a **Nominated Training Certifier** in the theory and site practice elements of the process as set out in Appendix B with renewal every three years.

OR 5.2: Implementation and Transitional Arrangements

1. Full certification in full accordance with clause OR 5.1 shall be required with effect from 1st April 2007.
2. Contractor personnel who gain formal certification in the theory and site practice elements in accordance with Appendix B in the period 1st April 2006 to 31st March 2007 shall be deemed to be certified from 1st April 2007.

OR 5.3: New Contractors

1. A **New Contractor** shall submit their draft quality manual, as it pertains to lining with the **Approved Coating Product** for which contractor approval is being sought, to the **Nominated Certifying Body** for

assessment before the supervised lining trial.

2. Following this assessment and any necessary modification to the quality manual, and after successful completion of the supervised lining trial, the **New Contractor** shall apply to a certification body with UKAS accreditation for an extension to the scope of the contractor's ISO 9001 Quality System.
3. An interim approval shall then be granted conditional to the requirement that within 3 months the *in situ* resin lining system for which approval is sought is explicitly included within the scope of the contractor's ISO 9001⁽³⁾ Quality System. Failure to meet this timetable shall result in the withdrawal of the interim approval.
4. **New Contractors** that do not operate an appropriate ISO 9001⁽³⁾ Quality System may still gain certification in supervised trials outlined in Appendix A. Following successful completion of the supervised lining trial, an interim approval shall be granted conditional to the requirement that within 18 months the **New Contractor** shall achieve full certification of their Quality System. Failure to meet this timetable shall result in the withdrawal of the interim approval.

OR SECTION 6: APPLICATION PROCESS

OR 6.1: Cleaning

1. The main shall be suitably cleaned to remove all loose or adhered material resulting from corrosion and mains deterioration processes apart from graphitisation.
2. After cleaning, the pipe bore shall be smooth, clean, and free of dust, standing water and particulate matter.
3. Cleaned mains shall only be returned to service prior to lining in emergency circumstances. Approval shall be obtained from the **Utility Representative** who shall specify in writing the appropriate disinfection, flushing and customer care requirements that the **Approved Contractor** shall carry out.

OR 6.2: Pre-Lining Inspection

1. A CCTV inspection of the whole main with video or digital recording shall be carried out to check the quality of the cleaning and highlight any potential problems that would result in poor lining quality.
2. The **Approved Contractor** and/or the **Utility Representative** shall carry out this inspection. The results of this survey shall be recorded on the CCTV Record and Resin Lining Record (see OR Section 7).

OR 6.3: Lining Rig Preparation

1. The lining hoses shall not be inserted into the main until the base and activator have been circulating through the hoses for sufficient time to attain a uniform temperature that is within the resin manufacturer's specified temperature range.
2. Where possible, there shall be sufficient base and activator in the reservoirs to complete the lining. Should the addition of **Approved Coating Product** be required during a lining, it shall be pre-conditioned to within the resin manufacturer's specified temperature range and transferred to the reservoirs in accordance with the Instructions for Use (IFU) document.

OR 6.4: Weight Checks

1. Weight checks of the base and activator shall be carried out prior to every lining to ensure the rig performance and material output is within the resin manufacturer's specification.
2. Such checks shall conform to the weight check procedure given in the Code of Practice⁽¹⁾ and be reported on the Resin Lining Record.
3. Before lining can commence, 3 consecutive weight checks shall be within $\pm 5\%$ (by weight of activator) of the resin manufacturer's specified mix-ratio, calculated as 100: (weight of activator/weight of base x 100);
4. If unheated lining hoses are used, the time between the final weight check and the start

of lining application shall not exceed 30 minutes. If heated umbilical lining hoses are used, the time between the final weight check and the start of lining application shall not exceed one hour.

OR 6.5: Lining Hose Insertion

1. Lining hoses shall be inserted into the main at a safe speed by means of a clean winch cable. Pipe end rollers shall be used to minimise damage to the pipe, hoses and winch cable and ensure no snagging occurs during the pulling-in operation.
2. Lining hoses shall not be allowed to come into contact with the excavation edge.
3. Lubricants shall not be used to aid the travel of the hoses through the main.

OR 6.6: Spin-up Procedure

1. The minimum spin-up time for each combination of **Approved Lining Rig** and **Approved Coating Product** shall be determined at the start of any lining contract, at least quarterly thereafter for the first year of operation (to build up a year-long record of spin-up times versus weather conditions), or at the request of the **Utility Representative** when weather conditions vary significantly from that for which spin-up determination records are available.
2. The procedure for the determination of minimum spin-up time is given in Appendix D. All spin-up determination tests shall be carried out in the presence of a **Utility Representative**.
3. To check the lining application head and in-line mixer are working correctly and to ensure material stabilisation, a test spin-up shall be conducted before each lining into a suitable container, which shall be kept well clear of the pipe ends.
4. All operatives involved in the spin-up procedure shall wear appropriate safety equipment.
5. For the lining to commence the **Approved Contractor** and/or **Utility Representative**

shall be satisfied that the following have been achieved:

- i) minimum spin-up time has elapsed. This shall not under any circumstance be less than 1 minute;
- ii) material consistency is acceptable;
- iii) mix-ratio is within the required $\pm 5\%$ tolerance band; and
- iv) a record of the material consistency and mix colour has been taken by inserting a dip card into the material spray at the end of the spin-up period.

OR 6.7: Application Temperatures

1. Resin linings shall not be applied when the pipe wall temperature is 3°C or less; the procedure for assessing the pipe wall temperature is given in Section CP 4.14.1 of the Code of Practice ⁽¹⁾.

OR 6.8: Application of Coating

1. The **Approved Contractor** shall monitor the entire lining paying specific attention to the following:
 - pump performance;
 - mix-ratio;
 - lining speed;
 - coating thickness;
 - application head operation; and
 - smooth hose withdrawal.
2. Should a fault occur, the **Approved Contractor** can decide to abort the lining at any time as long as acceptable rectification works are carried out to the satisfaction of the **Utility Representative** prior to restoration of supplies to customers.
3. Upon exit of the lining application head from the pipe and whilst still functioning, the lining application head shall be transferred to a container and an exit dip card taken.
4. Immediately after application of the lining, the **Approved Contractor** and/or **Utility**

Representative shall review the mix-ratios recorded by the monitoring system.

