Aqualiner

a new process for the lining of water and sewer pipes

by
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The Aqualiner process is different from traditional 'Cured in Place Pipeline' (CIPP) systems as it does not use chemical based liquid resins such as polyester, epoxy or polyurethane's. An integral part of the Aqualiner material is a thermoplastic fibre which makes up around 50% of the composite. The material that arrives on site for installation contains both glass fibres, for stiffness and strength, and thermoplastic polymer fibres that becomes the matrix that surrounds the reinforcing fibres after processing. This means that there is effectively no shelf life on the material and few concerns about toxicity.

Inversion drum preparation

Inversion bag and heater pig

Inversion into sewer

Site trials: Wellington, England 2008

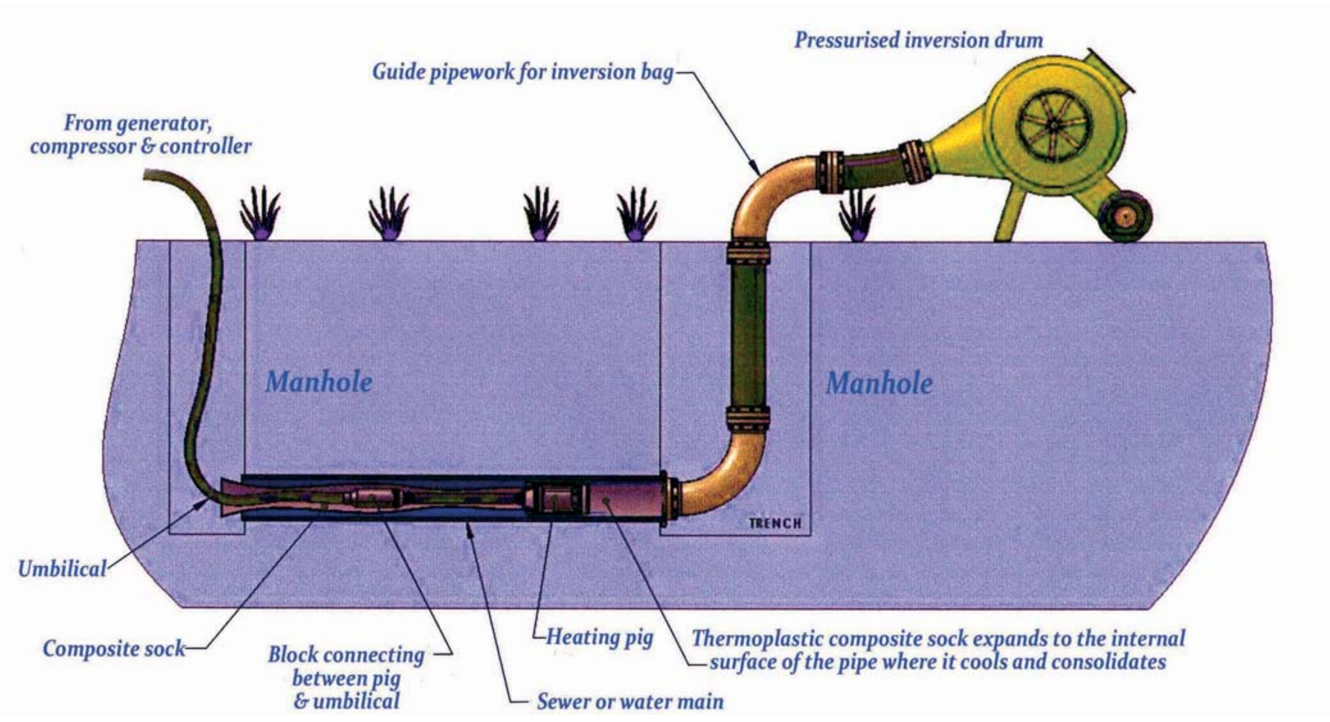
Finished liner

Courtesy of Wessex Engineering and Construction Services

Typical CIPP systems, sometimes referred to as 'softlining', use thermosetting resins such as polyester and epoxy. Thermoset materials are characterised as materials that permanently change their state. Liquid resins undergo a chemical reaction that changes the resin into a solid material, commonly called 'cure'. The process is accompanied by volume shrinkage and thermal stress. Thermoplastics are not like thermosets, and heating will cause the material to melt, and cooling the material causes it to solidify. This is a reversible process and can be repeated. A new term has therefore been derived, known as Melt in Place Pipeline (MIPP).

