Certificate

independent certification of your products & services

This is to certify that the following product or service has met the requirements detailed below

ClearLine Profiler

For the accurate provision of empirical data for internal pipe dimensions developed and manufactured by

Redzone Robotics NZ Ltd
13 Tarndale Grove
Albany
Auckland 0632
New Zealand

This product meets the requirements set out in WRc Assessment Schedule PT/356/1214-AS.

assessor

director

1st December 2014

issue date

1st December 2019

expiry date

WRc™ Approved

PT/356/1214

certificate number

RedZone Robotics

WRc

WRc Approved: ClearLine Profiler Approval Report

Report Reference: 10512.02
December 2014

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Report Reference:	10512.02
Date:	December 2014
Authors:	Killian Spain
Project Manager:	Killian Spain
Project No.:	16325-0
Client:	Redzone Robotics
Client Manager:	Phil Anderson

RESTRICTION: This report has the following limited distribution:

External: Redzone Robotics

This document has been produced by WRc plc.

Any enquiries relating to this report should be referred to the Project Manager at the following address:

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Version Control Table

Version number	Purpose	Issued by	Quality Checks Approved by	Date
V1.0	Report issued to client	Killian Spain, Project Manager	Nick Orman	18/12/2014
V2.0	Updated Assessment Schedule included	Killian Spain, Project Manager	Nick Orman	18/12/2014

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i Reasons

WRc require that products holding a WRc Approved™ certificate meet existing relevant requirements. The certificate is valid for a period of 5 years. Following this period the product must be resubmitted for evaluation. The evaluation is based upon an Assessment Schedule that is prepared by WRc in conjunction with the manufacturer of the product.

ii Objectives

The objectives of this project are to establish that:

- The finished laser profiling product and software meet current requirements as defined in the Assessment Schedule PT/356/1214-AS;
- Appropriate material, production, operation and analysis quality control methods are employed; and

The ClearLine profiler originally achieved WRc Approved™ certification in September 2004 (certificate no. PT/09/2004). Since it has been 10 years since original approval, a practical test programme is to be undertaken as part of this approval process.

iii Benefits

Redzone Robotics wishes to demonstrate the performance of their ClearLine Profiler system. A WRc Approved™ certificate offers an independent technical view of a product's performance.

iv Conclusions

The ClearLine Profiler system has been assessed against Assessment Schedule PT/326/1214-AS. The product meets the requirements in all aspects.

vi Résumé of Contents

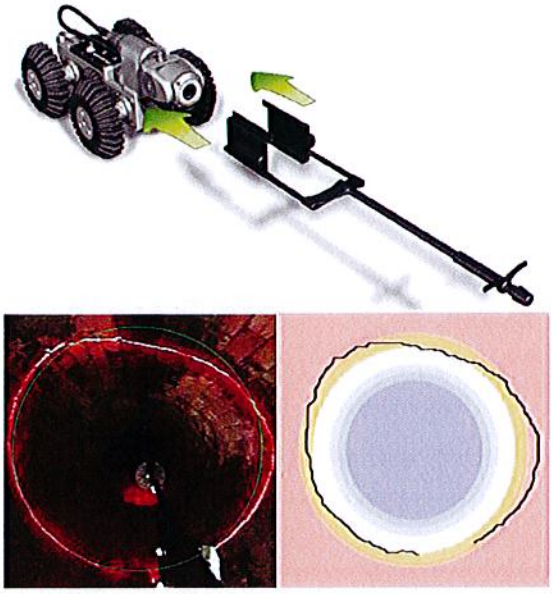
This report describes the assessment of the ClearLine Profiler system. This includes changes made to the Assessment Schedule following a review of relevant documentation and the audit process of testing and quality control records.. The report closes with a set of conclusions and recommendations.

1. Introduction

1.1 System outline

The ClearLine Profiler system consists of a 'SnapOn' laser head and ClearLine software. The laser head has been developed to attach to specific models of CCTV camera/tractor unit and project a ring of laser light onto the internal pipe surface. The position and shape of the ring of laser light is subsequently recorded during the survey. After calibration and application of an image distortion correction, the Profiler using the proprietary software is used to analyse the recorded survey images. The software is able to analyse the dimensions of the laser light ring and infer details of the pipe dimensions. The pipe dimensions can subsequently be viewed and interrogated with several automated reports and graphical tools.

Figure 1.1 ClearLine Profiler system and outputs



1.2 The WRc Approved™ scheme

Redzone Robotics believes that WRc Approved™ certification of the ClearLine Profiler provides marketing benefits for the product. The WRc Approved™ Scheme assesses the performance of a product or service to confirm that it is fit for its intended purpose.

The evaluation of a product is based upon an Assessment Schedule that is prepared by WRc in conjunction with the manufacturer or supplier of the product. Once a product has been approved and the certificate is issued, the Assessment Schedule becomes a publicly available document. The requirements of an Assessment Schedule typically include:

- The description of the product and scope of the approval;
- The tests used to assess the performance of the product;
- An evaluation of the installation instructions including witnessing the use of the product onsite at two locations; and
- An audit of the quality control procedures used in the manufacture/operation of the product.

The Assessment Schedule for ClearLine Profiler is contained in Appendix A**Error! Reference source not found.**.

1.3 ClearLine Profiler WRc Approved™ scheme history

The ClearLine Profiler was originally awarded WRc Approved™ certification in September 2004 (certificate reference PT/09/2004). The ClearLine Profiler was reassessed for WRc Approved™ certification in September 2009 (certificate reference PT/286/0709).

2. Scope of Assessment

2.1 Assessment scope

During November 2014, in association with Redzone Robotics, WRc developed a draft test schedule and specification for the product. The approval was split into the following stages:

Stage 1 – Review of documentation

Review of evidence (manual(s) and written statements) supplied by Redzone Robotics to confirm that there have been no changes to the product audit any changes, and determine whether additional testing is required due to any changes.

Stage 2 – Update Assessment Schedule

Update of the Assessment Schedule in light of the documentation review and check if there have been revisions or new standards that would impact on the assessment.

Stage 3 – Testing and QC records

Audit of test results and QC records, where available.

Stage 4. Testing Schedule

As the initial assessment was undertaken 10 years ago, a focused test programme was undertaken to confirm the continued accuracy of the system to measure ovality and detect operational and structural defects. A test programme was developed between WRc and Redzone Robotics and one day of testing was undertaken at WRc Swindon test facilities

Stage 5. Client feedback

WRc to contact a client(s) and/or user(s) of the ClearLine Profiler system to ascertain how well the system has performed in-line with claims/expectations.

Stage 6. Reporting and issue of new certificate

Provide a short report detailing the assessment and, where appropriate, issue a new WRc Approved™ certificate.

