Comparison of the Speed Control Pig Cleaning Tool vs. a Standard Hard-Bodied Cleaning Pig

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Background

The Enable Midstream Partners LP. (formerly CenterPoint Energy, Inc.) (Enable) “CP” and “SESH” 42 inch and 36 inch natural gas pipelines originate at Carthage, Texas and run 446 miles to their terminus at Coden, Alabama. SESH links the onshore natural gas supply basins of east Texas and northern Louisiana to markets now predominantly served by offshore natural gas supplies from the Gulf of Mexico. Enable cleans these pipelines on an annual basis in order to enhance gas quality, maintain throughput efficiency, remove potentially deleterious liquids and debris, reduce the risk of internal corrosion and assure the best performance from ILI inspection runs.

Figure 1: Coordinating plans to launch a pipeline cleaning tool

It is commonly accepted in the pipeline industry that ordinary cleaning pigs do not effectively clean a pipeline when run in many of today’s elevated gas flow volumes and velocities. Gas lines are prone to experience velocity surges or speed excursions due to the compressibility of gas. When run at the higher gas flow velocities, cleaning pigs tend to “hydroplane“ over liquids and leave liquids and debris in the

pipeline. This viscous and dynamic action tends to increase with the speed of the pig. At elevated pig speeds, aquaplaning often occurs consequently leaving potentially significant volumes of liquids in the line. In order to be effective, cleaning pigs should be run at a constant predictable lower speed. The industry accepted optimal pipeline cleaning pig speed is below 10 mph.

There is also considerable concern that at elevated speeds, cleaning pigs tend to jump over or across internal circumferential girth welds and spiral weld areas thus leaving residual liquids and debris in the pipeline at the weld areas. Therefore, it is necessary to decrease the speed of cleaning pigs by reducing gas flow in order to achieve maximum cleaning effectiveness. Consequentially, reducing gas flow and throughput while cleaning a pipeline can result in a significant loss of gas flow revenue for a pipeline operator as well as disrupt gas delivery reliability to the downstream client base.

A Speed Controlled Pig (SCP) was developed under a joint Technology Development Agreement between Enable Midstream Partners LP. , Inline Services Inc. (Inline) and Pipelines 2 Data Ltd. (P2D) to provide a tool which could effectively clean pipelines without the need to sacrifice reliable gas delivery to the downstream client base or losing transportation revenue by reducing normal gas flow volumes or gas velocity.

Figure 2: Speed Controlled Pig (SCP) tool

The SCP tool was designed to provide a method to safely by-pass natural gas while simultaneously controlling tool speed. The tool can clean effectively at speeds of 6 to 10 mph while the natural gas velocity in the pipeline continues to flow at normal rates of anywhere from 15 to 35 mph. The use of the SCP not only facilitates effective cleaning but also optimizes gas transportation revenue for the pipeline operator by not having to reduce gas flow and throughput while lowering pig speeds to assure effective cleaning of the pipeline.

The SCP tool is equipped with a number of features such as a transmitter for ease of tool tracking. Dual odometers provide accurate distance measurement to points of interest. A state-of-the-art data logger records pipeline slope, pressure, temperature and tool orientation. An Inertial Measurement Unit (IMU) detects Roll, Pitch, Yaw and Vibration. Pressure differential across the tool is continuously recorded and can be used to calculate drag. Condition of the internal surface of the pipe, the presence of liquids, debris and Black Powder can be inferred from the changes in ride characteristics, tool dynamics and drag.

With recent changes in the gas market, and as production facilities and pipelines continue to age, there is an industry trend being observed, consequently requiring operator capability to handle more liquid laden gas in pipelines. It is widely recognized that more liquids and debris are now being delivered in gas from producers. Liquids and debris tend to build up in low spots in a pipeline. The IMU accurately shows the location, angle of slope and the extent of elevation change in a pipeline. The slope data is valuable for locating low spots in a pipeline or profiling elevation changes such as a River Crossing where liquids may tend to reside. Removing these liquids and debris from pipelines can enhance gas quality, improve pipeline operation efficiency, prevent internal corrosion and reduce the risk of failed ILI inspection runs.