5. For a lining to be considered acceptable, 95% of mix-ratios recorded by the monitoring system shall be within $\pm 5\%$ of the resin manufacturer's specified mix-ratio and 100% shall be within $\pm 10\%$. If these criteria are not met, a non-conformity record shall be filled out and actions undertaken as deemed necessary by the **Utility Representative** (see Section CP 4.13.1 of the Code of Practice⁽¹⁾ for guidance).

OR 6.9: Coating Thickness

1. With the exception of joints where full coverage may not always be achieved, the coating thickness shall be a minimum of 1mm.

OR 6.10: Cure Period: End of Application to Post Cure Inspection

1. From completion of application and before CCTV inspection can commence, the whole lining shall be air-cured for a minimum period in accordance with the resin manufacturer's Instruction For Use (IFU) document.
2. When unattended, open pipe ends shall be capped off using secure end caps that prevent contamination.

OR 6.11: Post Cure Inspection

1. Upon completion of the minimum cure period required before CCTV inspection can take place (as specified in the IFU) the **Approved Contractor** shall carry out the following inspections and record the details:
 - i) inspect the pipe for uniformity of application and cure by visual examination (using suitable lighting) and touching of all pipe ends;
 - ii) CCTV survey the entire length of lined pipe with video or digital recording.
2. The main shall not be considered for return to service until:

- i) post cure inspections are complete;
 - ii) the full air-cure period specified in the IFU has elapsed (if different to the period required before CCTV inspection).
3. The CCTV inspection (recording or actual survey) and the lining rig printout shall be reviewed and signed off by the Utility Representative within 24 hours of the completion of the lining.

OR 6.12: Lining Defects

1. Any lining defects shall be rectified by the **Approved Contractor** to the satisfaction of the **Utility Representative** within the following timescales:
 - i) defects that could impact on water quality (such as severe water damage, the presence of unmixed resin components, or faulty mix ratio) shall be rectified before the main is returned to service; and
 - ii) linings that show only physical defects and that will not adversely affect water quality can be returned to service but shall be rectified within a timeframe determined by the **Utility Representative**.
2. Certain lining defects can be rectified by over coating the original lining after the minimum cure period has elapsed.
3. Over-coating shall only be carried out using the same resin material, unless the lining manufacturer has conducted tests to confirm compatibility between specific linings which are then stated in the approved lining information for use (IFU).
4. Any pipe lengths contaminated with unmixed resin components shall be re-laid. Under no circumstances shall any attempt be made to clean and reline such contaminated lengths.

OR 6.13: Disinfection, Sampling, and Return to Service

1. The main shall be disinfected in accordance with the principles of Technical Guidance

Note No 4 Distribution System (Renovated Mains) contained in Principles of Water Supply Hygiene and Technical Guidance Notes¹⁽⁴⁾.

2. Disinfectant concentrations used shall also be consistent with any restrictions contained in the IFU for the **Approved Coating Product**.
3. After disinfection the main shall be flushed for the period stated in the manufacturers Instruction for Use (IFU), or if no period is stated then for a minimum period of 1 hour at 0.5 ms⁻¹ or available mains velocity before return to service. It should be checked that chlorine concentrations have returned to background concentrations.
4. For lined pipe sections with dead ends a flow regime shall be established such that the residence time shall not exceed 1 hour in the first 24 hours of service after recommissioning.
5. Before recommissioning, the **Utility Representative** shall assess the risk as to whether contamination has occurred during relining. If the **Utility Representative** decides that there is a risk that contamination may have occurred, corrective action shall be taken and precautionary advice to boil water shall be issued to affected consumers unless re-connection is not made until a clear bacteriological sample has been recorded.
6. As a minimum, all mains shall be sampled as soon as they have been put back into service and analysed for free residual chlorine, E. coli and coliforms and turbidity and checked for qualitative taste, odour and appearance.
7. If a sample from a re-lined main fails the bacteriological standards, it shall be re-sampled immediately. If the re-sample fails, 'advice to boil water' notices shall be issued in the affected area and appropriate

investigations and remedial actions instigated.

OR 6.14: Pipe Samples

1. The requirement for taking pipe samples shall be at the request of the Water Undertaker.
2. Before disposal, pipe samples shall be inspected by the **Approved Contractor** and **Utility Representative** for lining quality and thickness and the details recorded on the relevant Pipe Sample Quality Record (see OR Section 7)
3. Additional guidance on pipe sampling is given in Section CP 4.16 of the Code of Practice⁽¹⁾.

OR SECTION 7: QUALITY CONTROL DOCUMENTATION

1. The form of documentation used in lining contracts shall conform to the minimum content specification given in Appendix E and be as specified by the Water Undertaker.

Note: Example standard documents are contained in Appendix A of the Code of Practice: *In Situ* Resin Lining of Water Mains⁽¹⁾. No copyright attaches to these forms and they may be freely reproduced.

2. The following fully completed sheets shall be provided for every lining:
 - i) Resin Lining Record (RLR) to include a copy of the numerical rig printout; and
 - ii) CCTV Record (CCTVR) and recording.
3. The following sheets shall be provided when circumstances dictate:
 - i) Non Conformance Record (NCR) – to report any defect experienced during lining;
 - ii) Pipe Sample Quality Record (PSQR) – for each pipe sample exhumed;
 - iii) Spin-Up Determination Record (SUDR).

¹ Each Water Undertaker publishes a Disinfection Code of Practice which is aligned to Water UK's Principles of Water Supply Hygiene and Technical Guidance Notes⁽³⁾. This shall also be consulted.

