RUSSELL
NDE SYSTEMS

Remote Field In-Line Inspection Technology for Water And Waste Water Mains

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Remote Field Technology

For Water and Waste Water Infrastructure Assessment

Introduction

Remote Field Technology (RFT) Tools have been used for the condition evaluation of cast iron, ductile iron and steel pipelines for more than ten years. They are particularly useful for evaluating pipelines which cannot be inspected by traditional Ultrasonic (U.T.) or Magnetic Flux Leakage (MFL) Tools.

Examples of pipelines that cannot be inspected by traditional tools are:

- Pipelines with internal encrustations (e.g. distribution pipes in hard water service)
- Pipelines with tight elbows, Tees and possible diameter changes
- Pipelines with internal liners (cement, HDPE, PE etc.)
- Riveted lines
- Cast/ductile iron lines due to nodularity of the material
- Low-flow pipelines which have low differential pressure.

Evaluation of the above pipelines can be accomplished with RFT Tools.

RFT (Remote Field Technology) is not new. It was first patented in the 1940's, and was applied to the evaluation of down-hole casings and tubings. Later, it was extensively adopted for carbon steel heat exchanger tubing inspection, followed by evaluation of cast iron water mains, deep water well steel casings, concrete pressure pipe, oil and gas (steel) pipelines and more recently waste water pipelines.

The technology is recognized by many code and standards bodies such as:

- The American Society of Mechanical Engineering (ASME section V)
- The American Society for Testing of Materials (ASTM)
- The American Society for Nondestructive Testing (ASNT)
- The Electric Power Research Institute (EPRI)
- The Chinese Electric Power Research Institute (Ch-EPRI)
- The American Water Works Association research Foundation

The RFT technique has the advantage that it is a “through transmission” technique, and therefore is not sensitive to the proximity of the exciting and sensing coils to the pipe material. Hence its ability to detect wall-loss defects at (sensor lift-off) distances of up to 1.5”.
Russell NDE Systems Inc. (RNSI) is well known for its leadership in applying RFT to many industries. While primarily a designer/manufacturer of RFT instrumentation, RNSI has also performed inspection services using the specialized RFT tools it designs and manufactures. One service in particular is for the evaluation of water and waste water pipelines.

Tools available at the moment are to fit the following pipe sizes:

- 4” (100mm) free swimming
- 6” (150mm) both free swimming and tethered
- 8” (200mm) tethered
- 12” (300mm) both free swimming and tethered
- 15”-16” tethered
- 22”-24”-26” currently being manufactured as a free swimming Tool.
- 78” large diameter tool for raw water pipelines (requires draining the line)

With the exception of the 78” Tool, all Tools can run in pressurized mains up to 300 psig.
The tethered Tools have a limited range of 1km (3300’), while the free-swimming Tools can travel up to 8 miles (12km) “with the flow”.

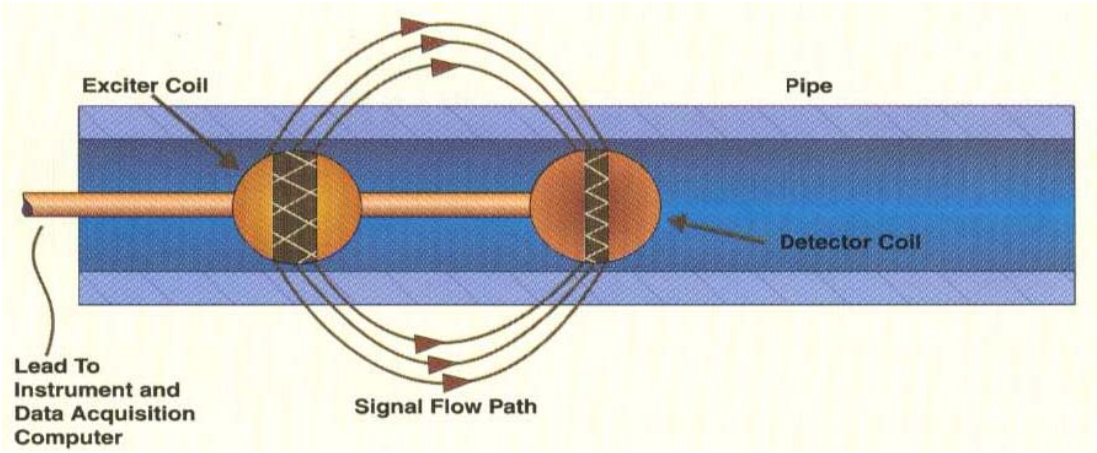
RFT Equipment for water mains

Given the presence of a possible internal liner, and the potential for corrosion if the liner is removed, it is critical that damage to an internal liner is avoided during an inspection. This is important - not just for the inspection tool but also for the delivery method (pull pig, wireline cable rubbing against the inside of the pipe, etc).

