Electro Scan

a quantum leap in the identification of sewers subject to groundwater infiltration

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Groundwater infiltration into sewers is recognised as a considerable problem in the UK and a recent Regulatory Position Statement from the Environment Agency, in October 2012 entitled '*Discharges made from groundwater surcharged sewers' LIT 7457/1409 12*, stated:

> *'We will not support any acceptance of continued, long term, groundwater infiltration into sewers where the infiltration risks the need for pumping out of sewers into watercourses'*

This means that water companies will have to pay greater attention to sealing sewers and Wessex Water has been at the forefront of supporting and developing trenchless solutions to meet that need, and there have been two successful development programmes driven forward by the WECS Rehabilitation Team (RT) in the last few years.

Electro-scanning - Courtesy of Electro Scan Inc

Developments

The first programme was the development of a latex reinforced polyacrylate gel for joint injection, in conjunction with supplier De Neef of Belgium, which won the Innovation Award at the ISTT conference in Rome 2007. This material has been used extensively in the Wessex Water region. Secondly, Wessex Water assisted the R & D of the EPROS Trelleborg epoxy 'seal liners' and has an existing on going lining programme of close to £2m across the last three years of AMP5.

Identifying applicable sewers

So the tools for preventing groundwater infiltration and sewage exfiltration are available and well established, but identifying which sewers present the potential for groundwater infiltration has, until now, been absent from the armoury. In addition, once identified, it is imperative that the available TOTEX capital is targeted at those sewers which can be ranked as contributing the most cumulative infiltration, to ensure best value is achieved.

The benefits to all sewerage companies in sealing sewers are numerous, including:

- Reduced treatment costs at the sewage works.
- Reduced power consumption when pumping forward to treatment.
- Reduced Totex for pump maintenance and replacement.
- Reduced premature initiation of CSO spills.
- Improved environmental standards.
- Improved customer experience in using facilities.
- Lower overall carbon footprint.
- Greater capacity in existing sewer to serve additional development.

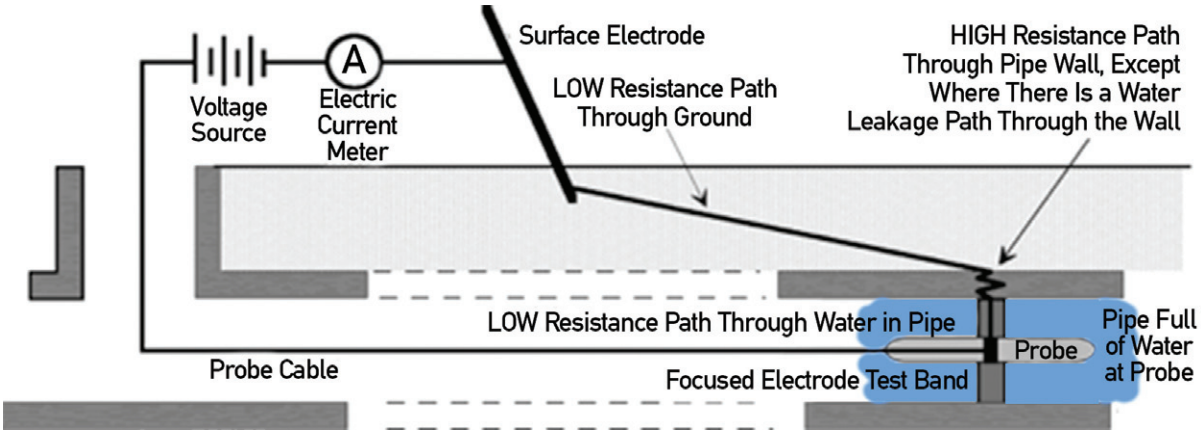


Figure 1 - Electrical Schematic of electro-scanning - Courtesy of Electro Scan Inc

Historically CCTV survey has been very poor at identifying points of water ingress and so a 21st century appraisal and analytical location tool, and definitive method of leak detection for gravity sewers was required, which was not dependant on water table elevation due to seasonal rainfall.

System evolution

The WECS RT was aware of the Seba Fell 41 system which had developed over the ten years up to 2011, and had observed early success across various municipalities in the United States. It had developed to a stage whereby it was granted its own American ASTM standard (comparable to a BS standard) entitled ASTM F2550 06 *'Standard practice for locating leaks in sewer pipes using the variation of electrical current flow through the pipe wall'.*

The system has undergone a quantum leap in improvement and evolution since being acquired by CEO Chuck Hansen of Electro Scan, Inc. Sacramento, California, who collaborates in this paper.