4. The **Approved Contractor** shall supply all documentation relevant to each lining to the **Utility Representative** according to the following requirements:

Documentation	Requirement
CCTV recording Lining rig print-out	Within 24 hours of completion of lining
RLR CCTVR	Within one working day of return to service
NCR PSQR SUDR	Within three working days of return to service

5. All sheets shall be cross-referenced, signed, and dated by the **Approved Contractor** and the **Utility Representative** as being a true and accurate record of each lining and each shall retain a copy.
6. If pipe lined in tests carried out above ground is to be used subsequently as pipe-make up pieces, the requirements of this Section apply. Pipe from test linings shall not be used if appropriate documentation is not available for the test lining.

The **Utility Representative** shall be informed of the locations where such pipe-make up pieces are installed into the network.

7. The Water Undertaker shall retain all paper lining records (including printouts) for two years from the date of lining or for the period of the lining contract, whichever is the longer.
8. The Water Undertaker shall retain all CCTV recordings for two years or for the period of the lining contract, whichever is the longer.
9. Print-outs shall be treated and stored under conditions that will ensure legibility for two years from the date of lining or for the period of the lining contract, whichever is the longer.

REFERENCES

This document makes reference to the latest edition of the following publications (except where otherwise stated) including all addenda and revisions which should also be consulted.

1. IGN 4-02-02 Code of Practice: *In Situ* Resin Lining of Water Mains. Water UK, 2007.
2. Water Supply (Water Quality) Regulations 2000. HMSO, 2000 in England (2001 Wales) or the Water Supply (Water Quality) (Scotland) Regulations 2001 in Scotland or the Water Supply (Water Quality) Regulations (Northern Ireland) 2007 in Northern Ireland.
3. BS EN ISO 9001 Quality Management Systems. Requirements. BSi, 2000.
4. WATER UK. The Principles of Water Supply Hygiene and Technical Guidance Notes. Water UK, 1996 (Supplemented 1998).
5. DWI. "List of Approved Products". (www.dwi.gov.uk/cpp/pagea.shtm)

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APPENDICES

Appendix A – Contractor Certification

PROTOCOL TO BE USED FOR LINING TRIALS REQUIRED FOR CERTIFICATION AND RE-CERTIFICATION OF CONTRACTORS USING *IN SITU* SPRAY-APPLIED RESIN MATERIALS

A.1 Introduction

This protocol has been developed on behalf of Water UK and in agreement with t. It relates to the lining trials that contractors are expected to undertake and perform satisfactorily to gain certification to allow them to operate within the UK as **Approved Contractors** for *in situ* lining.

The physical application of the lining shall need to be repeated at 5-year intervals to ensure that **Approved Contractors** are maintaining their standards and can continue operating.

In order to ensure that high standards of quality are maintained, it is essential that **Approved Contractors** operate an ISO 9001⁽³⁾ quality assurance scheme certified by a third party certification body with UKAS accreditation.

New Contractors not operating an ISO 9001⁽³⁾ quality assurance scheme shall be allowed an 18-month transition period after successful completion of a lining trial to become so certified.

A.2 Assessment Procedures

Each Contractor shall clean and line three separate 100m lengths of 100mm diameter main (other diameters can be used at the discretion of the **Nominated Certifying Body**). The whole lining process shall be witnessed and assessed by the **Nominated Certifying Body**.

For **New Contractors** these mains shall ideally be abandoned mains or a system specifically constructed for the purpose of such trials. Live parts of the distribution system may be used at the discretion of the Water Undertaker providing suitable precautions are taken to isolate the mains from domestic supply during the course of the trials and that any problems encountered with the linings on the test sections are remedied by pipe replacement before return to service.

The decision to return a lined section to service will rest with both the **Nominated Certifying Body** and the Water Undertaker; if either party has any doubts as to the suitability of the lining, the main shall be replaced. Once the lining is applied, the **New/Approved Contractor** shall be expected to carry out at least one pipe sample per lined length to assess coating thickness and undertake CCTV inspections.

Where live mains have been used, the mains shall be disinfected, flushed and returned to service as defined in the Operational Requirements and the **New/Approved Contractor** shall provide fully completed paperwork as specified in the Operational Requirements for each lined length including copies of rig printouts. In other circumstances the Contractor shall demonstrate a thorough understanding of the principles of re-commissioning through a simulated return to service.

The **Nominated Certifying Body** carrying out the assessment can request as many re-inspections or re-linings as deemed necessary to ensure the **New/Approved Contractor** is suitably proficient in the lining process.

Should any section or complete lining prove to be defective, rectification works shall be carried out that ensures the durability of such a lining is not compromised and there is no adverse impact on

water quality. As long as any defects are properly rectified to the satisfaction of the assessing **Nominated Certifying Body**, this shall not necessarily hinder certification.

A. 3 Certification

All contractors approved by a **Nominated Certifying Body** on behalf of Water UK to apply *in situ* spray-applied resin linings shall be given a 5-year certificate to that effect. They will be able to describe themselves as 'certified' for application of *in situ* spray-applied resin linings and shall appear in a list of **Approved Contractors** maintained by Water UK.

Approved Contractors who do not undertake spray-applied resin lining within any 12 month period shall have their certification revoked. Re-certification shall be required before the **Approved Contractor** can again practice spray-application of resin materials to potable water systems.

Any **Approved Contractor** who undergoes a merger with another company or changes the name of their company shall inform the **Nominated Certifying Body** who originally approved their certification of the change. The **Nominated Certifying Body** would then consider if further certification is required.

A. 4 Certification for Further Materials and/or Rigs

Approved Contractors are limited by each approval to the lining rig design and the material used for the certification. Should such an **Approved Contractor** wish to use an alternative or modified design of rig or a different material, the **Nominated Certifying Body** shall be consulted and further certification trials undertaken.

Re-certification of an **Approved Contractor** for use of a different material and/or lining rig will in most cases require the auditing of only one lining. However, a full assessment procedure shall be followed where:

- the resin material has significantly different properties to those for which the **Approved Contractor** holds existing approvals (for example, epoxy lining contractors seeking certification to apply rapid set materials); or
- the resin material is used with a different rehabilitation outcome in mind (for example, contractors seeking certification to apply semi-structural or structural lining who have previously only undertaken non-structural lining).