The need to prevent damage to an internal liner, and the presence of bends in combination with possible internal scaling, makes a non-contact NDE technique like RFT ideally suited for this type of application. The relatively small fill-factor of an RFT tool provides extra ID clearance and makes tight-bend negotiations less difficult. Russell NDE's latest generation of free swimming See Snake Tools are state-of-the-art, and specifically designed to provide accurate condition assessment information through internal liners and scale. Using the See Snake's results, operators will be able to determine the weak links in the line and implement a proactive maintenance plan to prevent future failures.

See Snake tool description

The Russell NDE Systems' See Snake line of RFT tools are flexible tools that employ Remote Field Technology for measuring pipe wall thickness. RFT technology works by detecting changes in an AC electromagnetic field generated by the tool. The field interacts with the metal in the encompassing pipe and becomes stronger in areas of metal loss. The field interactions are measured by on board detectors, and subsequently processed on the tool itself using A/D converters and digital processors. The processed data is stored on board. Once all the data is acquired, dedicated analysis software is applied to generate accurate information on the wall thickness of the line. Figure 1 below schematically shows the magnetic coupling path between the exciter section of the tool and the detectors.



- Figure 1. Schematic of magnetic interaction between RFT tool and Pipe

The See Snake tool employs an articulated mechanical design, which gives it its flexibility to negotiate 90-degree elbows. The hard diameter of the tool is significantly smaller than the ID of the pipe to allow for protrusions, lining and scale. Centralizers maintain a uniform annulus between the tool and the pipe.

The tool detects wall thinning caused by corrosion or erosion, as well as line features such as joint couplings, branches and elbows. The range is limited by battery power, which is adjustable by adding extra battery packs (and length) to the tool.

The complete system used to perform a waterline inspection includes the following equipment:

» Waterline See Snake RFT tool with data download USB box.
» Custom-design flexible polyurethane pull pigs to pull the tool to distance.
» Disinfecting chlorine solutions.
» Launch barrel & receive barrel.
» Flow control (either through valving or pumper truck).
» Laptop with wireless capability.
» Above ground tracking equipment.
» Data download and viewing software.

Inspection Procedure

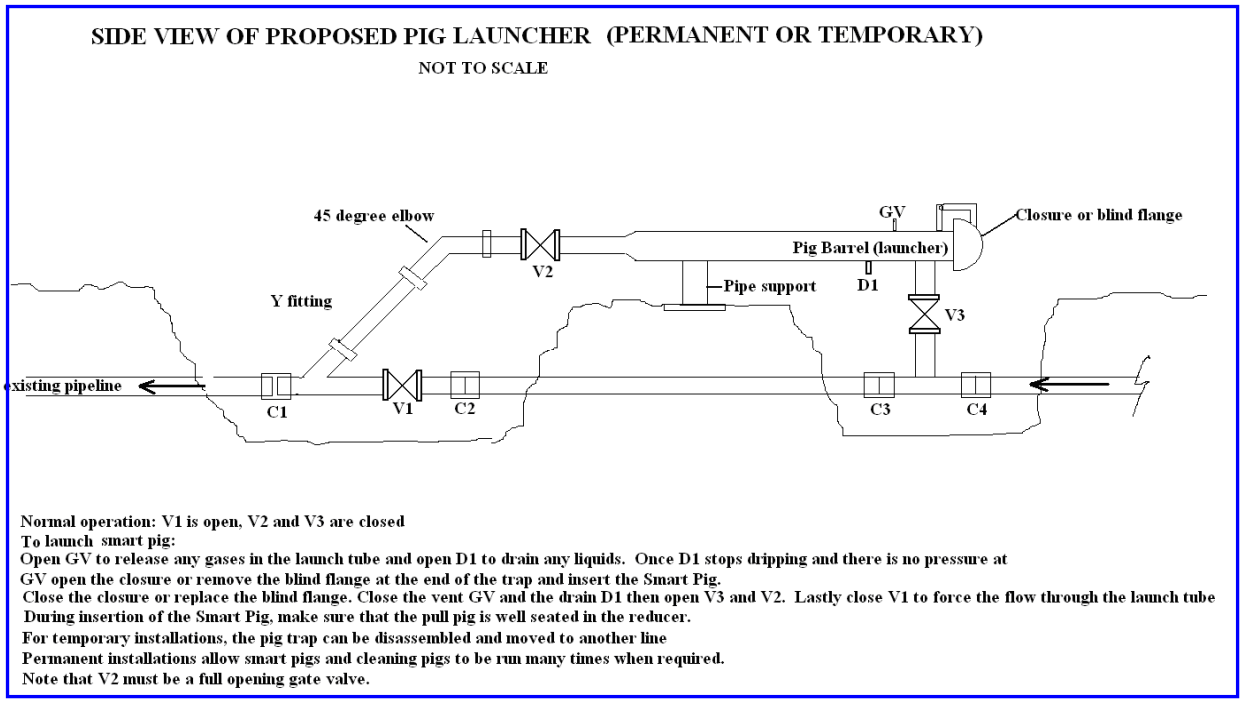
On the day of the inspection our employees will hold a “Tailgate Safety and Operations” meeting to discuss potential site/operations hazards as well as the procedure for the inspection. During the tailgate we would normally ask to see the pigs that were run through the pipe as part of the cleaning and gauging process.

