CONDITION EVALUATION OF IRON WATER MAINS - NON-DESTRUCTIVE TESTING FOR THE WATER INDUSTRY

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Cast and ductile iron water mains around the world are subject to graphitization which weakens the pipe wall and leads to leaks and breaks.

The water (and sewer) industry has been searching for a non-destructive method of inspecting the pipes, *in situe*, in order to determine where the breaks are likely to occur, and to assess the overall condition of the buried asset.

Engineering decision makers need precise condition information in order to make repair, replace, rehabilitate choices.

A new non-destructive testing system, the **Hydroscope 201**, is described. This new system offers complete information on the remaining wall-thickness of the pipeline over long lengths with minimal disruption of service.

HISTORY:

* Discovered, 1940's
* Developed for oil well inspections, 1950's
* Applied to heat exchanger tubes, 1980's
* Boiler tubes, 1990
* Pipelines, 1991
* Water mains, 1992

The Remote Field Eddy Current technique was discovered by Shell Development Researcher W. MacLean, and was patented in the 1940's. Early applications of the technique were for the inspection of oil-well casings to detect cracks and corrosion pits. The early tools were analog based, and gave information which was inferior to magnetic flux leakage tools.
Developments in computerization and mass data storage over the last decade have allowed development of digital systems which can measure the RFEC signals more precisely and display the data in color maps which are intuitive to interpret. The massive amounts of data gathered by

the new tools are stored on magnetic media for archiving and instant retrieval.

The first commercial RFEC system using the new technology was developed by Russell Technologies Inc. and first applied to the inspection of heat exchanger tubes in 1986. The Ferroscope System has evolved to a Mark-3 model and is now used to inspect boiler tubes and pipe sections. The patented Hydroscope System evolved from the Ferroscope.

DEVELOPMENT:

* AWWARF project 1991
* Evaluated state of the art NDT techniques
* Recommended RFEC for cast & ductile
* Prototype Tool: Russell Technologies Inc.
* Tested in Canada, Australia and U.K.
* Available for U.S. market 1997

The American Water Works Research Foundation commissioned a study in 1991 to evaluate non-destructive testing techniques which might be applied to the inspection of cast-iron and ductile iron pipes.

The study concluded that the Russell RFEC technique held the most promise, and recommended that a system be developed. Russell developed a prototype tool which was first field tested in 1992.

The System underwent several improvements, including the addition of automatic pattern recognition software, and was field tested on three continents between 1994 and 1996.

The first commercial tool was delivered to an Australian licensee in November 1995 and has been in use since then in 6-inch and 8-inch pipelines.

TRADITIONAL CONDITION ASSESSMENT:

- Pipe age
- Break frequency
- Soil resistivity
- Spot testing (sample removal)
- Multivariate modeling
- Direct measurement

The traditional method of replacing aging Water mains is by age or break frequency. Owners who have observed the condition of the pipes during removal have noted that the condition varies from heavy pitting and holes to "no visible degradation". Corrosion tends to be localized, and is mainly caused by galvanic cells which allow one area of the pipe to become anodic while another is cathodic. Corrosion occurs wherever the pipe is anodic.

Soil resistivity measurements can indicate where soils contain high electrolyte levels. Electrolyte allows electric currents to flow more freely and accelerates corrosion.

Engineers have performed direct measurements on pipes through sample removal and/or spot NDT tests from the outside of a flowing main. These tests, while useful, are ineffective in determining overall pipe condition due to the random location of pitting.

Pipes can be protected through cathodic protection or coating the pipeline during construction, however, most pipes were buried unprotected, and remedial protection is often cost-prohibitive.

WHY USE NDT?

- Avoid costly reactive repairs
- Evaluate condition of asset (valuation)
- Knowledge-based engineering decisions
- Proactive asset management
- Avoid wastage of treated water, erosion
- Avoid third party liability
- Find and repair leaks before they happen

NDT offers the means to inspect long lengths of pipeline to determine overall condition and to locate local areas of severe degradation. Owners who have to determine whether to replace a pipe or to install a liner, need an accurate condition assessment. There's no point in lining a pipeline which is structurally unsound for most of its length. Conversely, it is more cost-effective to extend the life of a pipeline which is in relatively good condition but which has a few areas where local repairs are needed.

Costs of replacing pipe can be as high as US $150/foot (for 6-inch pipe) in busy downtown areas. Peripheral costs of traffic and business disruption can increase the total bill significantly.

Third party liability costs for flooded premises and disrupted service due to leaks are rising in pace with the leak frequency.

Water system owners are under increasing pressure to reduce leaks and increase dependability of supply. Many owners spend more than 8% of their income on water lost due to pipe breaks.

FEATURES

- Non-contact
- Tests through scale and linings
- Fast: 20 feet/min
- Thorough: 100% examination of pipe wall
- Efficient: 3300 feet tested in 4 to 6 hours
- Non-disruptive: can test in live lines
- Easy access: (for 6-inch lines) through hydrants

The RFEC technique uses electro-magnetic energy which does not require intimate contact with the pipe wall. Unlike ultra-sonic and magnetic flux leakage techniques, RFEC can tolerate up to 1-inch of internal scale in the pipe and still obtain good quality data.

Removal of scale can result in "red water" problems which may continue for months, so any technique which allows inspection without removal of all of the scale offers tremendous advantages.