In these cases, the full assessment procedure is required so that the **Nominated Certifying Body** can confirm that the **Approved Contractor** has taken into account the difference in the resin material and application process, as specified in the IFU.

A.5 Updates to Specifications

It should be noted that specifications and performance requirements for *in situ* spray-applied resin lining systems are under constant review and that when requirements change, existing and new contractors shall have to demonstrate compliance. An appropriate transition period shall be negotiated to enable such new requirements to be met.

Appendix B - TRAINING REGIME

PERSONNEL EMPLOYED IN THE *IN SITU* SPRAY APPLICATION OF RESIN LININGS

B.1 Introduction

The training regime for *in situ* spray-applied resin lining is designed to ensure that application of such linings is only undertaken and monitored by personnel who have proven competence and possess an understanding of the entire process.

A rigorous schedule is set in order to fulfil all the requirements of these Operational Requirements and the Code of Practice⁽¹⁾, which requires stringent certification criteria that are subject to formal renewal at intervals not exceeding 3 years.

Such training can only be carried out by ***Nominated Training Certifiers***, as appointed by Water UK, and shall be subject to regular audit by ***UKAS*** to ensure that the high standards specified are maintained.

The content of the training courses given here is the minimum that is acceptable. Completion of such training does not preclude either the ***Approved Contractor*** or Water Undertaker from carrying out further training on the subject.

The key personnel working for an ***Approved Contractor*** that require training and certification are defined as:

Site Agent	The person responsible for the management of a number of lining gangs, providing all lining records to the Water Undertaker and ensuring all work undertaken is in compliance with the Operational Requirements. The Site Agent shall understand all aspects of the lining process, the requirements of the Operational Requirements, health and safety implications and the significance of quality assurance.
Foreman/Ganger	The person responsible for all activities of the lining gang and, whilst he may not regularly operate the lining equipment, he is expected to demonstrate a detailed understanding of rig operation and all aspects of the process and the requirements of the Operational Requirements.
Rig Operator	The person responsible for the operation of the lining rig and providing key information for quality assurance records. The Rig Operator shall demonstrate a detailed understanding of rig operation and maintenance, and all aspects of the process and the requirements of the Operational Requirements.
Application Head Operator	The person responsible for the operation and maintenance of the applicator head and in-line mixer. The Application Head Operator is expected to understand rig operation, undertake pre- and post-lining inspections and be aware of all aspects of the process and the requirements of the Operational Requirements.
Recognised Fitter	The person responsible for ensuring that lining rigs are set up in accordance with the conditions (alarm conditions, set-points, etc.) used when rig approvals were granted, and that rigs can perform in accordance with the Operational Requirements.

The minimum requirement is for three fully trained personnel for each operating gang excluding the Site Agent throughout the entire rehabilitation process. Failure to maintain this level of qualified staff shall result in suspension of lining operations until such time as sufficient qualified personnel are available.

The key personnel working for a Water Undertaker that require training and certification are defined as:

Utility Representative	The person engaged by the Water Undertaker shall understand all aspects of the process to ensure that all lining work fully complies with the Operational Requirements. The Utility Representative is ultimately responsible for monitoring the quality of application and validation of all records in accordance with the Operational Requirements.
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B.2 Training Requirements for Lining Operatives

Part 1: Theory and Understanding

Lining operatives shall attend a course that provides a broad understanding of all aspects of *in situ* spray-applied resin lining. The minimum contents shall include:

- regulatory aspects of water main rehabilitation;
- background of *in situ* spray-applied resin lining;
- material formulation and details;
- material, machinery and personnel accreditation criteria;
- details of Operational Requirements and the Code of Practice ⁽¹⁾;
- cleaning and lining machinery;
- cleaning and lining process;
- inspection criteria;
- CCTV inspection;
- recognition and rectification of lining defects;
- principles of disinfection;
- Quality Assurance paperwork;
- health and safety;
- requirements of ISO 9001.

A written assessment shall be successfully carried out to gain Part 1 Certification. Part 2 can only be awarded upon successful completion of Part 1.

Note: The Part 1 certification is transferable when personnel change employment between the various **Approved Contractors**.

Training can only be considered transferable to another rig type and material type following consultation with a nominated certifying body who will make an assessment based on the relevant training requirements. If the nominated body considers that training is not transferable then appropriate training as determined by the nominated body must be completed

Part 2: Practical

Prior to undertaking this Site Assessment, the **Approved Contractor** shall ensure that formal training of all personnel has been undertaken in the operation and maintenance of all relevant plant and machinery associated with the lining process.

During the practical assessment, personnel shall display a practical understanding of the following:

- lining rig operation, maintenance, cleaning and calibration;
- application head operation, cleaning and maintenance;
- weight checks;
- determination of spin-up times;
- cleaning and lining process;
- pre- and post-lining inspections;
- CCTV operation and interpretation;
- principles of disinfection;
- rectification of lining defects;
- completion of Quality Assurance paperwork;
- health and safety.

Failure to successfully complete Part 2 Certification shall require further training before resubmission.

Note: The Part 2 Certification is transferable when personnel change employment between the various **Approved Contractors** but is limited to the material/rig for which the certification was awarded.

Upon transfer of a lining operative to a different **Approved Contractor**, it is the explicit responsibility of that **Approved Contractor** to ensure that formal training is given in the operation and maintenance of all relevant plant and machinery with which the lining operative is not familiar.

B.3 Training Requirements for Utility Representatives

Part 1: Theory and Understanding

The **Utility Representative** shall attend a course that gives a broad understanding of all aspects of *in situ* spray-applied resin lining.

The course content is identical to the Contractor course with the addition of the following items:

- site monitoring procedures;
- client (Water Undertaker) responsibilities;
- understanding Quality Assurance paperwork;
- good working practice;
- range of cleaning and lining machinery.

A written assessment shall be successfully carried out to gain Part 1 Certification. Part 2 Certification can only be awarded upon successful completion of Part 1.

Note: The Part 1 certification is transferable when personnel change employment between the various Utilities.