When all launch equipment is in place and the tools have been sprayed with a sanitizing chlorine solution, the RFT tool will be powered up outside the pipe to confirm proper operation. Correct tool operation is confirmed through a wireless link. Tools are thoroughly cleaned and soaked in a 5% chlorine solution between jobs and are sprayed down again just prior to insertion.

• Figure 2. Tool Sanitization before job

Next, the tool is loaded in an oversized launch barrel. The launch barrel is isolated from the line through valves, and has a larger diameter than the line to be inspected to facilitate insertion of the RFT tool. The following images show the tool insertion process as well as a schematic overview of the launch barrel.

• Figure 3a. Tool insertion into Launch Barrel – 3b. Closed barrel after tool insertion.



- Figure 4. Launch Barrel Sketch

Pig launchers can be permanent or temporary, and can include features such as viewing glasses, pressure gauges and a pig passage indicator. Before launch of the tool, all air must be removed from the launch chamber. This is accomplished by filling the line through inlets at the 6 o'clock position, while venting air through vents at the 12 o'clock position. Once all the air has been removed, the flow can be redirected from the main line to the launch barrel by controlling the main line valves. It is important that the flow rate is carefully monitored to ensure that the tool travels at the correct logging speed.

For buried lines, the progress (and speed) of the tool are monitored through AGMs (Above Ground Markers) that are placed above the pipeline to record the time that the Tool passed. The geographic location of the AGMs is known through the use of survey-grade GPS units. We also have Tool Tracking equipment that tracks the tool out of the launch barrel and follows the tool as enters the receive barrel.

The Tools gather and store the data on board the Tool. They are fully self-contained and can travel through the pipe without having a wireline attached. Once the tool arrives in the receive barrel (which is very similar to a launch barrel), the tool is extracted and cleaned if necessary.

The data is downloaded and the batteries charged overnight.

The downloaded data is checked for quality and the odometer data (from on-board odometers) is reviewed to ensure accurate distance information. If the data is found to pass quality checks, the files are uploaded onto our secure server (SFTP site), from where the data is downloaded in Edmonton for analysis.

Along with the data, there is a field report providing details of the run location, AGM times, weather and time of run information etc., plus any photos taken during the run. The data analyst filters the data and begins the analysis process. Normally a formal report will lag the field inspection by 2-3 months, depending on the length of the line and how many defects are to be reported.

The image below shows a simple launch setup, with pumper truck, oversized launch barrel, and access hatch. As can be seen from the image on the left, the valve isolating the launch barrel from the line is actually positioned after a 90° elbow.

- Figure 5. Launch setup using pumper truck.

- Non-contact NDT method.

RFT has the advantage that it does not require intimate contact with the pipe wall to detect changes in remaining wall thickness. Therefore, internal scale, sludge, sand and liners such as HDPE, cement mortar or clay do not interfere significantly with the operation of the Tool.

- Equally sensitive to internal and external flaws.

RFT also has the advantage that it is equally sensitive to ID or OD wall loss. In other words, it does not matter whether the wall loss (usually graphitization in cast iron pipes) is on the soil side, or the product side of the pipe: it will be detected equally well.

- Complete coverage at fast inspection speeds. RFT is faster and more complete than isolated excavations and spot measurements, which could miss localized corrosion. The maximum speed is 10m/min.