3. Review of Documentation

3.1 Introduction

WRc reviewed the ClearLine Profiler to establish whether there have been any changes since previous approval in September 2009.

3.2 Assessment standards

WRc requested Redzone Robotics to provide the following:

1. Submission to WRc of the current operation manual(s).

2. A written statement from Redzone Robotics that it has not changed any of the following:

   - Component materials or material suppliers.
   - Method of manufacture.
   - Design/installation/operation manual or the installation practice.

3. Details of any type and quality control testing results from the last five years.

4. Submission of a list of clients within the last five years to WRc, WRc will then request contact details for selected clients to obtain product feedback.

3.3 Information provided by Redzone Robotics

3.3.1 Manuals and product documentation

The Redzone Robotics operation (Profiler Field Handbook Version 3.1 August 2014) and analysis (Profiler CCTV Ovality Basic Software Training V6.2.3 August 2014) material provided for the profiling hardware and software gives clear instructions for installation.

These instructional materials are fit for purpose and sufficient for installation.

3.3.2 Letter of confirmation

Redzone Robotics provided a letter of confirmation (Appendix B) dated 26th August 2014 from Mr. Phil Anderson Anderson, General Manager, Redzone Robotics NZ. The letter confirmed that aside from the specified changes, there have been no additional changes to the product since previous approval in 2009.

3.3.3 Component materials and suppliers

The letter of confirmation from Redzone Robotics provided details where component materials and suppliers have changed since WRc Approved™ certification in 2009.

Where changes to materials and suppliers had been changed since previous approval, supporting documentation was supplied by Redzone Robotics.

3.3.4 Testing and Quality Control

Redzone Robotics provided details of their quality control procedures including quality control documentation concerning:

- Repair control;
- Shipping control; and
- Laser profiler control.

Additional documentation was provided outlining the internal testing undertaken by Redzone Robotics and their training programme for operators and engineers using the profiling system.

3.3.5 Client contact details

Redzone Robotics provided a list of 24 UK and international customers within the last 5 years to WRc.

4. Update Assessment Schedule

4.1 Introduction

WRc undertook a review of the standards and requirements identified in the December 2009 Assessment Schedule. The requirements specified in those standards were reviewed to ensure that they are current and have not been superseded in the period since previous approval. Where standards have been superseded, the current version was reviewed to identify whether the pertinent requirements have also changed. Any changes require supporting evidence from Redzone Robotics that their products meet the revised requirements.

The Assessment Schedule was reformatted to align them with the current WRc Approved™ format.

The ClearLine Profiler system was assessed against the updated Assessment Schedule (Appendix A**Error! Reference source not found.**) to ensure that the product is fit for purpose and meets the requirements of current industry standards. Section 4.2outlines the standards and requirements reviewed as part of this process.

4.2 ClearLine Profiler

As an innovative product there are no existing specifications for light ring systems. However, there are requirements in several documents that are relevant to the technology. A specification drafted by WRc based on the minimum requirements of the industry for such a product. Guidance for the UK water industry for CCTV surveying of gravity sewers is contained in the following documents:

- **MSCC5 (Manual of Sewer Condition Classification Fifth Edition).** This publication provides the current standard method of sewer and defect classification and provides guidance on the accuracy required by the UK water industry. This is a revision of the Fourth Edition identified in the 2009 Assessment Schedule. The document updates do not alter the current Assessment Schedule requirements.

- **Model Contract Document for Sewer Condition Inspection, Second Edition.** This publication includes guidance on contract procedure, contract conditions and a specification for inspection equipment. This is a revisíon of the Second Edition identified in the 2009 Assessment Schedule. The document updates do not alter the current Assessment Schedule requirements.

- **Sewers for Adoption 7th Edition.** A design and construction guide for developers preparing a submission to a Sewerage Undertaker and contains a clause that requires

newly installed sewers are CCTV surveyed prior to adoption. This is a revision of the Fifth Edition identified in the 2009 Assessment Schedule. The document updates do not alter the current Assessment Schedule requirements.

- **ASTM F1216-09.** Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube. This standard provides a specification for assessing pipe ovality and the use of the quantity in the rehabilitation of pipelines. This is a revision of the 03 version identified in the 2009 Assessment Schedule. The document updates do not alter the current Assessment Schedule requirements.

4.3 Summary

The updated Assessment Schedule is contained in Appendix A. Updates to the Assessment Schedule were made to reflect the updates to the relevant standards and to align the Assessment Schedule with WRc's most recent template formatting.

5. System Testing

5.1 Introduction

The type testing element of the WRc Approved™ scheme is used to assess the ability of the ClearLine Profiler hardware and software to determine the ovality of pipelines (and other specific claims identified on the Assessment Schedule) using laser/light ring technology.

By undertaking inspection of pipes with a set deformation, it was possible to assess the profiling system in determining pipe ovality and assess any variances in the accuracy of measurements. Controlled variables used in testing of the ClearLine software included:

- Hardware system as selected by Redzone Robotics; and,
- Pipe materials, pipe sizes and pipe colours as selected by WRc.

Tests were carried out under controlled conditions on 26/11/2014 at WRc's Engineering Test Facility in Swindon, Wiltshire.

Representatives of Redzone Robotics supplied and operated the equipment and software required for testing and analysis.