The material used in the Aqualiner process is a mixture of polypropylene (PP) fibres and glass fibres that are intimately mixed. When heated, the PP fibres melt and flow around the glass fibres to form the finished composite.

The PP is held at a temperature 220°C for a period of approximately one minute. After melting the PP, a consolidation pressure is required to force the PP around the glass fibres. This pressure is between 1 - 3 bar. The higher the pressure and temperature the better the material can consolidate. The key to a successful process is tight control of temperature and a uniform heating throughout the material.



Schematic of the Aqualiner process *Courtesy of Wessex Engineering and Construction Services*

The Aqualiner process and equipment
Aqualiner has developed a set of bespoke equipment (see above). The essential elements of the process are:

1. Heating pig
2. Temperature controller
3. Compressor (for heating air and inversion drum)
4. Generator (provides electrical power for heaters)
5. Thermoplastic composite sock
6. Inversion drum
7. Inversion bag
8. Umbilical (provision for air, electrical power cables and temperature sensors)

The process is as follows: compressed air (7 bar and 200cfm) is fed down the umbilical. The air enters the heating pig where on board heaters raise the temperature of the air to approximately 200°C. The temperature is controlled by the heaters using a PID loop and held within 2°C of the set temperature.

The inversion drum is pressurised at up to 3 bar and the inversion bag is let out at a controlled rate. The pressurised inversion bag both pushes the heating pig along the pipe and consolidates the material to the internal periphery of the pipe.

As the inversion bag pushes the pig along the pipe, the heating zone on the material progresses along the pipe. This means that even though the material is heated to a relatively high temperature, the residence time at that temperature is only in the order of 1 minute. So even though the temperature is high, the short duration means that there is minimal heat input into the surrounding area.

The heating pig is a robust configuration with no moving parts, designed to heat the material away from the outside of the pipe, which means that the material heating is unaffected by the pipe material or external environment.

Trials and Testing
A number of trials have been carried out in the field by Onsite, Wessex Water's framework contractor in Wellington, Somerset, and the tripartite relationship of client, designer and contractor has steered the process development to provide a user friendly and robust lining process that can withstand the rigours of field use.

Underground trials of up to 35m in length have been successfully carried out. There is conceptually no limit on the length of the lining that can be made, since the material is heated whilst moving along the length of the pipe. Also, initial developments have concentrated on the diameters DN200 to DN250 since this is a major segment of the water distribution market. Developments are underway to offer larger and smaller diameter linings for water trunk mains.

Mechanical properties of trial samples have been measured. Bending stiffness (i.e. flexural modulus) of up to 13,000Nm-2 is typical, depending upon materials used. Potable water approval is also underway for the American standard NSF61 and UK DWI Regulation 31. Sewer approvals using WRc Approved process are also underway.

Environmental Impact
Aqualiner has a low overall energy burden leading to very low environmental impact and reduced construction time which mitigates against socio economic costs.

Wessex Water's Critical Sewers Team have been able to calculate their 'Carbon Footprint' based upon the calculator developed by Dr Mark Knight of Waterloo University, Canada in conjunction with the North American Society of Trenchless Technology. Taking a single tranche of work in Redland, Bristol, over the months January to March 2008, the comparison of carbon derived from traditional open cut excavation and CIPP was compared. The results can be seen in Appendix 1 (see next page).

In the Redland example, had the 1050m of sewer been replaced by open cut the resultant carbon generated would have been some 2776 tonnes, but the figure generated in reality was a much reduced 79 tonnes as the sewers were lined with hot cure softlining. In relation to Aqualiner, the rate of 'cure' or lining installation would be much faster, meaning that all works could be carried out and completed between rush hours, avoiding the element of carbon generated by waiting traffic. It is anticipated that if this was the case the sum of 79 tonnes could drop to a lower figure which will be identified in due course.