- Accurate results that identify both the severity and location of areas of wall thinning. RFT technology is well established and has been deployed on metallic pipes since the 1980s. The See Snake Tools are the latest in RFT technology and have numerous detectors covering the circumference of the pipe, providing enhanced resolution and accurate wall thickness information.

The Tool records the clock position of any wall-thinning defect that it detects. In addition, the Tool's progress is tracked above ground using "Above Ground Markers" (AGMs) at known GPS station-points. These serve as additional "weigh points" in combination with the data from the on-board odometer to increase accuracy of locating defects such as pits.

- Novel mechanical design can accommodate ID variations as well as traverse sharp bends. The Tools are able to negotiate elbows, and are completely self contained and "free swimming". That is, they have all required electronics, batteries, memory and sensors on board, and they can travel un-tethered down long lengths of pipeline.

- Compact and Transport friendly.

See Snake tools are light weight and transported easily in man-handlable shipping cases.

- There are areas of reduced sensitivity when the exciter or detector array passes areas with external metal (for example through a valve, flange or at pipe joints).

- The Tools cannot pass through plug valves or butterfly valves. Valves must provide pipe bore opening, and must be fully opened during inspection runs.

- Like other inspection tools, See Snake tools have an optimal inspection speed. The flow rate must be controlled to stay within the optimal range.

- The minimum defect detectable has a volume equal to a 2.5” diameter by 20% deep defect at normal Tool operating speeds and centralization.

- External noise sources, such as railway tracks, electric power lines, motors, welders etc. can induce noise which may mask defect signals. Active cathodic protection must be shut down during an inspection.

Company Background and Experience

Russell NDE Systems is part of the Russell Group of companies, which includes PICA Pipeline Inspection and Condition Analysis Corp, R.T.Co. Inc., Polar Projects Inc., and Russell Technologies (USA).

In 1985, Russell NDE Systems Inc. (known then as Russell Technologies Inc.) developed the first instrumentation for the inspection of carbon steel heat exchanger tubes. The equipment used a technique known as Remote Field Technology (RFT) whereby a low frequency AC field is sent from an exciter coil to a detector coil, using the pipe wall itself as a wave guide. The equipment measures the “time of flight” and signal amplitude of the received signal from which the remaining wall thickness and surface area of wall loss can be computed. The technology had great appeal due to its ability to read through internal deposits with negligible loss of accuracy.

Over the next decade, Russell NDE adapted the technology for applications such as down-hole tubular, boiler tubes and pipelines.

In the mid 1990’s Russell worked with the American Water Works association, Research Foundation, the National Research Council of Canada and the City of Edmonton to apply the technology to the inspection of cast iron water mains. A special Tool was developed that could enter the water mains (6” size) through hydrants, evading the need to excavate and cut the line for access. This Tool, known then as the Hydroscope, was patented and went on to perform long term inspection contracts for many Canadian cities.

The success of the Hydroscope Tool was instant and the company went on to develop Tools for pipe sizes 4” through 15”. The company has also received the prestigious ASTech Award for industrial innovation for two of its inventions, including the Hydroscope.

In the last decade the company has gone on to improve the Hydroscope Tool and to apply it to the inspection of oil and gas mains. The Tools are now known as “See Snakes” and “EMIT Tools” (Electro-Magnetic Inspection Technology), and have the capability to “free swim” through many kilometers of pipeline (whereas the Hydroscope Tools were wireline tethered and had a limited reach of 1 km). The resolution and accuracy of the Tools have been improved, and software has been developed to display the data in pseudo-3D.

Over the years, the company has worked with code bodies such as A.S.M.E. and A.S.T.M. to produce standard practice procedures for using RFT Tools. We have also worked with The American Society for Nondestructive Testing (A.S.N.T.) to create Classroom Training Books, the Electromagnetic Testing Handbook, and a set of guidelines under ASNT-TC-1A for training and examination criteria for operators of RFT equipment.

Russell NDE is considered the premier authority in the world for this particular technology, and is now a manufacturer of many types of Tools based on RFT and adaptations thereof. We have published widely, and have deployed our products across the world.

Over the last two years, we have performed water and wastewater inspections for numerous clients and cities in Canada and the US (recent ones include Longueil, Montreal, Calgary, Pinellas, Malibu). Our free swimming See Snake tools have performed inspections of industrial waste waster lines for the oil and gas industry, where high accuracy and reliability are critical.