RFEC is a fast technique: 1000 foot lengths can easily be inspected in two hours, and can be inspected "on-line". The technique measures remaining wall-thickness, whether the corrosion takes place from the outside or the pipe bore. It has equal sensitivity to both.

The tool head is designed to go around multiple bends and 90 degree elbows so that it can be introduced into the pipeline through hydrants. The set-up time is minimal (20 minutes) and the inspection proceeds at 20 feet/minute.

MORE FEATURES

- Equally sensitive to internal & external loss
- Extensive cleaning not necessary
- Use water flow to drive tool or ... tow through with tag line
- Detects graphitization, piffing, erosion, cracks
- Accurate odometer to locate thin areas for repair
- Report ready within hours

The Hydroscope Tool may be pulled through the pipeline with a tag line (a thin steel cable); therefore the line may be tested under pressure or "dry" (as may be the case just prior to a lining operation).

An onboard odometer measures the distance from the launch hydrant accurately, and an above ground sensor can tell within 12 inches the exact location of the tool. This is used to mark the "zero" position from which all measurements are taken.

The data is frilly analyzed overnight, and an instant overview can be given within an hour after the inspection run if required.

Breaks in the line are detected easily, and prior repairs (where clamps have been installed, or a piece of plastic pipe used) are identified quickly and accurately.

HYDRANT ACCESS

- Clean section with soft foam pigs
- Isolate section and remove hydrant & valve

- Install Hydroscope Hydrant
- Hook up hoses to upstream hydrant
- Insert Hydroscope 6-inch Tool
- Tool is pushed to far end with water flow
- Tool is retrieved by wireline winch

The owner will generally perform the cleaning operation. A series of soft foam pigs are introduced into the launch hydrant and flowed to the receive hydrant with water pressure. These pigs are designed to remove only the loose tuberdes and any debris in the pipe, not to clean down to bare metal.

Once the pigs are flowing through easily the Hydroscope Tool may be used. A "dummy hydrant" is used to replace the launch hydrant, and the Tool is forced through the pipe section with water pressure. Once reaching the target distance, the water is shut off and the Tool is retrieved by means of the wireline winch.

Data is gathered in both directions to assure that nothing is missed.

DATA GATHERING

- Data may be gathered in each direction
- Above ground sensing for "zero" marking
- Valves, spigots, tees, branches identifiable
- Continuous wall-thickness graph
- General and localized thinning detected
- Storage on above ground computer H.D.
- Long term data storage on CD-Rom

Features such as tees, elbows, branches, repairs and spigot joints all give distinctive signals which are easily recognizable by a trained operator. Some of these features are recognized automatically by the HYD-ADEPT software (spigot signals in particular). The software automatically calculates variations in wall-thickness and presents the results in a colour map and spreadsheet which is GIS-compatible.

The data is stored initially on the above-ground computer hard drive and is later transferred to CD-Rom or floppy-disks for archiving.

DATA ANALYSIS AND REPORT:

- Automatic thickness determination Over-ride by skilled technician
- Spreadsheet, colour maps, histogram
- Line length vs. thickness
- GIS-compatible format (mid-1997)
- Risk model, (mid-1998)

- Soil analysis comparison model (mid-1998)

The computer calculations ofthickness variations may be over-ruled by a skilled technician.

Histograms are also used to quickly show the distribution of thinned areas, and a risk analysis model is under development to add value to the data presented.

FIELD EXPERIENCE:

- City of Edmonton, 1994, 1995, 1996
- Cities of Sydney & Adelaide, 1995, 1996
- Five U.K. water authorities, 1995, 1996
- Five Cities in Quebec, 1995, 1996
- NRC evaluation, 1996
- Over 50,000, tested to date
- 80%+ accuracy confirmed

Hydroscope Inc. has developed a strategic partnership with the City of Edmonton whereby the City has tested the Hydroscope Tool in ten sections of pipeline. The pipe was subsequently removed, sandblasted and visual comparisons have been made to determine the reliability and accuracy of the data.

The following water authorities in England and Wales have also tested the System: Thames Water, Severn Trent, Welsh Water, North-West Water and Northumbrian Water. Thames Water has excavated a section of pipe and has confirmed the Hydroscope results.

In Australia, Sydney Water and South Australia Water have used the System extensively. In many cases the pipes have been excavated and examined visually.

The National Research Council of Canada has also performed an independent evaluation ofthe Hydroscope, as have five cities in the Province of Quebec.

WHAT'S IN STORE?

- 6-inch and 8-inch available now
- Southwest USA, Canada, Australia 10-inch & 12-inch by mid-1997
- 14-inch to 20-inch by mid-1998

Future plans are for larger-sized tools with additional capabilities. These would be launched through temporary TEES installed in the line.

There is theoretically no limit to the size ofpipeline inspectable, although power consumption and speed ofinspection become challenging in wall thicknesses over 1-inch.

WHO ARE YOU GONNA CALL?

- In Canada: Hydroscope Inc. (403) 469-4461
- In USA: Hydroscope Inc. (USA) (505) 344-7719
- In Australia: Tubemakers of Australia, Sydney

The Hydroscope System is a patented device available only through Hydroscope Inc. in Canada and the USA.

Potential marketing partners (licensees orj oint ventures) are invited to contact the author in Canada.