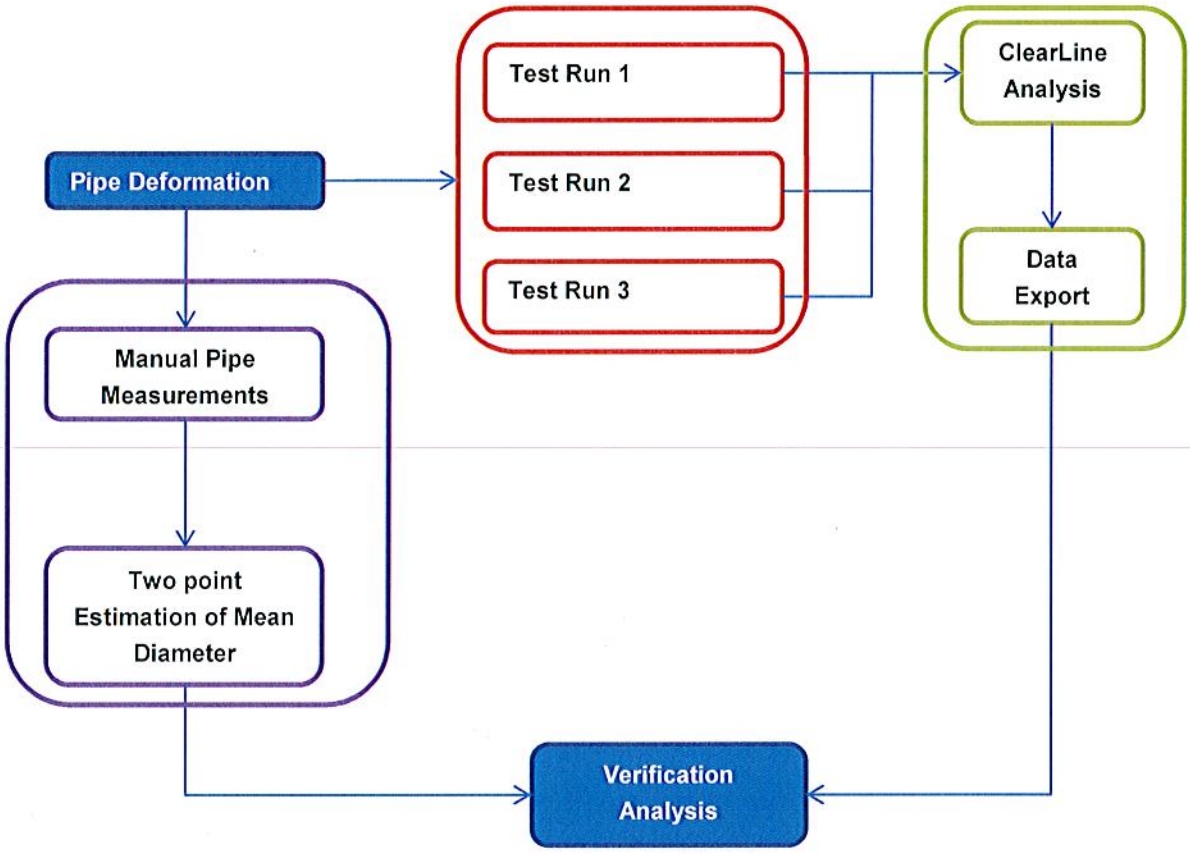
5.2 Test procedure

A copy of the test procedure developed as part of the approval validation testing is included in Appendix C.

5.3 WRc verification methods

WRc used ovality calculations using the physically measured maximum and minimum diameters (and subsequent, calculated mean) identified in Appendix C, which are compared against the data outputs from the ClearLine software. The outputs from each test run were considered individually and compared against the WRc calculations. Figure 5.1 outlines the process flow utilised for comparison and verification.

Figure 5.1 Verification flow diagram



Where image interpretation allows, the ClearLine software can generate a report that includes (among others); continuous pipe profiling, maximum and minimum pipe diameters (about the x and y axis) and pipe ovality. WRc's pipe deformation rig was used to produce pipe deformations and the data outputs from the ClearLine software were examined to assess the ovality calculation. The data was manually processed in a spreadsheet as follows:

- A two point estimation of the mean pipe diameter using the WRc physical measurements;
- A margin of ±1% was attributed to all measurements; and,
- A comparison of the above two outputs for each test run on each pipe involved in testing.

Considering the automated ovality report.

The automated ovality report was compared to the findings from the WRc pipe deformation rig with the ovality calculated in by the two methods listed below:

- Using the WRc physical measurements; and,
- Using the ClearLine reported maximum and minimum diameters, obtained by manually interrogating the data via the software but also obtainable by manually interrogating the data from the CSV file.

The purpose of this check was to ensure that the automatically reported pipe ovality remained consistent with the inputted data and to examine the software's handling of the ASTM calculation.

5.3.1 Ovality test measurements

Tests were undertaken on three pipes made from different materials and of different diameters. Varying levels of deformation were used for each test with results from the different measuring and calculations methods being collated for each deformation and pipe.

Appendix D Table D.1, Table D.2, and Table D.3 show the findings of the ovality tests with a summary of the results provided in Table 5.1. Comparisons were made based on different calculation methods in order to verify the automated report from the ClearLine software. The comparison of the manual (Physical) WRc calculations of maximum and minimum pipe diameters matches closely to those reported by the ClearLine software.

The manual recording of measurements was subject to measurement errors, including parallax errors and the selection of diameters measured as the maximum and minimum. To minimise these errors, 3 physical measurements were taken each time for the maximum and minimum diameters, with a different person taking each set of measurements. The manual measurements were then averaged to provide a result for the physically measured maximum and minimum.

The ClearLine Profiler uses the following method to establish the dimensions of the light ring and calculate ovality:

- The centre of the pipe is found (based on a heuristic calculation to find the centre of an object);
- 180 circumferential points are identified and recorded;
- Rogue points are ignored (generally due to video 'noise');
- 90 diameter calculations are analysed. [Note: If 15% of diameters not found (due to holes, noise, defined water-levels etc.) then radius is used];
- Maximum diameter (percentage variance) is identified;

- Minimum diameter (percentage variance) is identified;
- Mean diameter (percentage variance) is calculated using all identified diameters.

5.3.2 Ovality test findings

During the ovality tests, up to three separate surveys were undertaken on each pipe. The pipe deformation was not altered during each of the runs. In each case the tractor unit and light head were completely removed and replaced in the test pipe. Individual recordings of the laser ring were made and analysed.

Table 5.1 Reported Ovalities, Variation from Mean

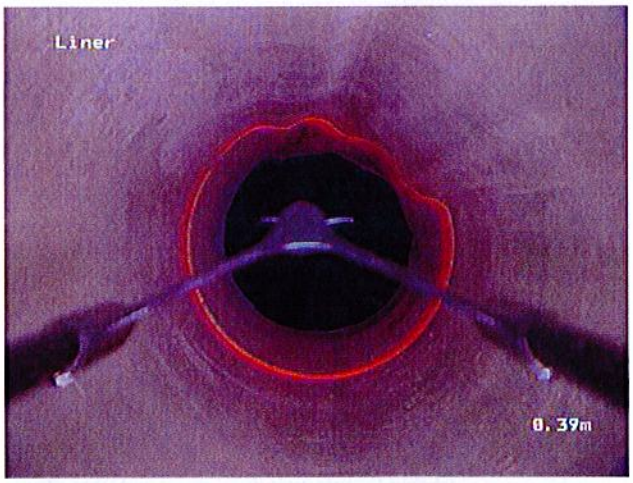
Pipe	Deformation	Physical Measure	Run 1	Run 2	Run 3	ClearLine Mean Value	ClearLine Max Variation From Mean
150 mm Terracotta	Medium	9.18%	9.2%	9.1%	9.2%	9.17%	0.26%
150 mm Black	Medium	9.46%	9.4%	9.6%	9.7%	9.57%	0.17%
	High	14.68%	14.3%	14.5%	No result*	14.4%	0.10%
300 mm Black	Low	6.24%	6.4%	6.4%	6.4%	6.4%	0.0%

*Data file not accounted for

5.3.3 Other observations

In addition to the ovality testing, the system also profiled a lined pipe with known liner defects. The system was capable of identifying and quantifying the defective liner membrane. See Figure 5.2.