Part 2: Process Appreciation and Site Supervision

During a site based assessment, personnel shall display a practical understanding of the following:

- material details;
- machinery details and operation;
- understanding of monitoring system;
- weight checks;
- determination of spin-up times;
- cleaning and lining process;

- pre- and post-lining inspections;
- understanding and interpretation of printout;
- CCTV operation and interpretation;
- principles of disinfection;
- return to service;
- rectification of lining defects;
- completion of Quality Assurance paperwork;
- health and safety.

Participants shall also be expected to demonstrate an understanding of alternative machinery and materials to those available during the assessment.

Note: The Part 2 certification is transferable when personnel change employment between the various Utilities.

B.4 Certification

Successful participants in these training schemes shall be issued with a registered identity card, which shall give the following information:

- ID photograph;
- Name;
- Role (Utility Rep., Recognised Fitter, Lining Operative);
- Reference number;
- Material;
- Lining Rig;
- Date of certification;
- Date of expiry;
- Name of certification agent.

Appendix C - LINING RIG ASSESSMENT SCHEDULE

C.1 Introduction

This schedule details the standard assessment procedure for determining whether a spray-applied resin lining rig complies with the design and performance criteria required to meet the conditions of approval. Note: This schedule may not be applicable to rigs that incorporate alternative monitoring technologies, assessed in accordance with the terms of Appendix F.

The standard assessment consists of three stages:

- i) A review of the rig design;
- ii) A yard-based assessment of rig performance;
- iii) An assessment of lining capability;

The assessment procedure shall be carried out for each rig-resin material and/or monitoring system-resin material combinations, as deemed appropriate by the **Nominated Certifying Body** undertaking the assessment.

Notwithstanding this consideration, the assessment shall be undertaken as a type test; that is, a one-off test of rig design.

In addition to the type test detailed herein, **Approved Contractors** shall monitor the on-going performance of every lining rig so as to facilitate the early identification of trends that indicate the need for maintenance and/or calibration.

C.2 Output

Upon successful completion of the assessment, the **Nominated Certifying Body** shall issue a certificate as proof that the rig and monitoring system meet the design and performance requirements for the *in situ* application of the specified resin material.

C.3 Review of Lining Rig Design

Objective

To review the design of the lining rig and ensure that it incorporates all required design features.

Method

If deemed necessary by the **Nominated Certifying Body**, a summary of the rig design and a schematic showing key components and hydraulic/pneumatic and base and activator circuits shall be submitted to the **Nominated Certifying Body**, at least one week prior to the assessment. The relevant key components are as follows:

- Transfer and metering pumps;
- Monitoring system including control panel(s);

- Flow meters;
- Temperature sensors;
- Speed encoder(s);
- Pressure sensors;
- Heating system(s);
- Storage reservoirs;
- Winch;
- Valving;
- Hose including heating system and pressure rating;
- Air filtration devices; and
- Suitable safety systems for high pressure working.

This list is not exhaustive and further information may be required upon examination of the rig.

The manufacturer shall submit a copy of the rig operating manual and their indicative calibration regime to the ***Nominated Certifying Body***, at least one week prior to the assessment.

The ***Nominated Certifying Body*** shall then inspect a lining rig to ensure it incorporates accepted design features and components.

It should be appreciated that whilst the rig specification given in the Operational Requirements defines key requirements, this should not limit any further development or inhibit innovation of new types of systems.

Should the rig manufacturer propose to include any developments that are potentially outside of the specification, full details of such equipment shall be submitted at least one month prior to the rig assessment for consideration of suitability.

The rig owner should be aware that retrospective fitting of unapproved equipment to any approved rig design shall contravene the Operational Requirements and will lead to suspension of their certifications.

C.4 Rig Performance Assessment Procedure

The procedure for the rig performance assessment is as follows:

- i) The rig shall not be preconditioned; i.e. it shall not have been operated on the day of the assessment;
- ii) The rig shall be started and conditioned as if in use on a lining site under standard operating conditions;
- iii) When the materials are at suitable temperatures (as defined in the manufacturer's IFU), the rig shall commence short and, subsequently, long cycle recirculation;
- iv) Whilst on recirculation, the rig shall be set to run at a suitable flow rate (this will be determined per rig depending on individual rig performance);
- v) During the course of these activities the basic performance and operation of the rig shall be monitored.

When the rig is performing suitably a number of procedures shall be carried out to confirm monitoring system compliance, as detailed in C.5 to C.7.

C.5 Response to Fault Conditions

Objective

To ensure that appropriate alarms are given when there is an operational fault and that spurious alarms do not occur.

Method

The performance of the alarm system shall be monitored throughout the assessment process. In addition, the following fault condition shall be simulated in the presence of the **Nominated Certifying Body**.

The following tests shall be carried out with the rig operating as if lining except that the hoses do not have to be reeled in.

Condition	Pass Criteria
<p>1. Simulated Hose Burst: A hose burst shall be simulated by rapidly opening a dump valve installed downstream of delivery pumps and upstream of the hoses and flow monitoring devices.</p> <p>This test shall be repeated at least twice for valves operated on both the base and activator supply lines at a range of flow rates as requested by the Assessor.</p>	<p>A low-pressure alarm that would be obvious to the Approved Contractor shall be given within 10 seconds of the simulated hose burst on both the base and activator supply lines.</p>
<p>2. Simulated Increase in Material Pressure: An increase in material pressure shall be simulated by closing a valve installed in an appropriate location, as determined by the Assessor.</p> <p>This test shall be repeated at least twice for valves operated on both the base and activator supply lines at a range of flow rates as requested by the Assessor.</p> <p>Should this test be deemed detrimental to the rig, it can be curtailed (at the discretion of the Assessor). However, confirmation of the alarm operation shall still be provided.—</p>	<p>An alarm that would be obvious to the Approved Contractor shall be given within 10 seconds of the simulated pressure increase on both base and activator supply lines.</p>
<p>3. Loss of Power to the Monitoring System: This fault condition shall be simulated by interrupting the power supply to the monitoring system.</p>	<p>It shall not be possible to inadvertently line with the monitoring system switched off.</p>

General Pass Criteria

During the assessment the rig alarms shall function appropriately and there shall be no spurious alarms triggered by normal operation.

