SmartBall® Gas Leak Inspection

EnCana – Severn to Crowfoot Pipeline

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Executive Summary

EnCana partnered with Pure Technologies (Pure) to conduct a series of trial inspections of their Severn to Crowfoot 6-inch gas transmission pipeline. The trial inspections were intended to further test Pure's natural gas leak detection platform, Smartball™. This particular pipeline had already been successfully inspected twice in the past. The new inspections were intended to quantify the leak detection resolution of the Smartball tool, specifically determining the smallest detectable leak under normal pipeline operating conditions. 4 separate inspections were conducted with a simulated leak created at a midpoint riser location. The simulated leaks were created at progressively smaller leak rates. The intention was to determine the relationship between leak rate and the acoustic energy of the leak as recorded by the Smartball tool as it passed by the leak location. The resulting logarithmic curve can be used to extrapolate a theoretical lower leak detection threshold for specific flow/pressure parameters, making the EnCana inspections an invaluable asset in the continuing development of the Smartball tool for natural gas applications.

The Severn to Crowfoot line is a 6 inch steel pipeline that transports natural gas from the Severn Compressor Station to the Crowfoot Gas Plant for dehydration prior to returning to the Severn plant and on to sales.

During the four (4) surveys conducted, the SmartBall device was inserted into the pipeline through a standard pig launcher and released into the flow of the pipeline. It traversed the pipeline with the gas flow and in so doing acquired acoustic and positional data. The tool was subsequently extracted through a standard pig receiver fitted with a strainer to prevent passage of the tool through the kicker line. This data was evaluated to identify the acoustic activity associated with leakage.

During the evaluation of the data of all four inspections, Pure conclusively detected 3 acoustic anomalies that resembled leaks in the line. The survey and the results are summarized in Table 1.1.

Table 1.1

Summary of SmartBall Survey Results

Pipeline Details	
Total Length of Pipe Surveyed:	26000.0 m
Pipe Material:	Steel
Diameter of Pipe:	150 mm
Product:	Natural Gas

SmartBall Survey Results	
No. of Leaks Detected	3 (82.4 LPM, 45 LPM, 22 LPM)
Duration of Survey	5 hours, 7 minutes (each)
Average SmartBall Velocity	1.4m/s

1) Inspection Summary:

1.1 Background:

The Severn to Crowfoot line is a 6 inch steel pipeline that transports natural gas from the Severn Compressor Station to the Crowfoot Gas Plant for dehydration prior to returning to the Severn plant and on to sales. Flow rates throughout the data were in the 218,000 standard cubic meters per day range. However, maintenance to a booster pump later in the day required a temporary drop in rate. Pressure on the line averaged 55 Bar.

The approximate line location is displayed in green below in Figure 1.1.1.

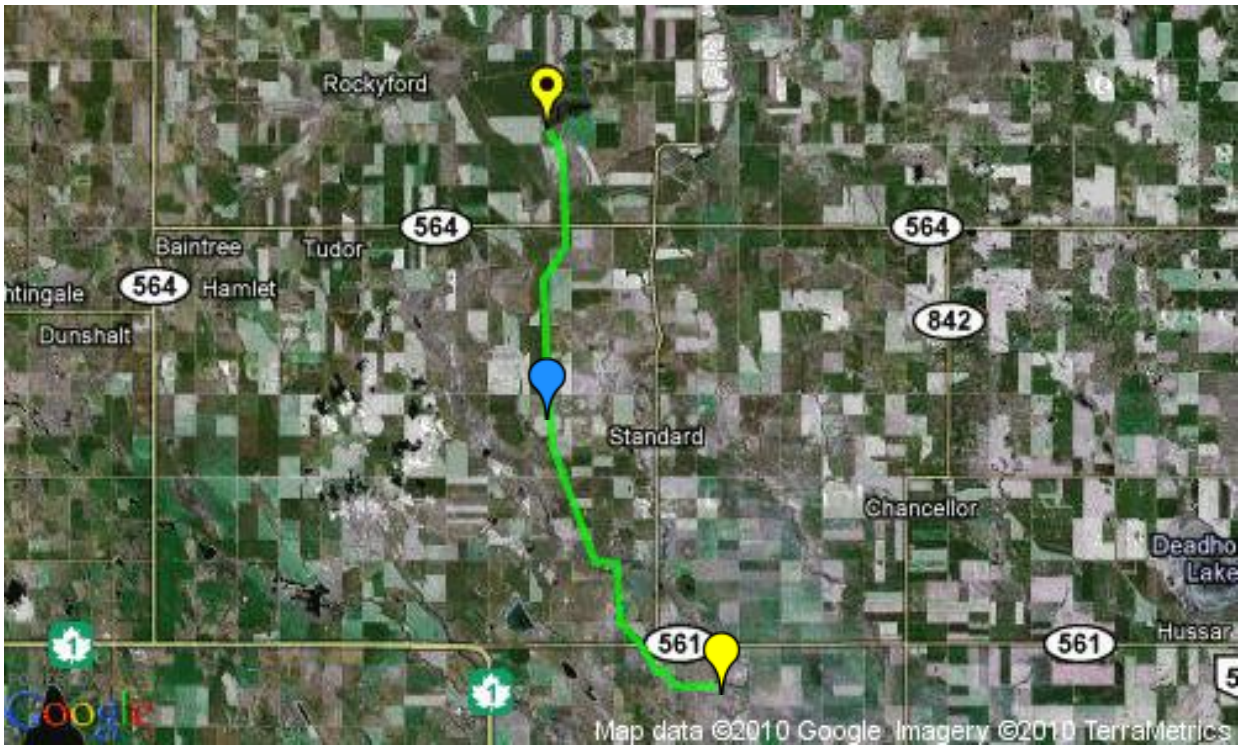


Figure 1.1.1: General layout of the pipeline inspected for EnCana

Approximate sensor locations ( ), actual leak locations ( ) for the inspection.

1.2 Test Set Up:

The pipeline in question is configured with pig launch and receive facilities. Sensors were mounted to both the launch and receive trap, as well as a section where the pipeline comes above ground, approximately 13,350 meters into the inspection.

The above ground section was used as a simulated leak point. An existing 1" tap and needle valve on the pipeline was used to release product from the pipeline to create the leak.

In addition, gas flow metering equipment was onsite, supplied by EnCana, to quantify the rate of all simulated leaks.

Figure 1.2.1 - Simulated Leak Point and Gas Flow Measurement Equipment.