APPENDIX 1: C9303 Bristol Redland Phase 1 - Carbon Footprint : Traditional Open Cut v Hot water 'Cure' Softlining

							Carbon Emissions						
Site	Length	Size	Depth (IL)	Bedding	Traffic	Time	Traffic	Trucks	Machines	Material	Total	CIPP	Saving
	(m)	(mm)	(m)	(mm)	Vol	(days)	(t)	(t)	(t)	(t)	(t)	(t)	(t)
1	94	450	2.5	750	1000	70	19.98	5.93	5.01	6.02	36.94	0.74	36.2
61	70	750	3.2	1000	10000	75	318.46	6.64	3.73	6.43	335.26	6.7	328.55
2	72	750	3.5	1000	10000	80	339.7	7.3	3.8	6.97	357.8	7.16	350.65
252	82	750	4.7	1000	10000	95	403.38	10.36	4.37	9.55	427.93	8.56	419.37
258/259	108	750	5.5	1000	1000	105	29.96	15.81	5.75	14	65.53	6.55	58.97
124	46	750	3.4	1000	15000	55	1046.63	4.66	2.45	4.38	1058.12	21.16	1036.96
54	145	750	2.6	1000	500	165	40.53	11.79	7.73	11.9	71.94	1.44	70.5
171	43	450	2.5	750	1000	60	17.12	2.69	2.29	2.75	24.85	0.5	24.36
172	41	525	2.5	825	1000	60	17.12	2.76	2.18	2.8	24.87	0.5	24.37
133	47	450	2.85	750	500	65	15.96	3.32	2.5	3.23	25.02	0.5	24.52
418	46	450	2.3	750	500	60	14.74	2.8	2.45	2.82	22.81	0.46	22.36
419	53	450	2.5	750	500	70	17.2	3.39	2.82	3.4	26.81	0.54	26.27
305	32	450	1.8	750	10000	40	169.84	1.64	0.78	1.76	174.02	17.4	156.62
328	45	300	5	600	500	80	19.65	4.18	2.4	3.8	30.02	6	29.4
330	38	450	1.4	750	500	40	9.82	1.57	0.93	1.81	14.13	0.28	13.84
256/57	67	750	5.5	1000	1000	120	34.24	9.85	3.57	8.68	56.34	1.13	55.22
210	30	45	1.5	750	1000	35	9.99	1.42	0.73	1.53	13.66	0.27	13.39
Total	**1059 m**									**Totals**	**2766.05**	**79.89**	**2691.55**

Key

Total CO_2 omission based upon traditional open cut techniques in tonnes

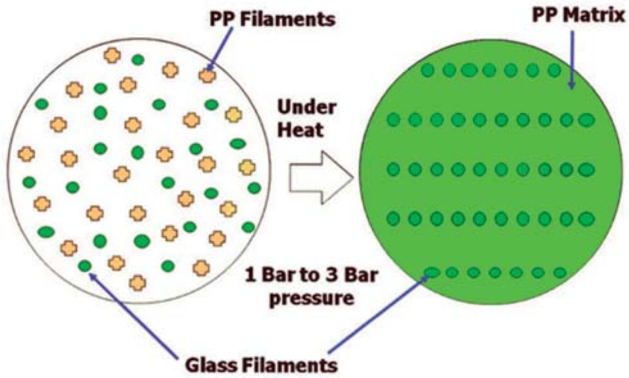
Total CO_2 omissions based upon hot water 'cure' softlining

Summary

Aqualiner offers the following benefits:

- Trenchless - no major excavations required.
- Simple - no complicated storing and mixing of chemicals.
- Long shelf life - no liquid resins mean that there are no shelf life concerns.
- Potable (no harmful chemicals to leach out of the liner).
- High strength (a structural liner that can withstand mains water pressure - 10 bar).
- Thin liner - good hydraulic conductivity.
- Sustainability - low carbon footprint .
- Low socio-economic costs - low energy consumption and short lining times.

Aqualiner was awarded the worldwide 'Rehabilitation Innovation' prize by the International Society of Trenchless Technology at their annual conference in Toronto, Canada in April 2009. this was in recognition not only for the ingenuity, but for the potential for worldwide commercial possibilities it brings to sewer and water main renovation.



Construction of a bundle of fibres *Courtesy of Wessex Engineering and Construction Services*

Notes: ***The Editor & Publishers thank Julian Britton, Senior Engineer, Critical Sewers Team with Wessex Engineering and Construction Services, for providing the above article.*** ■