Figure 5.2 ClearLine Profiler in pipe with defective liner



6. Client feedback

WRc drafted a short questionnaire regarding the installation and performance of the ClearLine Profiler system. The questions are listed below:

1. Are you the operator of the ClearLine Profiler system or the operator of the structure in which it is used?

2. For what purpose did you use the system?

3. Did the hardware and software arrive as expected / Have any products been returned due to condition upon receipt?

4. Are the installation requirements/operation instructions clear for the conditions encountered on site?

5. Has the structure been inspected since use of this product? If yes, have any (additional) defects been noted?

6. Any other comments you wish to make?

WRc contacted a ClearLine Profiler customer (Anthony Foden, Director – Underground Vision UK Ltd) via telephone. WRc received a completed response from this customer. The completed questionnaire is presented in Appendix E.

7. Conclusions and Recommendations

Redzone Robotics has provided the necessary information to WRc for assessment of the ClearLine Profiler system.

The ClearLine Profiler system was tested at WRc's Engineering Test Facility (ETF) on 26th November 2014.

The ClearLine Profiler produced by Redzone Robotics has been found to meet the performance set out in the Assessment Schedule PT/356/1214-AS.

A WRc Approved™ certificate, reference PT/286/0709, was issued September 2009 for a period of 5 years. The new certificate and Assessment Schedule reference is PT/356/1214 and is valid for a period of 5 years.

Appendix A Assessment Schedule

PT/356/1214-AS December 2014

Assessment Schedule for the ClearLine Profiler as supplied by Redzone Robotics

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1. SCOPE

This schedule specifies requirements for the ClearLine Profiler system which provides accurate empirical data on the ovality, capacity and other conditions in new and existing pipelines.

This assessment schedule applies to the performance of the 'Profiler' device and the 'ClearLine' software.

2.PRODUCT DESCRIPTION

2.1 Introduction

The laser Profiler device can be retro fitted to several makes and models of CCTV cameras and produces a ring of laser light on the inside of the pipeline. The resulting images are analysed using the ClearLine software

2.2 Applicable standards

At present there are no existing standards that are relevant to the system on which to base a test schedule. WRc has drafted a test schedule based on the current needs of the UK Water Industry and to account for materials and conditions encountered within the industry.

WRc identified the following documents as relevant to develop a performance test schedule.

- Manual of Sewer Condition Classification Fifth Edition 2013 (MSCC 5)[1]
- Model Contract Document for Sewer Condition Inspection, Second Edition 2005[2].

2.3 Approval History

The ClearLine Profiler system was originally awarded WRc Approved™ certification in September 2004 (Certificate reference PT/09/2004).

The system was reassessed for WRc Approved™ certification in September 2009 (Certificate reference PT/286/0909).

3. TESTING & REQUIREMENTS

3.1 Type testing

The ClearLine Profiler system shall be assessed for:

- Functionality;
- Calibration, scaling and image distortion; and
- Accuracy and repeatability.

Specific manufacturer's claims are listed below.

Reporting: The system shall provide automated reporting for ovality, hydraulic capacity, delta x/y, minimum and maximum diameter, 2D and 3D models and median diameter (for each image frame).

Output: The system shall provide data output in CSV file format.

Diameter range: The system shall provide accurate data for a pipe range of 150 mm to 450 mm.

Materials: The system shall provide accurate data for PE (including 'black' PE), GRP, clay, brick, concrete, cured-in-place liners and patch repair materials.

Accuracy: The system shall provide data to an accuracy of ±0.5% or better for linear measurements.

Repeatability: The system shall provide data with a repeatability of ±0.12% or better for linear measurements.

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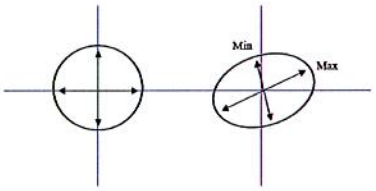
Assessment Schedule for the ClearLine Profiler as supplied by Redzone Robotics

Ovality: The ASTM F1216-09[3] standard for cured in place pipes defines a percentage ovality of the original pipe as:

$$\left\{\frac{(\text{Maximum Inside Diameter} - \text{Mean Inside Diameter})}{\text{Mean Inside Diameter}}\right\} \times 100$$

Where the maximum and minimum inside diameter is measured as follows:



and the Mean Inside Diameter could be calculated as:

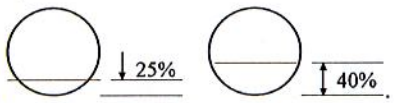
$$\frac{\text{Maximum Diameter} + \text{Minimum Diameter}}{2}$$

The system shall meet the specified accuracy requirements for ovalities between 0% and 15%.

Surcharge: MSCC5 defines level of surcharge by depth as a percentage of the pipe diameter.

The system shall be capable of operating between 0% and 30% and remaining fully functional.

Settled deposits: MSCC5 defines levels of percentage area reduction by settled deposits or debris



The system shall be capable of operating between 0% and 30% and remaining fully functional.

Area reduction: MSCC5 defines percentage area reduction.

The system shall provide accurate data to an accuracy of ± 3% of the measured area.

Structural defects: Defect sizes are inferred with the aid of the light ring Profiler and verified by manual measurement. Defects include:

- Fracture longitudinal;
- Crack longitudinal;
- Patch repair; and
- Hole.

3.2 Product documentation

The product and installation documentation supplied by Redzone Robotics shall be complete and accurate and allow for the full benefit of the product to be achieved.

3.3 Site Audit

When used in accordance with the suppliers' instructions, the ClearLine Profiler system shall be reasonably expected to perform as described.

3.4 User requirements

Operators operating the hardware and interpreting survey results shall have sufficient experience, training and guidance documentation.

PT/356/1214-AS December 2014

Assessment Schedule for the ClearLine Profiler as supplied by Redzone Robotics

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4. APPROVAL

The ClearLine Profiler system has been audited and has successfully met all of the requirements stated within this assessment schedule.

5. REFERENCES

1. ISBN 9781898920700: Manual of Sewer Condition Classification Fifth Edition 2004 (MSCC 4).

2. ISBN 9781898920564: Model Contract Document for Sewer Condition Inspection, Second Edition 2005.

3. ASTM F1216-09, Standard practice for rehabilitation of existing pipelines and conduits by the inversion and curing of a resin impregnated tube.