Note: The device that looks like a plunger is the collection head for the gas metering equipment and is placed over top of the 1" tap that is being used to create the leak.

1.3 Procedure:

The 4" uncoated Oil/Gas Smartball cores were used for all four inspections, mounted inside a 5" foam overshell. The Smartballs were each synced with the GPS time clock and the recordings were started. The Smartball tools were all launched on the same day, however due to the client's reluctance to have all four tools inside the pipeline at one time the launches were delayed so that there were never more than 2 Smartball tools inside the pipeline at a given time. Table 1.3.1 below shows the tracking points and the tool's arrival time at each location, for each of the 4 inspections.

Distance from Start	Time Since Launch	Description	GPS Location
Inspection 1			
0m	0:00:00	Insertion	51.2177, -113.0430
13,350m	2:10:35	Simulated Leak Location	51.1219, -113.0425
26,000m	5:07:36	Extraction	51.0229, -112.9489
Inspection 2			
0m	0:00:00	Insertion	51.2177, -113.0430
13,350m	2:02:33	Simulated Leak Location	51.1219, -113.0425
26,000m	6:16:49	Extraction	51.0229, -112.9489

Inspection 3			
0m	0:00:00	Insertion	51.2177, -113.0430
13,350m	3:21:22	Simulated Leak Location	51.1219, -113.0425
26,000m	6:35:30	Extraction	51.0229, -112.9489
Inspection 4			
0m	0:00:00	Insertion	51.2177, -113.0430
13,350m	2:47:53	Simulated Leak Location	51.1219, -113.0425
26,000m	5:13:35	Extraction	51.0229, -112.9489

Table 1.3.1 – Reference Points for All 4 Smartball Inspections

Each Smartball was loaded into the pig launch trap and the appropriate valves exercised to launch the tool down the pipeline once approval was obtained from the pipeline's operations group. The inspections were timed such that the tool's arrival at the simulated leak point would not interfere with another tool's arrival at any of the tracking points.

Fig. 1.3.1 - Pig Launch Facility at Severn Compressor Station

Each simulated leak was created at the above ground section of the pipeline prior to the Smartball arrival by means of an existing 1" tap on the pipeline. The existing tap is capped with a 1" gate valve and plug. For the purposes of the inspection, the plug was removed and replaced with a 1" pipe nipple. Above the nipple a 1" needle valve was installed in order to have precise control over the quantity of escaping gas. The collection manifold of the flow metering equipment was then placed above the needle valve to quantify the leak rates.

The intention was to create a progressively smaller leak for each pass of the Smartball tool in order to gain a better understanding of the lower leak detection threshold of the Smartball tool in natural gas pipelines.

Fig. 1.3.2 – EnCana Staff Measuring Gas Leak Flow Rate

The Smartball is then tracked into the pig receive trap at the end of the line and removed from the pipeline. A custom made strainer device is used to prevent the Smartball tool from passing through the bypass line coming off the barrel of the pig receiver.

Fig. 1.3.3 – Pig Receive Trap at Crowfoot Gas Plant

Figure 1.3.4 - Strainer Device

1.4 Results

The position of the SmartBall within the pipeline is critical for locating important features, such as leaks and gas pockets. Individual SBR's and AGM's were able to track the ball's progress through the pipeline for up to 300 metres. The distance between and location of these SBR's and AGM's is based on the information provided by EnCana. The result of the rotation profile and SBR/AGM tracking is a position versus time relationship for the entire run of the tool. The exact location of where each SBR/AGM was placed along the pipeline during the run is detailed in Appendix A. The methodology used to locate leaks as the tool traverses the pipeline involves obtaining a velocity profile using data obtained from the accelerometers and magnetometers on board the SmartBall. Absolute position reference points obtained from the SmartBall Receivers (SBR) and AGM's are then applied to time stamped data.

Figures 1.4.1 through 1.4.11 provide plots of the position of SmartBall versus time for each inspection. The position of the SmartBall indicated by the blue line is fixed by fitting the position profile to known locations along the pipeline. The red dots indicate absolute position data when the ball passes an SBR or AGM location. The slope of the blue line indicates the instantaneous velocity of the tool. The velocity of the ball as it traveled through the pipeline is shown below for each of the 4 inspections.

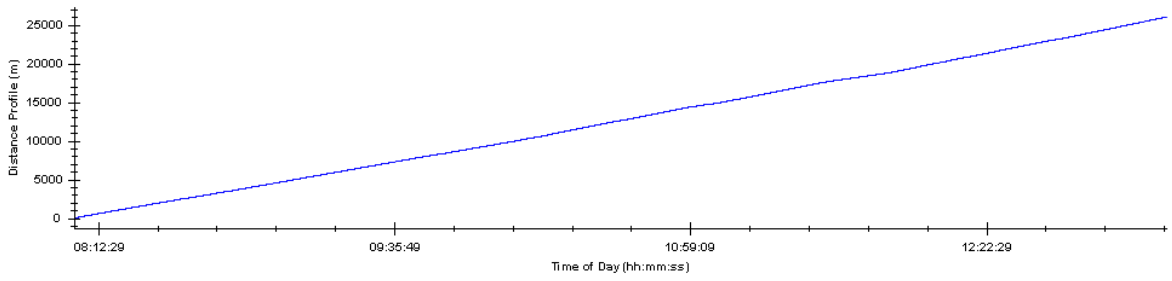


Figure 1.4.1: Position Profile of the SmartBall vs. Time of Day for the 1st June 8, 2010 inspection

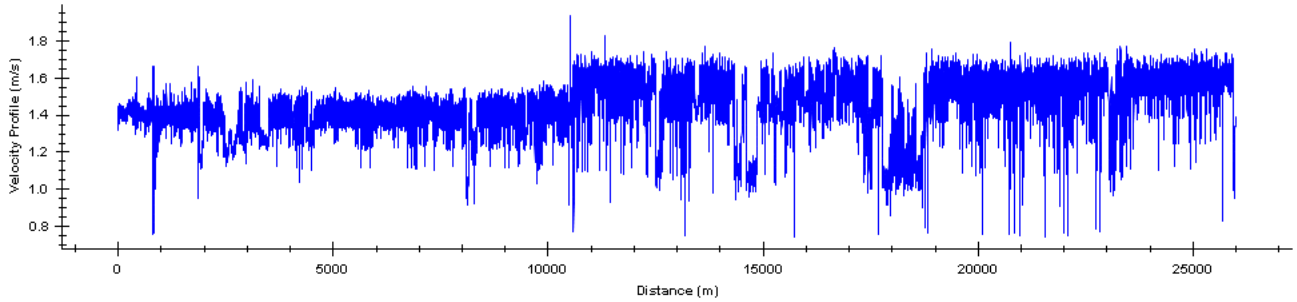


Figure 1.4.2: Velocity Profile of the SmartBall vs. Distance Traveled for the 1st June 8, 2010 inspection