C.6 Suitability and Accuracy of Monitoring Equipment

Objective

To determine if the monitoring system is suitable and if recorded/displayed mix-ratios are representative of the actual mix-ratio output by the rig.

Method

Monitoring system suitability and accuracy shall be assessed in four stages in the presence of the ***Nominated Certifying Body***.

1. Review of Meter Constants:

All multipliers and/or functions used to convert meter/transducer/encoder readings for display/recording purposes shall be documented and submitted to the ***Nominated Certifying Body*** for review.

2. Response Time of Mix-Ratio Monitoring System:

The monitor response time shall be assessed by running the rig under normal operating conditions, at the maximum delivery rate (base plus activator) attainable for the rig under test. A change in the mix-ratio shall then be imparted by opening a valve positioned downstream of the pumps and upstream of the flow meters (these can be the same dump valves used to simulate hose burst, as described above).

For rigs where monitoring system updates are linked to the metering pump cycle, rather than an explicit time base, the leak shall be initiated at the start of the pumping cycle. (Discounting the effect of leak size, this is the worse case scenario, as the monitoring system would not update again until the end of the pumping stroke or cycle.)

Note: In some cases, the response time of monitoring systems can be assessed by reviewing the alarm conditions and timing the pump stroke/cycle. Such an approach can be used at the discretion of the ***Nominated Certifying Body***.

The time taken for the monitoring system to register a change in mix-ratio (by volume) in the interval +/-5% to +/- 20% shall be measured.

This test shall be repeated at least twice for valves operated on both the base and activator supply lines.

This test shall be carried out with the rig operating as if lining, except that the hoses do not have to be reeled in.

3. Suitability of the Monitoring System:

The suitability of the monitoring system shall be tested by review of the alarm conditions and/or by simulating faults on the rig so as to generate out of tolerance mix-ratios directly (for example, by operating a valve so as to induce a mix-ratio error), as required by the ***Nominated Certifying Body***.

This test shall be carried out with the rig operating as if lining, except that the hoses do not have to be reeled in.

4. Accuracy of Monitoring Equipment:

The accuracy of the monitoring system shall be assessed by comparing weight check data to the mix-ratios output by the monitoring system. 10 weight checks carried out in accordance with the standard weight check protocol given below, shall be made under each of the following conditions:

- Total flow rate: maximum attainable for the rig;
- Total flow rate: 2/3 the maximum attainable ($\pm 10\%$);
- Total flow rate: 1/3 the maximum attainable ($\pm 10\%$).

Weight checks shall be taken at intervals of at least 1-minute using the following standard weight check protocol.

- i) Cups of at least 0.5-litre capacity shall be used.
- ii) At least 200 grams of the activator shall be collected for each weight check.
- iii) The checks shall be carried out whilst re-circulating and taken at the end of the hoses using the provided weight check facilities (usually on the rig tanks).
- iv) Balances shall be calibrated at a maximum interval of 6 months and be accurate to $\pm 1\%$. The balance shall record to the nearest gram.
- v) The weight check data shall be recorded on a form showing:
 - date;
 - rig identification number;
 - operator;
 - time of the weight check;
 - flow of the base and activator;
 - component pressures;
 - component temperatures;
 - weight of the base;
 - weight of the activator;
 - calculated mix-ratio (by weight of activator);
 - monitor mix-ratio.

At the discretion of the **Nominated Certifying Body**, process parameters that change gradually through the type test (such as pressure and temperature) need only be recorded intermittently (rather than for each weight check).

The mix-ratios calculated from the weight checks shall be compared with the mix-ratios recorded by the monitoring system at the time of the weight check. The mix-ratio output by the monitoring system may be obtained from either the screen display (recorded manually) or the printout, but the **Nominated Certifying Body** shall be satisfied that the screen display and printout are consistent.

Pass Criteria

The pass criteria for the above tests are given below. It should be noted that where monitoring systems are not capable of explicitly implementing the requirements given in 2 and 3 below, alternative criteria shall be considered if they are, in the opinion of the **Nominated Certifying Body**, at least as onerous as those stated.

1. Review of Meter Constants:

The **Nominated Certifying Body** shall be satisfied that all functions (including any averaging or smoothing functions) and/or constants used to convert meter/transducer/encoder readings for display/recording purposes (including those determined during calibration) are required and do not distort the output of the monitoring system.

The **Nominated Certifying Body** shall also be satisfied that all functions and/or constants used are consistent with the mix-ratio response time requirement outlined below.

It shall be demonstrated that on-site personnel cannot change the meter constants.

2. Response Time of Mix-Ratio Monitoring System:

The time taken for the monitoring system to register a change in mix-ratio (by volume) in the interval 5% to 20% shall meet the following criteria:

$$\text{response time} \leq \left| \frac{1}{R} \times 50 \right| \text{ seconds}$$

Where R is the total pumping rate in l/min (for example, if R = 5 l/min, then the monitoring system shall register the change in less than 10 seconds).

It shall also be demonstrated that on-site personnel cannot change the time over which meter signals are averaged or the monitoring system is updated.

3. Suitability of the Monitoring System

A steady measure of mix-ratio shall be given and displayed clearly on the monitoring system. Mix-ratio shall be permanently recorded on the printout; mix-ratio faults shall also be registered on the printout.

Any two consecutive mix-ratio readings that exceed the $\pm 5\%$ allowable tolerance band shall produce an audible alarm that would be obvious to the **Approved Contractor**.

Any reading that exceeds the $\pm 10\%$ tolerance shall produce an audible alarm that would be obvious to the **Approved Contractor** and shall cause the lining to be automatically aborted. Linings must be automatically aborted by shutting the rig down immediately.

Within an acceptable lining, 95% of mix-ratios measured (not recorded) during the entire length of main by the monitoring system shall be within $\pm 5\%$ of the required mix-ratio and 100% shall be within $\pm 10\%$. It is desirable that appropriate alarms that would be obvious to the **Approved Contractor** be given if the 95% criterion is not being met.