Appendix B Letter of confirmation

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Auckland 0632
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+64 9 479 9904
www.cleanflowsystems.com

WRc plc,

Frankland Road,

Blagrove, Swindon, Wiltshire,

United Kingdom SN5 8YF

Attn: Andy Russell

26 August, 2014

Re: Recertification of Profiler Equipment

Dear Andy,

Other than the items listed below, there have been no changes to the Profiler SnapOn.

Changes to Profiler

- Component materials or material suppliers
  - Laser diodes – we needed to change the diode used in our las50 due to previous supplier (Hitachi) no longer manufacturing this diode.
    Note: The supplier of our laser purchases standard laser diodes (from multiple diode suppliers) and circularises the laser. This supplier (Bluesky) has remained the same, only their external supplier changed (from Hitachi to QSI). Further the specs of the diode are effectively the same. Please see supporting sheets VPSL-0658-050-5-G (existing), PS110 (previous). The assembly procedures and design of our product have not changed.

  - Cones for the laser – now we have a backup supplier. http://epner.com/
    Cone quality is verified prior and during the assembly process.

  - Battery breather – Added battery breather to the carbon fibre battery casing. See BLD10518 INST ISS 01.pdf
- Method of Manufacture
  - No changes other than small additions such as battery breather, connector sleeves (structural support for extenders and laser)
- Design/installation/operational manual/procedure
  - Change of name of manufacturer in hardware manual, laser certification – 'Cleanflow Systems' to 'Redzone Robotics', address 13 Tarndale Grove, Albany, Auckland, New Zealand

- Analysis software
  - Current Analysis Graph Types;
    - Flat: The flat graph shows the pipe as if it had been cut lengthways along the base (invert) of the pipe, and then pulled apart and flattened.
    - Median Diameter: The median diameter selected from a possible 90 diameter readings and displayed as either a measurement (default) or percentage variance from the expected internal diameter.
    - Ovality: The ovality graph shows how oval or 'out of round' a pipe's cross-section has become due to deformation. This is displayed as a positive percentage and 0% is a perfectly round pipe.

      The formula is based upon the American Society for Testing and Materials F1216 standards where it states;

      q = percentage of ovality of original pipe

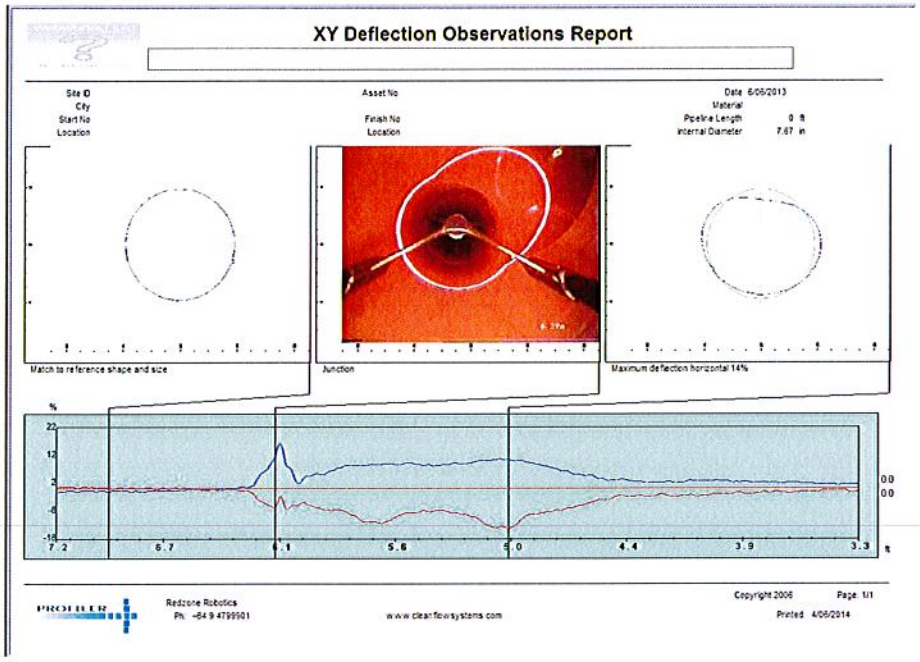
      = 100 x (Maximum inside diameter – Mean Inside Diameter)/ Mean Inside Diameter

    - Min Diameter: The minimum diameter is selected from possible 90 diameter readings and displayed as either a measurement (default) or percentage variance from the expected internal diameter.
    - Max Diameter: The maximum diameter is selected from possible 90 diameter readings and displayed as either a measurement (default) or percentage variance from the expected internal diameter.
    - XY Diameter: X diameter and Y diameter are displayed as a percentage variance from the expected internal diameter. Where no diameter reading exists (due to radial point missing) but a single radius has been obtained, the radius is multiplied by a factor of 2.

      Blue line = X diameter
      Red line = Y diameter

    - Capacity: The capacity graph shows a percentage variance of cross-sectional area derived from the expected internal diameter. A figure of 0% shows a pipe of exactly the cross-sectional area expected from the entered internal diameter.

    - Alternate analysis method for the Flat and X/Y diameter reports – instead of using the 'internal diameter' field (one diameter for the whole pipe), this method uses the median diameter for each frame. This was created in response to some US DOT's wanting to see deflection of the pipe based on the actual pipe size at the analysis point. This parameter is changed via the options page.



- XY Deflection Report example

- Waterlevel Mask

  For use where water or debris exists in the invert. This functionality can be used after a PVD is recorded or during setup for recording a PVD (Precision Vision Data file).

  A 'water level', defined by the user is used to:

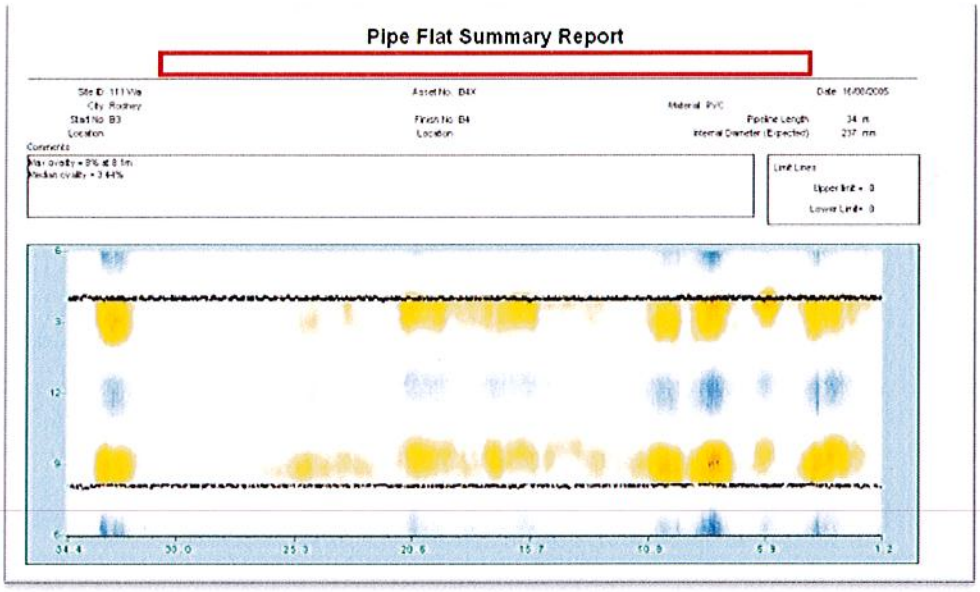
- Exclude all points below this level from calculation of the pipes Ovality and True Diameter.
- The automatic centre calculation algorithm will exclude the masked section. This is important for other reports including the Flat report.