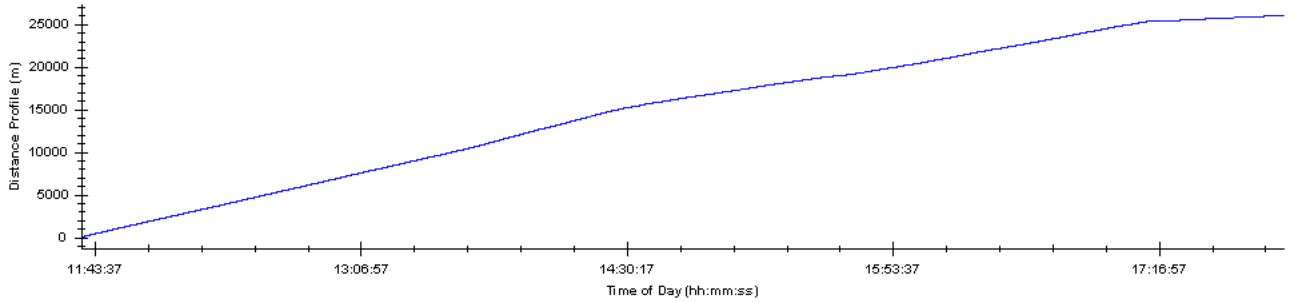


Figure 1.4.3: Position Profile of the SmartBall vs. Time of Day for the 2nd June 8, 2010 inspection

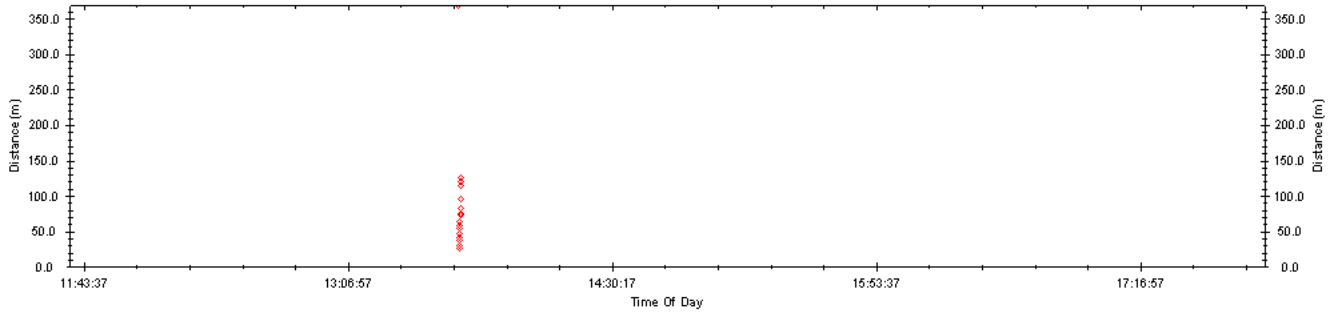


Figure 1.4.4 SBR Tracking of the SmartBall vs. Time of Day for the 2nd June 8, 2010 inspection

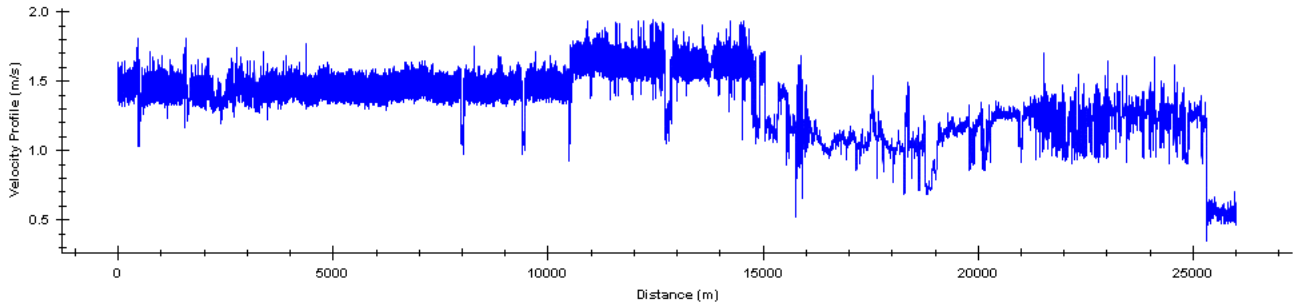


Figure 14.5: Velocity Profile of the SmartBall vs. Distance Traveled for the 2nd June 8, 2010 inspection

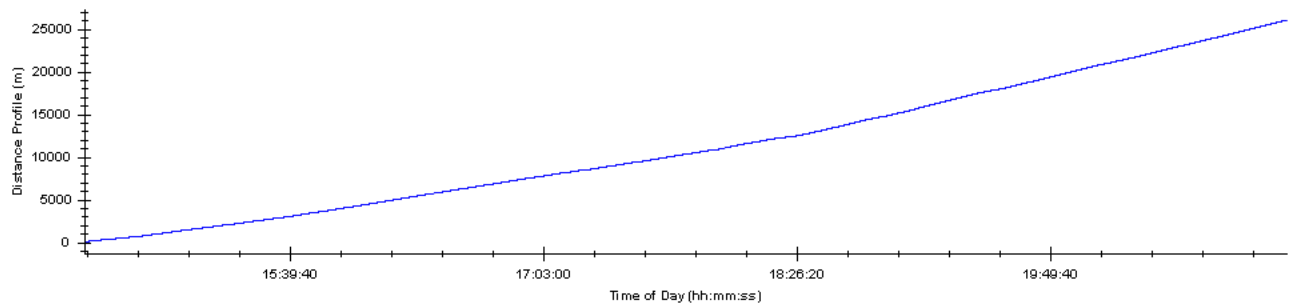


Figure 1.4.6: Position Profile of the SmartBall vs. Time of Day for the 3rd June 8, 2010 inspection

