

## Explorer 6/8: A Robotics System for the Inspection of 6” - 8” Unpiggable Pipelines

**Description:** A robotic platform able to: 1) operate in high pressure gas pipelines in the absence of flow, 2) negotiate commonly encountered features such as bends and mitered bends, and, 3) carry out non-destructive wall loss inspection

**Status:** The Explorer 6/8 system is commercially available through Pipetel Technologies

### **BENEFITS**

Explorer 6/8, also known as Explorer II, is a commercially available, modular, tetherless, robotic system featuring a Remote Field Eddy Current (RFEC) sensor for the non-destructive evaluation (NDE) of gas transmission and distribution pipelines in the 6” - 8” pipeline range. This technology provides the gas industry with the tool needed to meet the requirements of the 2002 USDOT/OPS ruling regarding the management of the nation’s transmission pipeline infrastructure. It allows the In-Line Inspection (ILI) of unpiggable pipelines and the generation of pipeline condition data of quality that cannot be generated by any other available technology.

### **BACKGROUND**

In early 2000, NYSEARCH initiated the development of Explorer, a visual inspection tool for distribution mains that featured a modular design that allowed the robot to negotiate bends, tees, and other obstacles within a main. The robot is self-propelled, using on-board batteries, and is tetherless due to its use of wireless communication between robot and operator for the transmission of control commands and live images from the robot’s cameras. The modular design of the system allows the future incorporation of additional capabilities that could expand its field of use. The introduction of non-destructive evaluation (NDE) tools for both transmission and distribution lines were thus possible and are the

focus of the present effort towards the development of Explorer 6/8.

### **TECHNICAL APPROACH**

NYSEARCH, with co-funding from the National Energy Technology Laboratory of the U.S. Department of Energy and the Office of Pipeline Safety of the U.S. Department of Transportation retained the Robotics Institute at Carnegie Mellon University (the developer of Explorer) to develop Explorer 6/8, a robotic



**Figure 1: The Explorer 6/8 Robotic Inspection Robot**

platform carrying a Remote Field Eddy Current (RFEC), developed by the Southwest Research Institute, for the visual and NDE characterization of gas transmission and distribution pipelines in the 6” - 8” range. Given that it is self-propelled and can negotiate mitered bends and tees, it is able to inspect pipelines that are presently unpiggable due to either low flow/

pressure or the presence of mitered bends or other obstacles (excluding plug valves). An Explorer 6/8 unit, which can operate under pressures up to 750 psig, consists of two camera modules, two drive modules, two or more battery modules, three support modules, and two sensor modules, as seen in Figure 1. The use of radio communication and rechargeable battery power has freed the robot from a power/communications tether, thus offering long ranges of operation from a single launching



Figure 2: Launching Installation

point. The two camera modules at the two ends of the robot contain the lighting and cameras (with a 190° field of view) for visual data collection. On-board wireless communication allows Explorer 6/8 to broadcast real-time color images of the pipe interior to the operator, who controls the unit's speed and direction of travel. In addition, the data collected by the sensor will be transmitted live to the operator, offering the capability of near-real time view of the NDE data. The robot is introduced into the live gas pipeline through a launch chamber, which is attached to a commercial tap-and-drill system, designed for live access to the pipe (see Figure 2).

The RFEC sensor was especially designed for Explorer 6/8, so that size does not limit Explorer's ability to operate in unpiggable pipelines. Two modules are used to deploy the sensor. One is used to store the fixed diameter excitation coil, which is driven with alternating current to produce the flow of eddy currents in

the circumferential direction in the pipe wall. Sensors placed adjacent to the pipe wall in another module measure these electric currents, which are sensitive to material-loss defects such as corrosion.

## PROGRAM STATUS

The NYSEARCH Explorer 6/8 project is closed out due to commercial transition to Pipetel Technologies Ltd. (Toronto, Canada and Buffalo, NY, USA). It is the culmination of a development effort initiated in late 2004, followed by extensive laboratory testing of the integrated platform and sensor system that was completed in early fall of 2007. The first successful field deployment took place fall of 2007 followed by additional ones through 2010. Since then, Explorer 6/8 has been used to inspect miles of unpiggable pipelines through commercial contracts with some of the major unpiggable pipeline owners in the U.S.

### Highlights

#### General metal loss detection capabilities

- Minimum anomaly size: 20% wall loss with a diameter of 3x pipe wall thickness
- Anomaly axial length sizing accuracy:  $\pm 0.5$  inches with 75% confidence
- Anomaly depth sizing accuracy:  $\pm 20\%$  pipe wall thickness with 75% confidence

#### Driveability

- Locomotes through mitered bends, back-to-back 90s, verticals and branch connections
- Inspects long distances with wireless communications

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