The American sewer diameters vary slightly in diameter, where they have constructed predominantly 8" or 200mm sewers rather than the British 9" or 225mm. That may not sound a huge difference, but when Hansen produced a 225mm version of the sewer transmitter for Wessex Water's trials at Newton Tony, Wiltshire in February 2013, it opened up, for the first time in the UK, the possibility of cost effective and accurate leak mapping of sewers.

Electro Scan: the process

Most sewer pipe materials such as clay, plastic, concrete, reinforced concrete, resin linings, and brick are poor conductors of electrical current. As a result, if a defect exists in the wall of a pipe, then the leakage of electrical current will indicate the source of a potential water leak, whether or not water infiltration or exfiltration actually occurs at the time of the Electro Scan.

Electro-scanning is carried out by applying an electrical potential (voltage) between an electrode (probe) in an electrically nonconductive pipe and an electrode on the surface, which is usually a metal stake pushed into the ground. A simplified electrical circuit for this procedure is shown in Figure 1 (top). The water in the pipe is at a level that ensures that the pipe is full at the probe location. Provided electrical current is prevented from flowing along the inside of the pipe, the electrical resistance of the current path between the probe in the pipe and the ground stake is very low except through the electrically non-conductive pipe wall.

In contrast, the high electrical resistance of a pipe wall allows only a very small electrical current to flow between the two electrodes unless there is a defect in the pipe such as a crack, defective joint or faulty service connection. The greater the electric current flow through the defect in the wall of the pipe, the larger the size of the defect.

Electro-scanning is carried out by pulling the probe through the pipe at a speed of 10m/minute and measuring the variation of electric current flowing between the probe and the fixed electrode on the surface. When the probe is close to a pipe defect the electric current increases because the defect decreases the electrical resistance of the pipe wall. The probe is designed to measure only that electric current which flows through a circular test band around the pipe wall. The test band is about 30mm wide and located at the middle of the probe.

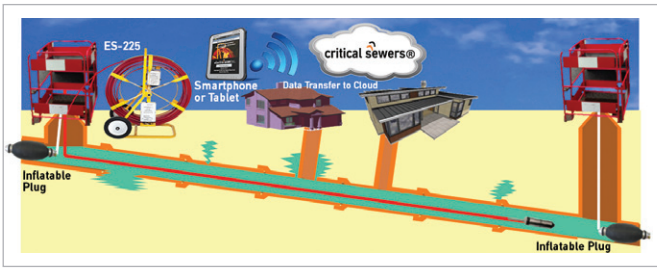
As the probe is pulled through the pipe the electric current flow and the position of the probe in the pipe are recorded and displayed in real time as a 'current trace' via a Bluetooth connection to a Smartphone computer, with data sent to the Cloud (See Figure 2 below).

When the middle of the probe is within 20 to 30mm of a defect in the pipe wall the electric current through the pipe wall increases, attaining a maximum value when the center of the probe is radially aligned with the defect.

Regions on the current trace, where the probe electrode current levels are above a threshold level, are defects in the wall of the pipe. The location and length of a defect indicates the location and longitudinal length of a defect along the pipe. The maximum current level of the anomaly is a measure of the amount of current flow through the defect and is related to the size of the defect.

Combe Florey Trials on Exmoor, Somerset

Wessex Water in partnership with Electro Scan, surveyed 1.5km of 150mm/225mm sewers known to be subject to considerable



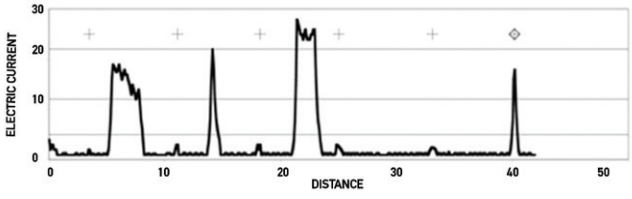


Figure 2. Electro Scan Testing and Current Trace - Courtesy of Electro Scan Inc

infiltration, in the villages of Newton Tony, Combe Florey and Cerne Abbas in February 2013.

The sewers in Newton Tony were surcharged after considerable rainfall, which showed a benefit of Electro Scan, as it has to be performed under water and so there were no delays, whereas the CCTV verification had to follow on later. The results can be seen below.

The base line is set at 100 and results below that are discounted. You will note two longitudinal cracks at around 5m downstream are elevated at over 700, and the area under the curve gave a quantitive cumulative infiltration flow for this section of pipe of 66l/minute.