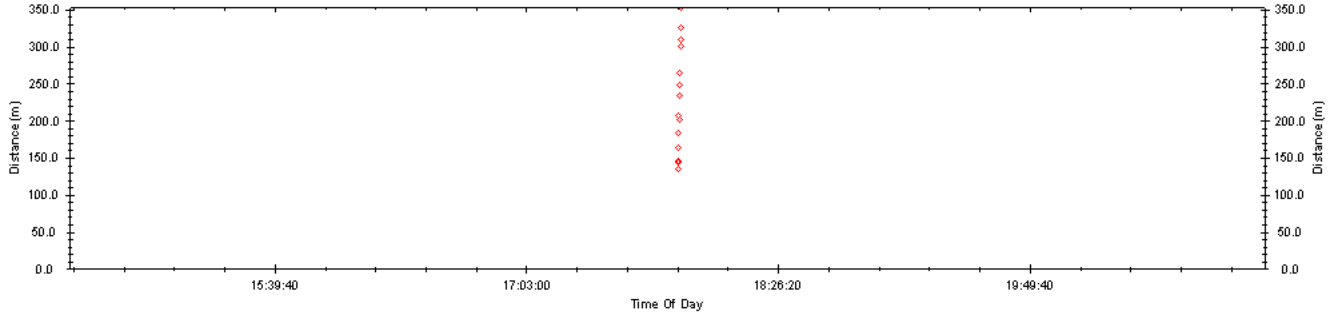


Figure 1.4.7: SBR Tracking of the SmartBall vs. Time of Day for the 3rd June 8, 2010 inspection

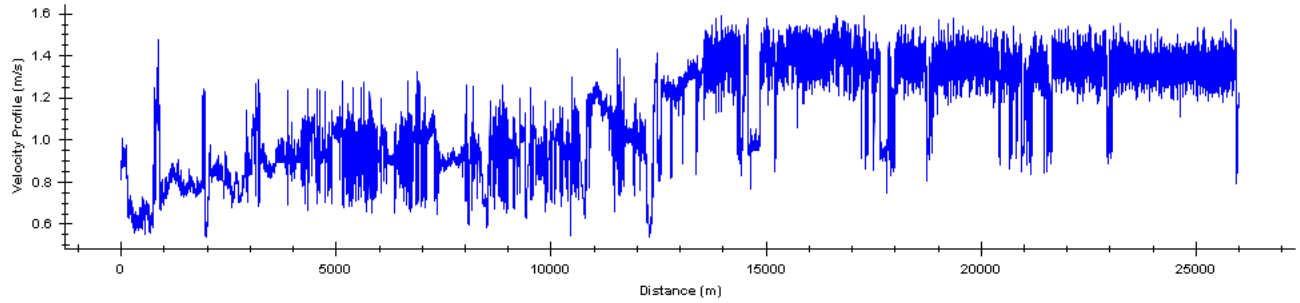


Figure 1.4.8: Velocity Profile of the SmartBall vs. Distance Traveled for the 3rd June 8, 2010 inspection

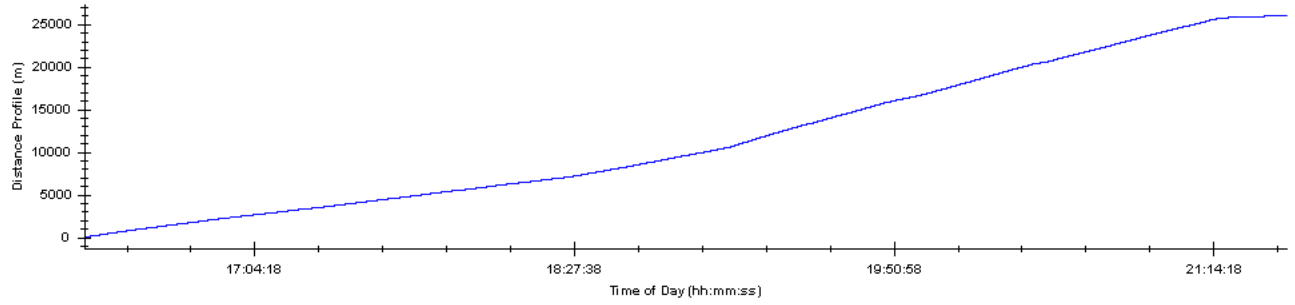


Figure 1.4.9: Position Profile of the SmartBall vs. Time of Day for the 4th June 8, 2010 inspection

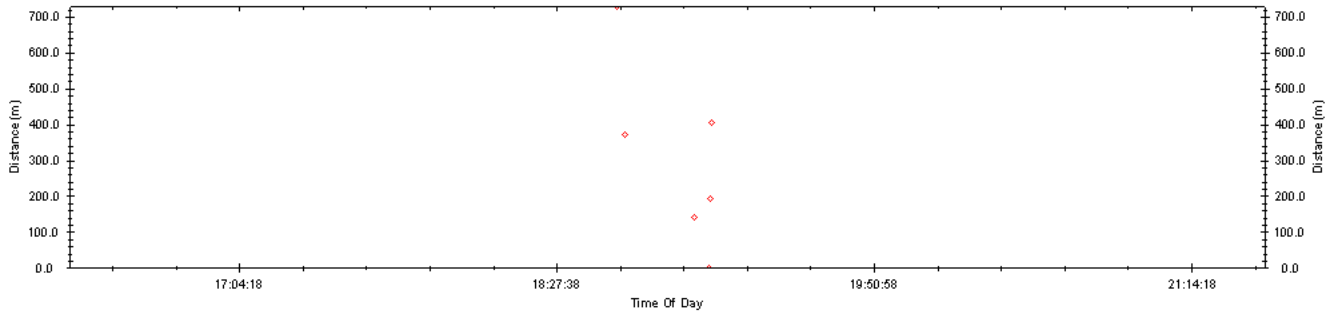


Figure 1.4.10: SBR Tracking of the SmartBall vs. Time of Day for the 4th June 8, 2010 inspection

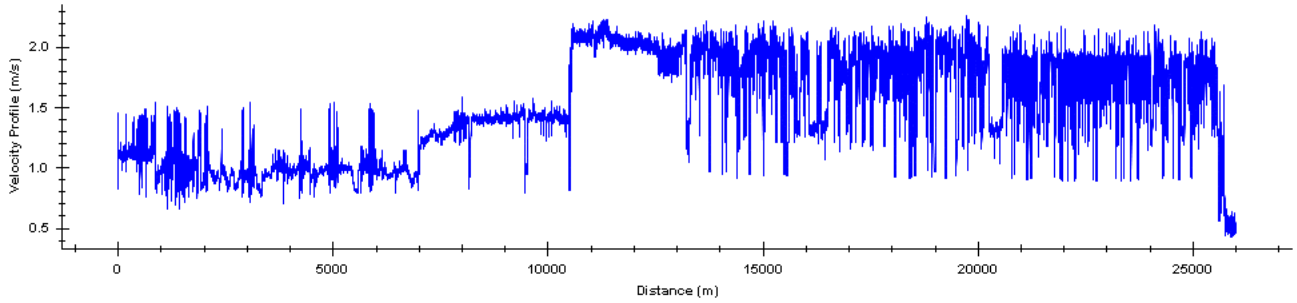


Figure 1.4.11: Velocity Profile of the SmartBall vs. Distance Traveled for the 4th June 8, 2010 inspection

The acoustic data recorded by the SmartBall is then analyzed and cross-referenced with the position data from the SBR to determine a location for each anomaly. A summary of the leaks and pockets of trapped gas identified during the SmartBall survey is provided below.