- Reports

  There are now four main reports utilised (all reports are shown – some have changed slightly, or have been added (observation report);

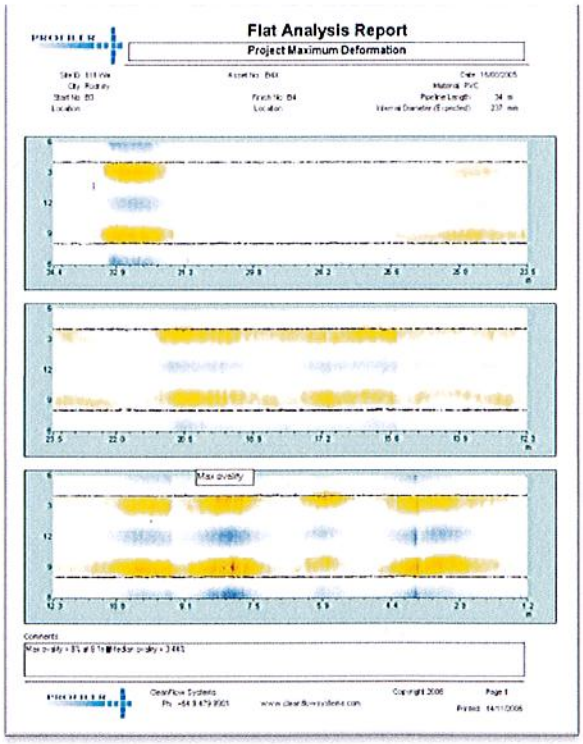
- Summary Report

  Displays the current graph from profiling start point to profiling end point on one easy to read compressed page.



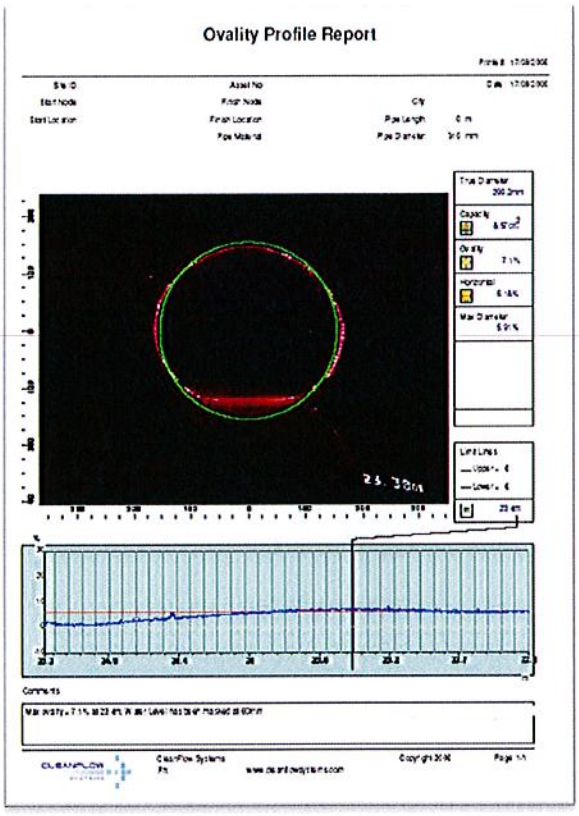
- Analysis Report

  Displays selected graph from profiling start point to profiling end point on a scrolling page report. This report should be used where complete detail is required, such as with large pipes or badly deformed pipes.



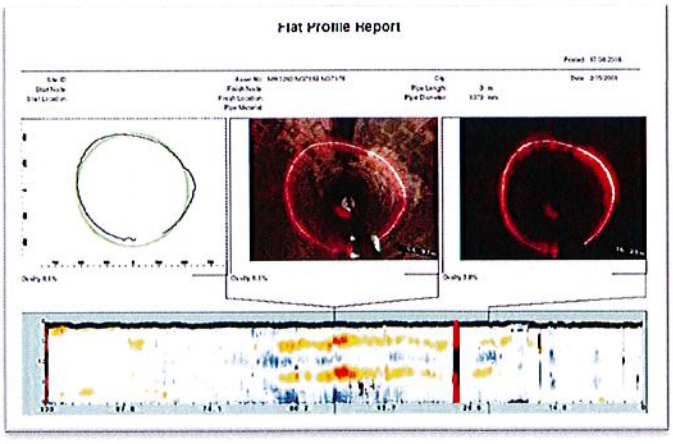
- Profile Report

  Displays either a cross-sectional snapshot from CCTV video, a cross-sectional digital image or a 3-Dimensional image; cross-referenced to the selected graph location. The displayed cross-sections can include text, measurements and various onscreen drawing functions



- Observations Report

  To display observations and observation images.



Appendix C Testing Procedure

Proposed Testing of ClearLine Profiler

1. Introduction

The type testing element of the WRc Approved™ scheme is used to assess the ability of the hardware/software to determine the ovality of pipelines using laser/light ring technology.

By undertaking inspection of pipes with a set deformation, it is possible to assess the ClearLine profiler/software in determining pipe ovality and assess any variances in the accuracy of measurements from the different inspections systems used. Controlled variables used in testing of the product will include:

- Hardware systems as selected by Redzone Robotics; and,
- Pipe materials, pipe sizes and pipe colours as selected by WRc.

Representatives of Redzone will supply and operate the inspection hardware/software required for testing.

The pipes/deforming rigs/testing supervision will be supplied by WRc.

2. Pipe Selection

Pipes selected by WRc for the test are based on the following criteria:

- Diameter: Pipes are selected to be representative of the approximate diameter range 150 mm to 500 mm. The camera type selected for use with the profiling system will influence the effective range.
- Colour: For each diameter a "black" and "terracotta" coloured pipe is selected.
- Pipe material: Plastic pipes are selected for all testing purposes.

The selected pipes are considered to be typical of a drainage or sewerage network. The twin wall pipe is selected as the internal wall of the pipe undulates with the external ribbed structure of the pipe and therefore does not present a uniform surface for the laser profiler. This can give a different pipe diameter of ±1.5 mm as manufactured.