The trials at Combe Florey included undertaking the full survey with Electro Scan twice on consecutive days. This would allow us to compare the two graphs by over lay, which shows the system to be accurate and repeatable. Slight variations occur due to difference in speed of transducer transient pull through and slight reduction in the external water pressures and flows.

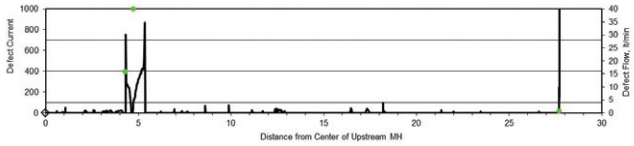


Fig 3. Typical Electro Scan trace for Combe Florey - Courtesy of Electro Scan Inc

At the time of writing WECS RT is establishing a process of drilling standpipes into the ground, to data log water tables, correlated to flow monitors and rain gauges, to match against the Electro Scan outputs of groundwater infiltration. From this the existing algorithms can be refined.

The Village of Mark, Somerset

The Electro Scan was successful when used on the section S105A sewers in the village of Mark, Somerset, where flows are transferred to a vacuum sewerage system, which had reduced serviceability due to groundwater inundation (extracts from the Mark, Somerset trials are shown in Fig 4 below).

Some 43 sewer laterals were identified as the most critical assets with a cumulative infiltration of 12 l/s, under a head of some 600mm of groundwater over pipe soffits, giving over 1,000m^3 of infiltration a day. The Opex cost of dealing with this groundwater would be in the region of £120K per annum.

Capital schemes to prevent the infiltration discovered, included epoxy 'seal lining' which has been very successful, and post Electro Scan surveys of the cured in place linings confirms they are effective.

But lining is not the only answer; in the process of utilising Electro Scan, the team developed a method of sealing a difficult knuckle bend under Cerne Abbas High Street, temporarily sealing the sewer with a heavy duty calibration hose under pressure, whilst rake drilling across the road to inject a foaming hydrophobic structural polyurethane to seal the bend from outside.

This prevented a £2k road closure for the day, and was economic, sustainable and customer friendly.

Upstream Services begins electro-scanning line in Combe Florey Courtesy of Electro Scan Inc

Conclusion

The comparison of the Electro Scan survey and the CCTV survey has produced the following conclusions.

Advantages:

- Electro Scan identifies locations where infiltration can occur, rather than defect locations, therefore it is less subjective when identifying infiltration locations; even the most insipient cracks, which the human eye would miss, can be identified.
- The Electro Scan survey covered significantly more metreage than CCTV at around 1,200m a day in comparison with CCTV which covers approximately 500m per day.
- There were no survey abandonments caused by debris, unlike CCTV.
- Electro Scan can be used within an already surcharged sewer, making timing of surveys less critical in locations where there is significant infiltration such as tidal zones and areas with high water tables.
- Electro Scan assesses a lateral connection as well as the main sewer.
- Data is available as it is upload to the cloud.

Disadvantages: Few disadvantages are evident, other than close scrutiny which should be taken to ensure premature initiation of spills at CSO's does not occur due to the temporary surcharging of the sewer during survey.

It is concluded that Electro Scan could be used at a preliminary stage of sewer system assessment prior to CCTV surveys. This would enable a more targeted CCTV survey, only used where significant defects are found, reducing unnecessary cleaning of sewers. For the future, the WECS RT and Electro Scan are developing other tools with the assistance of an internationally recognised university, which will allow the mapping and risk analysis categorisation of non-metallic pipes which have suffered diminution of wall thickness due to erosion and chemical attack.

The Editor & Publishers would like to thank Julian Britton, Rehabilitation Manager with WECS, Wessex Water, and Chuck Hansen, CEO Electro Scan Inc, for providing the above article for publication.

Summary List of Electroscan Data

					Pipe Details			Analysis_defect_grade				
Scan No	Scan ID	Date	From	To	Length of Scan (m)	Dia (mm)	Material	None	Large	Medium	Small	Litres per second
1	sww1_0151_nov72013104703am	11/07/2013	MH02	6001	19.37	100	VC		3			0.4
2	sww1_0152_nov72013112528am	11/07/2013	MH04	MH03	11.84	100	PF				10	0.1
3	sww1_0153_nov72013113129am	11/07/2013	MH04	6901	9.36	100	VC		5		1	0.25
4	sww1_0154_nov72013120947pm	11/07/2013	MH05	6901	5.72	100	VC			1	2	0.05
5	sww1_0155_nov7201313641pm	11/07/2013	MH08	4701	13.64	100	VC		4	1	7	0.5

Figure 4. An extract from part of the Electro Scan results from Mark, Somerset - Courtesy of Electro Scan Inc