Figure 1.4.12 through 1.4.15 shows the values of the leak indication power as detected by the SmartBall with respect to the position of the SmartBall along the pipeline. The magnitude of leaks is estimated by correlating the value of the leak signal (a calculated parameter) with calibrations performed on the SmartBall.

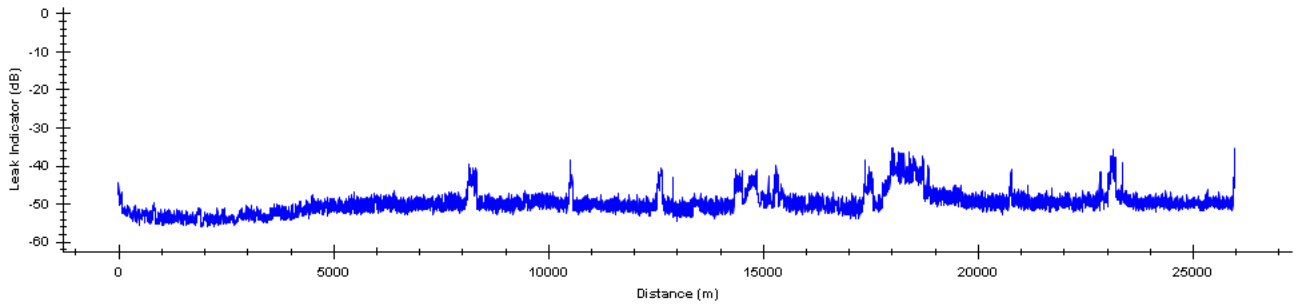


Figure 1.4.12: Acoustic Profile of the SmartBall vs. Distance Traveled for the 1st June 8, 2010 inspection

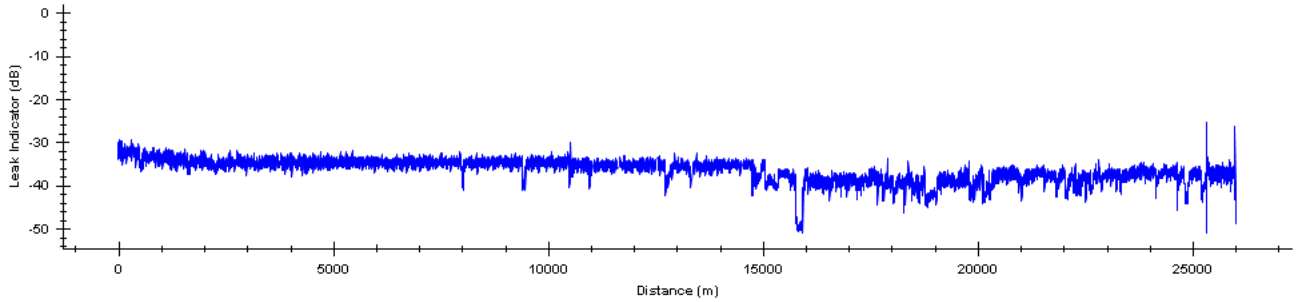


Figure 1.4.13: Acoustic Profile of the SmartBall vs. Distance Traveled for the 2nd June 8, 2010 inspection

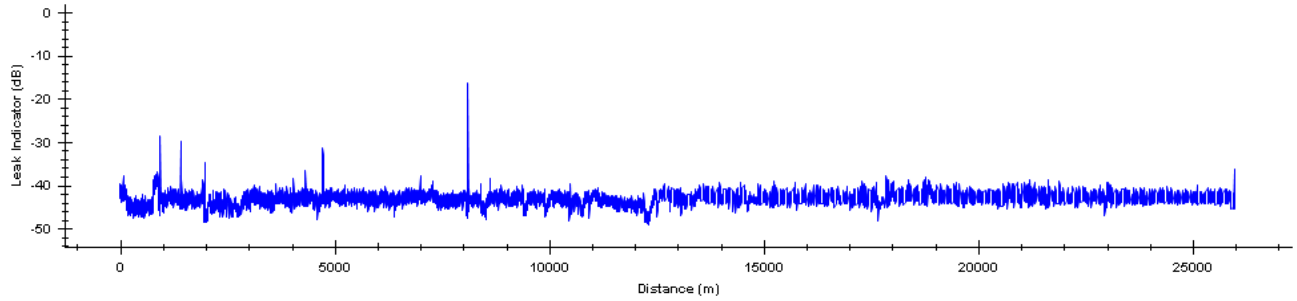


Figure 1.4.14: Acoustic Profile of the SmartBall vs. Distance Traveled for the 3rd June 8, 2010 inspection

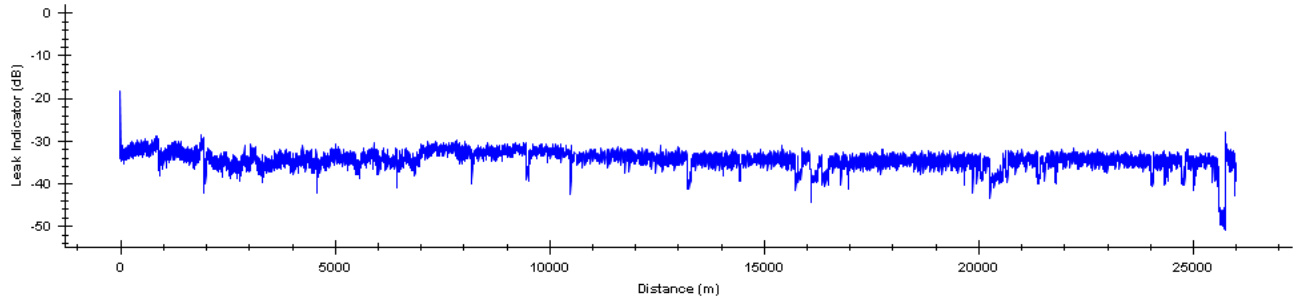


Figure 1.4.15: Acoustic Profile of the SmartBall vs. Distance Traveled for the 4th June 8, 2010 inspection

The critical findings of the pipeline inspection are summarized in table 1.4.1.