Pipes selected for use in testing

Diameter	Internal Wall Colour	Pipe Details
150 mm	Terracotta	Underground (Terracotta Colour)
150 mm	Black	Twin Wall (Black Unperforated)
300mm	Black	Twin Wall (Black Unperforated)

3. Ovality

Pipe 'ovality' can be used to describe pipe deformation. The expression of ovality can be used during the design of cured in place liners, and to assess the quality of installation of structural walled plastic pipes. The ASTM standard F1216-09 expresses percentage ovality as:

$$\left\{\frac{(\text{Maximum Inside Diameter} - \text{Mean Inside Diameter})}{\text{Mean Inside Diameter}}\right\} \times 100$$

or

$$\left\{\frac{(\text{Mean Inside Diameter} - \text{Minimum Inside Diameter})}{\text{Mean Inside Diameter}}\right\} \times 100$$

The ASTM F1216-09 standard requires calculation of the 'Mean Inside Diameter'. However, it is possible to interpret this in several ways and little guidance is available from the document.

For the purposes of this report, the mean diameter is taken as:

$$\text{Mean Diameter} = \frac{\text{Maximum Diameter} + \text{Minimum Diameter}}{2}$$

4. Testing Set Up

From the supplied pipe length, the pipe is cut into three sections; 1 m, 1.5 m and 4.5 m. The 1 m section is deformed at the centre point by compressing the pipe section between two lengths of angle steel with loading applied on the vertical axis either side of the pipe. The angle bars are maintained at the horizontal to ensure loading was entirely vertical in nature. Two deformations are required for each pipe under testing. The first deformation is a 'Low Deformation' that is difficult to ascertain with the naked eye. The second 'High Deformation' is sufficient to be visibly noticeable. Deformation measurements are taken from the internal wall in the vertical and horizontal plan using callipers. Additionally, the deformation measurements are verified through the use of AutoCAD to calculate the required dimensions from an image of the deformed pipe.

The deformed 1 m section is then placed between the 4.5 m and 1.5 m sections and all three sections are aligned. Joints between the sections are sealed to maintain alignment and exclude light penetration into the pipeline. Entry into the pipeline was via an open end access through the 4.5 m section. The end of the 1.5 m section is covered and sealed to exclude light penetration.

Deformation and profiling rig set up

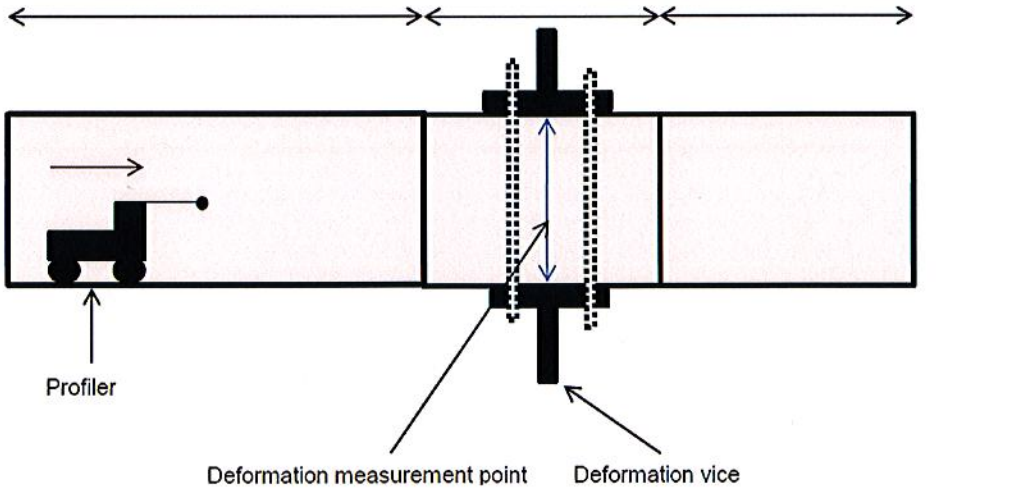
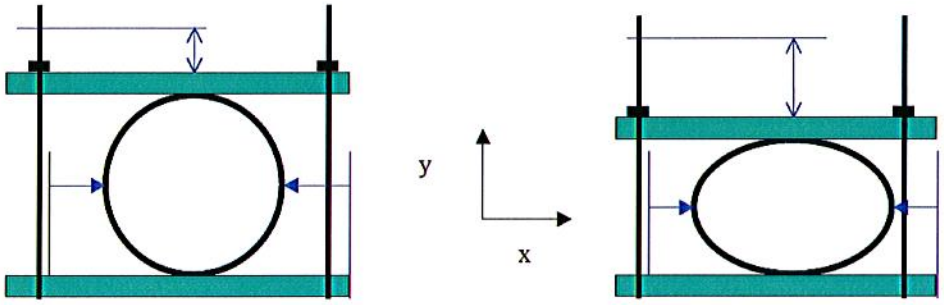


Diagram of WRc Pipe deformation and measurement equipment.



5. Test Run Procedure

For each of the three 1 m pipe sections under inspection, a deformation of >5% will achieved by application of the deformation vice as described. The WRc measurement will be taken immediately prior to commencement of the hardware inspection runs. The hardware system then inspects the pipe at the set deformation. The profiler system uses 90 potential diameters measured to derive the maximum and minimum measurements required.

Analysis of the test run data is performed on mpeg video. Measurements for the hardware system are taken up to, and past the point of deflection, which allows comparison with the WRc physical measurements recorded.

This procedure is repeated with the deformation up to 3 times to determine repeatability.

6. Additional Testing

Based on the previous Assessment Schedule PT/286/0709 AS September 2009, specific claims for the ClearLine Profiler are:

Table of ClearLine Claims (extracted from previous Assessment Schedule)

Claim	Detail
Automated reporting	Ovality, capacity, x/y diameter, minimum and maximum diameter, flat
CSV data output	Output file format
Diameter range	150mm to 450mm
Materials	PE including 'black' PE, GRP, clay, brick, concrete, cured-in-place liner materials, patch repair materials

Surcharge	In accordance with MSCC4 (now 5). 0% to 30%. Function after complete
Debris	In accordance with MSCC4 (now 5). 0% to 30%
Ovality	0% to 15%
Cross-sectional area	3 shapes to ± 3% of the measured area

The testing as outlined in Section 4 will be used for validation of a selection of these claims. Additional testing may be undertaken in the allocated testing day (time permitting) to revalidate additional claims in this table.

7. Software/Hardware Operation

Installation/use of the software will be demonstrated on a computer of suitable specification in line with the UK documentation supplied with the Profiler. Redzone Robotics to provide the software and hardware systems required for such demonstration.