The printout for a lining shall give a summary that clearly indicates whether the mix-ratio specification (95% of mix-ratios within $\pm 5\%$ and 100% within $\pm 10\%$) has been met.

A similar summary shall be given for the number of acceptable/unacceptable coating thicknesses.

4. Accuracy of Monitoring Equipment

When assessed against the mix-ratio given by a calibrated weight check, the monitoring system shall give a measure of mix-ratio that is accurate to within 5%. Hence, the monitor error shall be less than 5%, with monitor error defined as:

$$\text{Monitor error} = \text{absolute} \left(\frac{\text{Weight check mix ratio} - \text{Monitor output mix ratio}}{\text{Weight check mix ratio}} \right) \times 100$$

Note: This calculation requires the “as pumped” specific gravity of the resin components to be known.

C.7 Accuracy of Mix-Ratio Delivery

Object

To determine if the rig is compatible with the mix-ratio tolerance band of $\pm 5\%$ by weight of activator.

Method

Weight checks shall be taken using the standard weight check protocol given above. A minimum of 100 weight checks shall be taken over at least two days, with the rig being started from cold on each day of testing.

The rig operator shall follow normal rig start up procedures each day and start taking weight checks once the rig has reached operational temperatures and pressures at which lining could normally commence.

A minimum of 30 of the weight checks shall be audited; that is, carried out in the presence of the **Nominated Certifying Body** (these weight checks can be the same as those used to check the accuracy of the monitoring system).

At the discretion of the **Nominated Certifying Body**, this test may be carried out in long-circulation (warm-up) mode.

Pass Criteria

Weight check data shall fall within the following tolerance bands:

- 95% of audited weight checks within $\pm 5\%$.
- 100% of audited weight checks within $\pm 10\%$.
- 95% of total weight checks within $\pm 5\%$.
- 100% of total weight checks within $\pm 10\%$.

Where these pass criteria are not met, the test may be repeated at the discretion of the **Nominated Certifying Body**.

C.8 Suitability of Calibration and Maintenance Schedules

Upon completion of the rig assessment, the rig manufacturer or owner/operator shall conduct a complete rig calibration exercise. Such a procedure shall be conducted in the presence of the **Nominated Certifying Body**.

A suitable maintenance and calibration schedule, expressed as volume of resin components pumped (or equivalent measure) shall be determined and incorporated into the **Approved Contractor's** Quality System.

In this context, it is considered good practice that the performance of each lining rig is assessed on an on-going basis by analysing weight checks and the mix-ratio data output by the monitoring system. The maintenance/calibration schedule can be derived from the results of such ongoing performance.

It is recognised that the data required may, in the first instance, be sparse. This shall not be considered a barrier to the operational use of a rig providing the rig design is otherwise shown to meet the requirements of the assessment. However, an appropriately cautious provisional volumetric maintenance and calibration schedule shall be adopted until the wear characteristics of rigs have been fully evaluated.

C.9 Lining Trial

At least one lining shall be assessed so as to determine compliance with the Industry and Regulatory requirements under operational conditions, with key emphasis being placed on the coating application in terms of:

- i) compatibility of the lining equipment, including the lining application head;
- ii) overall ability of the rig to apply a lining of the correct specification;
- iii) compliance of the rig with the Operational Requirements for the *in situ* application of approved spray-applied resin materials to potable water mains.

At the discretion of the **Nominated Certifying Body**, these requirements can be assessed by lining of pipes laid above ground. In such trials, a minimum pipe length of 50 metres shall be lined.

Appendix D - DETERMINATION OF MINIMUM SPIN-UP TIME

D.1 Introduction

The spin-up time shall be established for the specific equipment and resin material being used.

Spin-up time is determined by spinning material into a suitable clean, empty container (e.g. a bucket) and taking a series of dip cards made of PVC, PE, PP or impermeable cardboard.

The dip cards are held in the stream of mixed resin coming from the application head. A sequence of dip cards is taken until the system stabilises and reaches the correct mix-ratio at the head. A stable colour is taken as an indication that the correct mix-ratio has been reached. Note: this assumes the mix-ratio at the pumps is correct; alarms would be given if this were not the case.

D.2 Procedure

The following procedure shall be adopted.

- i) Dip cards shall be taken at regular timed intervals of 10 seconds during spin-up for a minimum of 1 minute.
- ii) Dip cards shall cover the period prior to colour stabilisation and for several 10-second time intervals after stabilisation.
- iii) The cards shall be stored in chronological order at ambient temperature and allowed to cure for the resin manufacturer's specified cure period.
- iv) The degree of cure of the material on the dip-cards after this time shall be tested:
 - For resin materials that are brittle when correctly proportioned, mixed and cured, a simple way of assessing cure is to snap the cards; a fully cured resin material will break cleanly.
 - Some resins, however, demonstrate a ductile failure mode when correctly proportioned, mixed and cured, which makes this method unsuitable. For these ductile materials the spin-up time can be assessed through colour consistency and a subjective assessment of the degree of cure (in terms of tackiness, etc.).

The snap test is therefore only a guide. In practice, the first dip card that has the correct colour and is fully cured represents the minimum spin-up time for the prevailing conditions.

- v) A safety margin of at least 30 seconds shall be added to the minimum spin-up time.
- vi) Under no circumstances shall the spin-up time used in lining operations be less than 1 minute.
- vii) The results of the test shall be recorded on a Spin-Up Determination Record.

Appendix E – Documentation

E.1 Minimum Specification

The form of documentation used in lining contracts shall conform to the minimum specification given below. All documentation for a lining shall be given unique reference numbers and be cross-referenced to allow an appropriate audit trail to be maintained, in accordance with the requirements of the Water Undertaker and Contractor’s quality system.