Distance from Start	*Time Since Launch*	*Description*	*GPS Location*
Inspection 1			
0m	*0:00:00*	*Insertion*	*51.2177, -113.0430*
13,350m	*2:10:35*	*Simulated Leak Location*	*51.1219, -113.0425*
26,000m	*5:07:36*	*Extraction*	*51.0229, -112.9489*
Inspection 2			
0m	*0:00:00*	*Insertion*	*51.2177, -113.0430*
13,350m	*2:02:33*	*Simulated Leak Location*	*51.1219, -113.0425*
26,000m	*6:16:49*	*Extraction*	*51.0229, -112.9489*
Inspection 3			
0m	*0:00:00*	*Insertion*	*51.2177, -113.0430*
13,350m	*3:21:22*	*Simulated Leak Location*	*51.1219, -113.0425*
26,000m	*6:35:30*	*Extraction*	*51.0229, -112.9489*
Inspection 4			
0m	*0:00:00*	*Insertion*	*51.2177, -113.0430*
13,350m	*2:47:53*	*Simulated Leak Location*	*51.1219, -113.0425*
26,000m	*5:13:35*	*Extraction*	*51.0229, -112.9489*

Table 1.4.1 – General Points of Interest

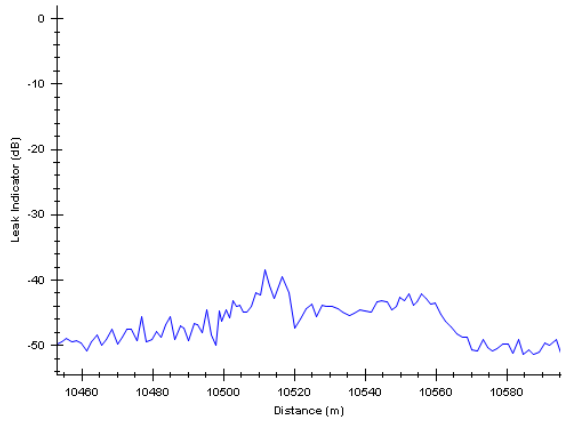
Details on all four simulated leaks that were created during the SmartBall surveys are provided below.

Inspection 1: Simulated Leak 3.9 LPM

Note: This 3.9 LPM simulated leak is extremely small and is on the verge of being undetectable by current methods. Indeed if we hadn't known specifically that this leak was present it would have gone undetected during an inspection. It is simply too small and will typically be obscured by other noise sources in the pipe.

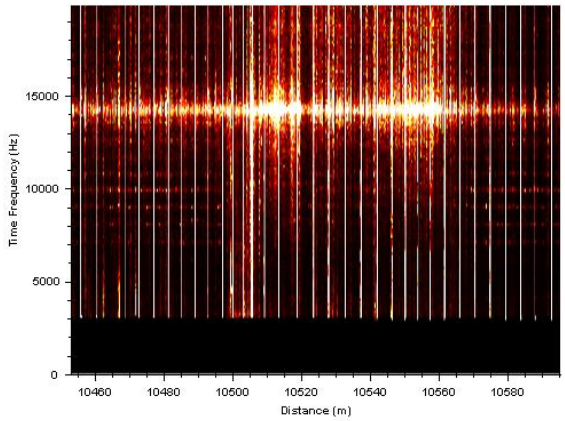
Distance from Insertion Point:	13,350m
Distance to Nearest Sensor:	13,350m after Insertion
Time Since Start of Rolling:	02:10:47
Time Since Tool Activated:	03:27:14
Time of Tool Pass (GMT-7:00):	10:16:23 AM
Approximate Latitude:	51.1218
Approximate Longitude:	-113.0425
Leak Indication Power:	-42.9 dB

Leak Indicator



Acoustic Power of Leak

Frequency Spectrum



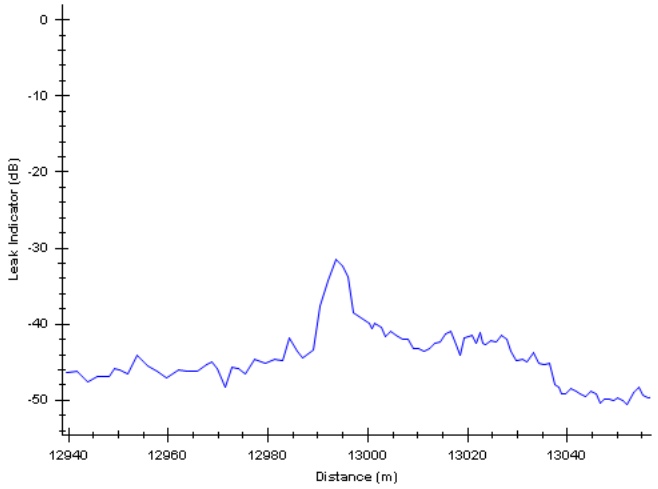
Frequency Spectrum of Leak

Approximate Location of Leak

Inspection 2: Simulated Leak 82.4 LPM

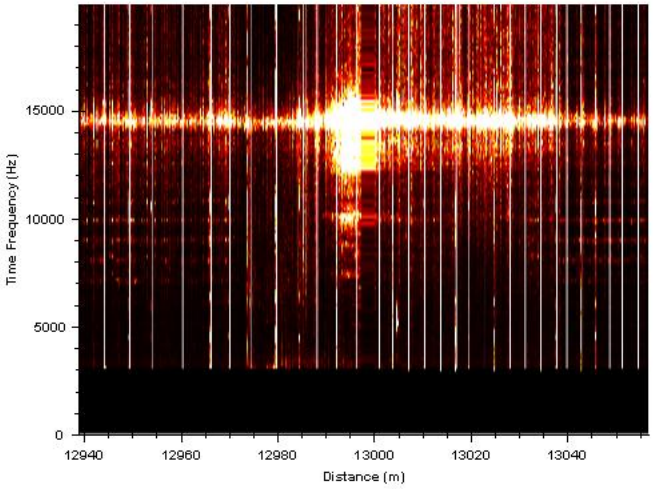
Distance from Insertion Point:	13,350m
Distance to Nearest Sensor:	6.0 m after SBR 2
Time Since Start of Rolling:	02:02:44
Time Since Tool Activated:	03:21:41
Time of Tool Pass (GMT-7:00):	01:41:58 PM
Approximate Latitude:	51.1218
Approximate Longitude:	-113.0425
Leak Indication Power:	-32.5 dB