Installation of the profile device on a suitable tractor unit will be demonstrated.

The calibration process will be assess in line with the system documentation.

The operation of the system will be assess during testing.

Qualities such as reliability/repeatability and ease of use will be considered during testing.

Approval will cover the range of pipe sizes/materials/ranges etc. of those claimed by Redzone Robotics (see Table 1).

Appendix D Ovality test measurements

Table D.1 Deformation of 150 mm Black coloured pipe

			As Supplied	Low Deformation				High Deformation			
Pipe	ND	Description of Measurement	Physical	Run 1	Run 2	Run 3	Physical	Run 1	Run 2	Run 3	Physical
Black 150		Minimum ø	150	135	135.1	135.1	134	126	127.4		125
		Maximum ø	151	162	162.3	161.8	162	169	170		168
		AMST Ovality*	0.33%	9.09%	9.15%	8.99%	9.46%	14.58%	14.32%	-	14.68%
		Software Reported Ovality**		9.4%	9.6%	9.7%		14.30%	14.50%		
		% Difference from AMST***		0.31%	0.45%	0.71%		0.28%	0.18%	-	
		% Difference, Software from Physical AMST Result ****		0.06%	0.14%	0.24%		0.38%	0.18%	-	
		Absolute Error, Physical AMST and Software AMST*****		0.37%	0.31%	0.47%		0.10%	0.35%	-	

* AMST standard F1216-03 Ovality = $\left\{\frac{Maximum\ Inside\ Diameter - Mean\ Inside\ Diameter}{Mean\ Inside\ Diameter}\right\} \times 100$ The mean is taken to be Mean Diameter = $\frac{Maximum\ Inside\ Diameter + Minimum\ Inside\ Diameter}{2}$

**Ovality outputed from profiling software

*** Percentage difference between outputed software ovality and the ovality calculated using the diameters recorded by the pipe profiler with the AMST formula.

**** Percentage difference between the outputed software ovality and the ovality calculated using the diameters recorded by physical measurement with the AMST formula.

***** Absolute difference between the outputed sofware ovaility and the Physical AMST ovality.

All measurements in mm unless stated otherwise

Table D.2 Deformation of 150 mm Terracotta coloured pipe

			As Supplied	Deformation			
Pipe	ND	Description of Measurement	Physical	Run 1	Run 2	Run 3	Physical
Terracotta 150		Minimum ø	150	135.7	136.7	135.2	136
		Maximum ø	150	162.9	162.9	162.8	163.5
		AMST Ovality*	0.00%	9.11%	8.74%	9.26%	9.18%
		Software Reported Ovality**		9.2%	9.1%	9.2%	
		% Difference from AMST***		0.09%	0.36%	0.06%	
		% Difference, Software from Physical AMST Result ****		0.02%	0.08%	0.02%	
		Absolute Error, Physical AMST and Software AMST*****		0.07%	0.44%	0.08%	

* AMST standard F1216-03 Ovality = $\left\{\frac{Maximum\ Inside\ Diameter - Mean\ Inside\ Diameter}{Mean\ Inside\ Diameter}\right\}$ x 100

The mean is taken to be Mean Diameter = $\frac{Maximum\ Inside\ Diameter + Minimum\ Inside\ Diameter}{2}$

**Ovality outputed from profiling software

*** Percentage difference between outputed software ovality and the ovality calculated using the diameters recorded by the pipe profiler with the AMST formula.

**** Percentage difference between the outputed software ovality and the ovality calculated using the diameters recorded by physical measurement with the AMST formula.

***** Absolute difference between the outputed sofware ovaility and the Physical AMST ovality.

All measurements in mm unless stated otherwise

Table D.3 Deformation of 300 mm Black coloured pipe

			As Supplied	Deformation			
Pipe	ND	Description of Measurement	Physical	Run 1	Run 2	Run 3	Physical
Black 300		Minimum ø	299	276.4	276.3	276.4	278
		Maximum ø	301	315.1	315.1	316.6	315
		AMST Ovality*	0.33%	6.54%	6.56%	6.78%	6.24%
		Software Reported Ovality**		6.4%	6.4%	6.4%	
		% Difference from AMST***		0.14%	0.16%	0.38%	
		% Difference, Software from Physical AMST Result ****		0.16%	0.16%	0.16%	
		Absolute Error, Physical AMST and Software AMST*****		0.30%	0.32%	0.54%	

* AMST standard F1216-03 Ovality = $\left\{\frac{Maximum\ Inside\ Diameter - Mean\ Inside\ Diameter}{Mean\ Inside\ Diameter}\right\}$ x 100

The mean is taken to be Mean Diameter = $\frac{Maximum\ Inside\ Diameter + Minimum\ Inside\ Diameter}{2}$

**Ovality outputed from profiling software

*** Percentage difference between outputed software ovality and the ovality calculated using the diameters recorded by the pipe profiler with the AMST formula.

**** Percentage difference between the outputed software ovality and the ovality calculated using the diameters recorded by physical measurement with the AMST formula.

***** Absolute difference between the outputed sofware ovaility and the Physical AMST ovality.

All measurements in mm unless stated otherwise

Appendix E Client feedback responses

WRc Approval Customer Feedback

Spain, Killian
Sent:17 December 2014 17:13
To: anthonyfoden@draintv.co.uk

Anthony,

As discussed, WRc are in the process of re-approving the ***ClearLine Profiler*** product, by ***Redzone Robotics***.

As part of the re-approval process we have asked Redzone Robotics to supply contact details so we may undertake client feedback.

Thank you for your time taken to provide customer feedback. I have written up your comments below. Please do not hesitate to contact me should you wish to have any of the below amended.

1. Are you the operator of the ClearLine Profiler or operator of the structure?
   Operator of the ClearLine Profiler

2. For what purpose was the ClearLine Profiler was used?
   The Profiler was used in PVS pipes to check for ovality

3. Did the ClearLine Profiler equipment/software arrive as expected/Have any products been returned due to condition upon receipt?
   Very happy with condition and build quality of the ClearLine Profiler. Have had the unit for 7 years no and no returns/issue so far.

4. Are the installation requirements/operation instructions clear and suitable for the conditions encountered on site?
   Yes

5. Has the structure been inspected since use of this product? If yes, have any (additional) defects been noted?
   Structure not inspected since

6. Any other comments you wish to make?
   This is a rather unique product from us and represents an area of innovation for our business. The use of this product has generated additional business for us. We are pleased with the product performance and our customers are please too.

Regards,

Killian Spain
Civil Engineer

Tel: +44 (0)1793 865031
Website: www.wrcplc.co.uk

my Linked in profile


WRc
Approved
PT/356/1214