Resin (RLR)	Lining	Record	<p>General:</p> <ul style="list-style-type: none"> • Contractor • Contract/ Scheme/ Location • Supervisor • Gang Ref. • Date <p>Pipe details:</p> <ul style="list-style-type: none"> • Pipe Diameter/ Material • Lining length • Access Hole Refs. <p>Rig/Resin details:</p> <ul style="list-style-type: none"> • Resin Material • Lining Rig No. • Head No. • Base & Activator Batch Nos./Quantity <p>Cleaning:</p> <ul style="list-style-type: none"> • Method of cleaning • Number of swabs used <p>Cleaning Survey Report:</p> <ul style="list-style-type: none"> • Summary of visual inspection • Summary of CCTV inspection <p>Weight check calculation record (pre/post):</p> <ul style="list-style-type: none"> • Weights of samples • Calculations of mix-ratio • Time of final weight check <p>Lining details:</p> <ul style="list-style-type: none"> • Temperature(ambient/base/activator/pipe wall) • Spin-up time • Start/end time of lining • Mix-ratio conformance • Cure start time (from exit of machine from pipe) / finish time (when post cure inspection is completed) / duration <p>Post cure observations:</p> <ul style="list-style-type: none"> • Uniformity (acceptability) • Quality (acceptability) • Thickness (acceptability) • Hardness (acceptability) <p>Post cure operations:</p> <ul style="list-style-type: none"> • Contact time - disinfection • Chlorination details • Time/duration of flushing <p>Form Verification/Sign-off</p>
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CCTV Record (CCTVR)	<p>General:</p> <ul style="list-style-type: none"> • Contractor • Contract/ Scheme/ Location • Supervisor • Gang Ref. • Date <p>Pipe details:</p> <ul style="list-style-type: none"> • Pipe material and diameter • Access Hole Refs. • CCTV Recording Ref. • Length surveyed • Resin material • RLR Number <p>Observations:</p> <ul style="list-style-type: none"> • Faults observed <p>Form Verification/Sign-off</p>
Non-Conformance Record (NCR)	<p>General:</p> <ul style="list-style-type: none"> • Contractor • Contract/ Scheme/ Location • Supervisor • Gang Ref. • Date <p>Pipe details:</p> <ul style="list-style-type: none"> • Pipe Diameter • Lining length • Access Hole Refs. • RLR Number <p>Resin:</p> <ul style="list-style-type: none"> • Resin Material <p>Nature of defect</p> <p>Reason for defect</p> <p>Remedial Action taken/Date</p> <p>Action taken to prevent recurrence</p> <p>Form Verification/Sign-off</p>
Pipe Sample Quality record (PSQR)	<p>General:</p> <ul style="list-style-type: none"> • Contractor • Contract/ Scheme/ Location • Supervisor • Gang Ref. • Date <p>Pipe details:</p> <ul style="list-style-type: none"> • Pipe Material/ Diameter • Lining length (m) • Access Hole Refs. • RLR number <p>Resin:</p> <ul style="list-style-type: none"> • Resin material <p>Measurement Record (both ends)</p> <p>Observations</p> <p>Form Verification and Sign-off</p>

Spin-Up Determination Record (SUDR)	General: <ul style="list-style-type: none"> • Contractor • Contract/ Scheme/ Location • Supervisor • Gang Ref. • Date • Resin material • Lining Rig Type • Lining Rig No. • Temperature (Base/Activator/umbilical/ambient) • Total Flow rate Spin-Up test results Minimum Spin-Up time Form Verification and Sign-off
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Example standard documents are contained in Appendix A of the Code of Practice: *In Situ* Resin Lining of Water Mains⁽¹⁾. No copyright attaches to those forms and they may be freely reproduced.

Appendix F - Alternative Monitoring technologies

F.1 Introduction

Pre-lining weight checks provide confirmation that the lining rig has attained a stable output, at the correct mix-ratio. Furthermore, weight checks carried out over consecutive lining processes, in conjunction with rig calibration and maintenance schedules, show that this stability is being maintained. This level of protection and monitoring is improved by the use of in-line flow meters, which allow direct monitoring of the mix-ratio during the lining process, and can therefore detect transitory problems.

Water UK has determined that a flow meter based monitoring system provides the necessary level of monitoring and alarm functionality for *in situ* resin lining rigs and should, therefore, be adopted as the industry standard. This determination is not intended to preclude the use of innovative technologies that afford the same level of monitoring, alarm functionality, and/or protection against inadvertent application of an out-of-ratio lining. The following procedure outlines the arrangements for facilitating the introduction of alternative systems.

F.2 Formal Procedure

The equivalence of the alternative technology shall be demonstrated through the following formal procedure.

Stage 1: The rig manufacturer shall submit to a **Nominated Certifying Body** a review of the design and operating characteristics of the alternative technology.

Stage 2: The **Nominated Certifying Body** shall formulate a performance-based test schedule and carry out a suitable test program to assess the equivalence of the alternative technology.

Stage 3: Where the **Nominated Certifying Body** deems the alternative technology appropriate, the results of the assessment shall be reported to a review body designated by Water UK.

Stage 4: The review body will assess the results and stipulate any additional conditions of use, as appropriate.

Should it be shown that the alternative technology complies with both Regulatory and Industry requirements, an approval certificate, together with any conditions of use, will be issued by the **Nominated Certifying Body**.

F.3 Generic Technologies

For the purposes of this document, alternative monitoring technologies will fall into two generic types:

Type 1: Equivalent measure of mix-ratio: Alternative in-line monitors that provide a real time and in-line measure of mix-ratio based on a direct measurement of flow, which is not inferred from other operational parameters such as pressure.

For this type of alternative technology, the performance criteria outlined in the Rig Assessment Schedule given in Appendix C will be applied. The pass criteria will be that the same level of monitoring and alarm functionality is afforded by the alternative system.

Type 2: Other Systems: Where systems do not give a real time in-line measure of mix-ratio it shall be demonstrated that the design of the rig is such that inadvertent application of an out-of-ratio lining is not possible when the rig is used under specified operational conditions. Further, the required operational conditions shall be set through appropriate design features (for example; appropriate control of operating pressure and temperature ranges).

For this type of alternative technology, it shall be demonstrated that the level of protection afforded by the system equals or exceeds that given by a flow meter based system.