Leak Indicator



Acoustic Power of Leak

Frequency Spectrum



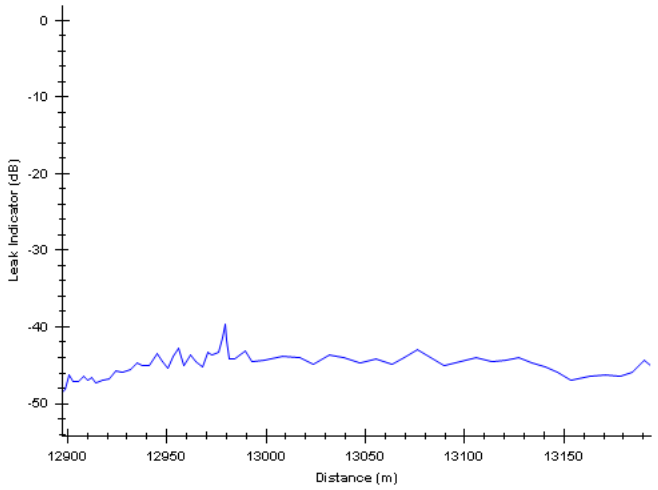
Frequency Spectrum of Leak

Approximate Location of Leak

Inspection Three: Simulated Leak 45 LPM

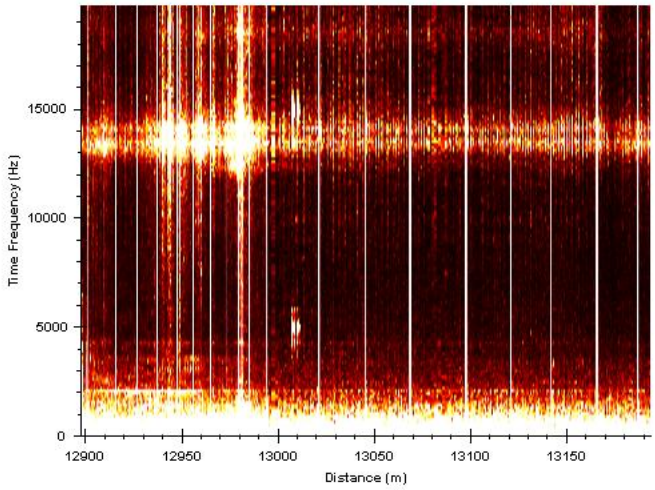
Distance from Insertion Point:	13,350m
Distance to Nearest Sensor:	6.0m after SBR 2
Time Since Start of Rolling:	03:21:17
Time Since Tool Activated:	03:36:49
Time of Tool Pass (GMT-7:00):	05:53:09 PM
Approximate Latitude:	51.1218
Approximate Longitude:	-113.0425
Leak Indication Power:	-44.3 dB

Leak Indicator



Acoustic Power of Leak

Frequency Spectrum



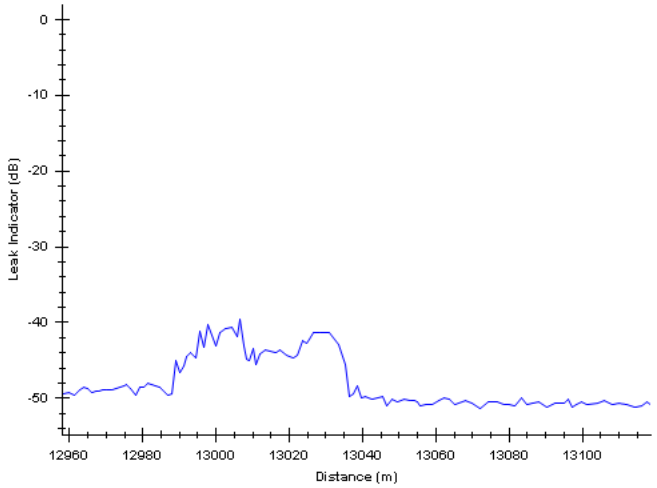
Frequency Spectrum of Leak

Approximate Location of Leak

Inspection Four: Simulated Leak 22 LPM

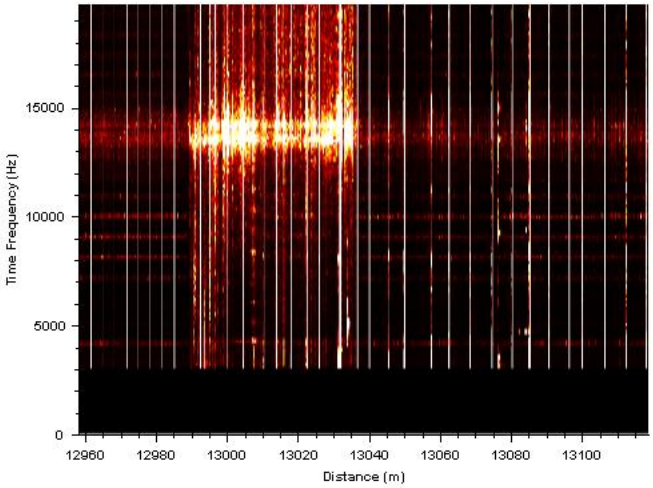
Distance from Insertion Point:	13,350m
Distance to Nearest Sensor:	6.0 m after SBR 2
Time Since Start of Rolling:	02:48:06
Time Since Tool Activated:	04:50:20
Time of Tool Pass (GMT-7:00):	07:07:58 PM
Approximate Latitude:	51.0978
Approximate Longitude:	-113.0349
Leak Indication Power:	-44.0 dB

Leak Indicator



Acoustic Power of Leak

Frequency Spectrum



Frequency Spectrum of Leak

Approximate Location of Leak

Appendix A: Ball Tracking Sensor Locations

For All Four EnCana inspections completed Tuesday Jun. 8, 2010

Inspection Number	One (1)
Time of Departure (GMT-7:00)	8:05 AM
Latitude	51.2176
Longitude	-113.0430
Distance from Launch	0.0 m

Inspection Number	Two (2)
Time of Tool Pass (GMT-7:00)	12:41 PM
Latitude	51.1243
Longitude	-113.0429
Distance from Launch	13,350m

Inspection Number	Three (3)
Time of Tool Pass (GMT-7:00)	5:53 PM
Latitude	51.1242
Longitude	-113.0428
Distance from Launch	13,350m

Inspection Number	Four (4)
Time of Tool Pass (GMT-7:00)	7:07 PM
Latitude	51.1242
Longitude	-113.0429

Distance from Launch	13,350m	

Appendix B: Planning Document

Encana, Severn to Crowfoot- SmartBall™ Leak Detection Survey
Preliminary Project Planning Document

Location – Drumheller, AB
Diameter – 6”
Material – Steel
Pressure – 6100 KPa
Flow Rate – 1.3 m/s
Distance – 26.65 KM

Purpose:

The document below contains details relevant to performing an additional four (4) SmartBall inspections of the 6”, 26.65 KM long pipeline for EnCana from the Severn Compressor Station to the Crowfoot Gas Plant; this further to the previously successful inspection conducted April, 2010. Though the previous inspection was successful insofar as the Smartball identified the simulated gas leak, the leak rate was not measured due to unavailability of flow measurement equipment at the time of inspection.

The purpose of the additional inspections will be to further quantify the lower leak detection threshold for the Smartball in natural gas pipelines. A flow meter will be used to gauge the simulated leak rates during each of the upcoming inspections to determine the resultant acoustic energy as recorded by the Smartball. One simulated leak will be created at the above ground section of pipe per inspection, with the leak rate decreasing with each inspection. Statistical analysis will then be used to determine a theoretical lower limit for the Smartball’s leak detection capability. In addition modifications to the Smartball hardware will be tested to gauge any increase in the leak detection resolution of the Smartball.

Location:

The pipeline layout is shown in Figure 1 below showing the location of the pipeline.

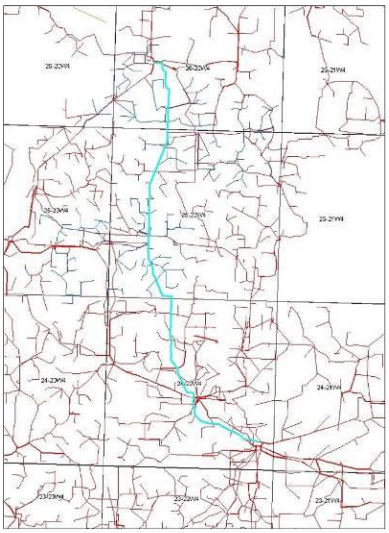


Figure 2: Summary of Pipeline Details

Pipeline Details:

The proposed pipeline for inspection is a 26.65km length of 6” diameter steel pipe.

Service	SmartBall Leak Detection
Material	Steel
Diameter	6”
Pressure	611 KPa
Length	26.65 km
Flow	1.3 m/s

Table 1: Summary of Pipe

The time required to complete the inspection is detailed in Table 2.

SmartBall Calculator
Pure Technologies Ltd.
Calgary, Alberta, Canada
1-800-537-2806

Diameter of Pipeline (ID)	6	in
Volume Flow Rate	83	cubic meters per hour (m^3/hr)
Average Flow Velocity	1.26391	m/s

Length of Run	26650	meters (m)
Velocity Efficiency	100%	
Estimated Time for Run	5:51	hours:minutes

Launch Time (hh:mm:ss)	9:00:00

				Arrival Times % of Flow Velocity		
Tracking Point	**Description**	**Distance from Launch (m)**		**100%**	**95%**	**90%**
1	Launch/SBR 1	0		9:00:00	9:00:00	9:00:00
2	SBR 2	13350		11:51:26	12:00:27	12:10:28
3	Extraction/SBR 3	26000		14:42:51	15:00:54	15:20:57

Table 2: Summary of Time Required for Inspection

Assuming an average flow rate of 1.3 m/s for the length of the pipeline, the whole inspection would require approximately 5 and a three quarter hours to complete. Please note that the time needed to complete the inspection is dependent on the flow rate and the time provided is only an estimate and the actual inspection may take longer then expected.

Site Preparations:

Insertion

The SmartBall Insertion will be conducted through the standard pig launcher at the Severn Compressor Station.

Sensor Location:

One mid point sensor location will be used approximately 13 KM into the inspection where the pipeline comes above ground.

Extraction Location:

The extraction will take place at the Crowfoot gas plant at the pig receiver. Pure Technologies will supply a strainer to be installed inside the pig trap to prevent passage of the Smartball through the kicker line.

Scope of Work per Inspection:

EnCana Responsibilities:

- Staffing at Severn Compressor plant to launch Smartball through pig launcher. Two launches per day, at 30 minute intervals, for two consecutive days. 4 total launches.
- Create simulated gas leak at above ground pipeline section. Simulated leak must be active prior to the passage of the Smartball to ensure the leak signature is recorded
- Measure the rate of gas leak with flow meter and provide data to Pure
- Staffing at Crowfoot gas plant to receive Smartball through pig receiver. Staff can wait for arrival of both Smartballs prior to isolating the receive trap and removing the tools

Pure Technologies Responsibilities:

- Smartball leak detection tool for 6” gas pipeline
- Configure and test all hardware to ensure operational success
- Assist with tool launch and track progress away from launch trap
- Track tool at above ground pipe section and assist EnCana staff with creating simulated leak at the appropriate rate.
- Assist with tool receive and track progress into the receive trap
- Provide strainer for receive trap to prevent passage of Smartball through kicker line
- Analyze inspection data and supply report on results to Encana

Proposed Schedule:

Day 1:

- 2 Smartball Inspections to be conducted during the day.
- Launch of the second Smartball to be 30 minutes after launch of the first Smartball.
- Simulated leaks to be created and measured for rate on both inspections.

- First leak to be set an arbitrary rate, as agreed upon by EnCana and Pure staff. Leak must be active prior to passage of the first Smartball tool.
- Second leak to be reasonably smaller than the first leak. Leak must be active prior to passage of the second Smartball tool.

Day 2:

- 2 Smartball Inspections to be conducted during the day.
- Launch of the second Smartball to be 30 minutes after launch of the first Smartball.
- Simulated leaks to be created and measured for rate on both inspections.
- First leak to be smaller than the smallest leak on Day 1. Leak must be active prior to passage of the first Smartball tool.
- Second leak to be proportionally smaller than the previous leak. Leak must be active prior to passage of the second Smartball tool.