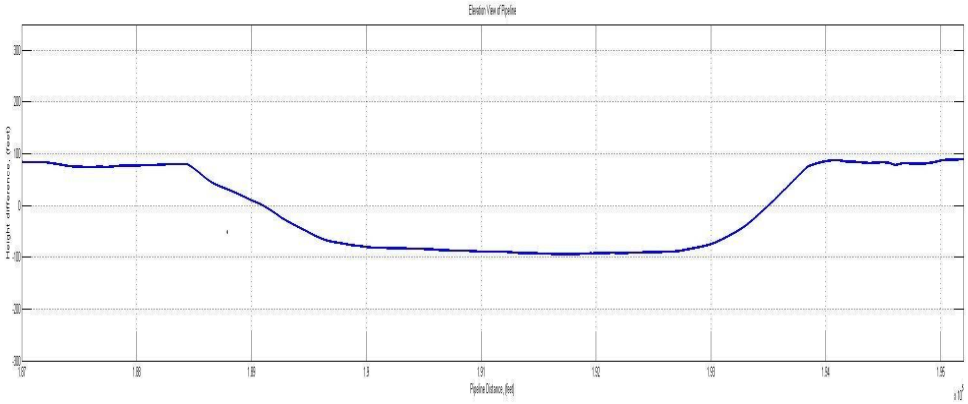

Figure 3: SCP profile of data from a 5532 foot river crossing on a 42 inch pipeline

The SCP tool is also equipped with powerful Neodymium Iron Boron (NdFeB) rare earth magnets which gather and remove magnetic types of metallic objects, welding debris and Black Powder.

Deformation and Debris Monitoring sensors can also be mounted on the SCP tool, the latter of which can be used to help locate where problem inputs may be contaminating a pipeline with deleterious solids.

With certain adaptations, the SCP tool is capable of recording actual parametric conditions, in-situ sampling of the composition of the gas and liquids to help determine the possible presence of MIC, evaluating the internal surface condition of the pipe, and collecting other relevant data to determine the actual areas which may be affected.

Therefore, the SCP is not just a speed controlled cleaning pig; it is a smart cleaning tool that can provide a vehicle or platform on which to accomplish other tasks. It can be used to focus inspection resources where they are needed. SCP is an integrated pipeline cleaning and inspection tool on which sensors can be mounted to monitor changes in operating conditions and gather other useful data points.

The Comparison Run

In October 2012, Enable ran a comparison of the performance of the SCP Cleaning Tool vs. a Standard Hard-Bodied Cleaning Pig in the Panola to Vernon section of their 42 inch CP pipeline.

This section of pipeline is 93.2 miles long. It crosses the Red River and the Pierre, Saline, Bistineau and Black Lake Bayous, a number of perennial streams and many other intermittent streams, ponds, lakes and wetland areas. On construction, the potential effects to sensitive water bodies were avoided through the implementation of Horizontal Directional Drilling (HDD) installation techniques. While most of the terrain is gently rolling, there are some steep inclines in and out of ravines and under streams. There are seven Main Line Valves spaced out along the line. The line had been previously cleaned with the SCP tool in December 2011 with gas flow velocity running as high as 24.5 mph in this pipeline section.

On October 9th 2012 the SCP tool was run in the Panola to Vernon 42 inch pipeline section

Although cups and discs on the SCP tool can be mounted in any number of preferred cleaning configurations, in this case the tool was configured with three DC cups, two Seal Discs and a Heavy Duty full encirclement brush for maximum cleaning capability.

In this instance the SCP instrumentation was set to control the cleaning tool speed in the range of 6 mph to 8 mph.

Tool launch from Panola was accomplished with a gas flow volume of 1.046 Bcf and a pressure of 1070 psi producing a starting gas flow velocity of 12.3 mph. Additional gas flow volume came on stream rising to 1.563 Bcf and providing gas flow velocity of 22.03 mph for the majority of the run.

Actual gas flow velocity depends on gas flow volume, pipe inside diameter, pressure, temperature, specific gravity, compressibility, efficiency factors and operating conditions. Average gas flow velocity calculations in this pipeline section are based on the thinnest (0.427”) pipe wall. Actual gas flow velocity was higher in all heavier wall thickness areas which in this case are comprised of 0.500”, 0.562”, 0.617”, 0.625”, 0.750” and 1.000” sections. The pipe is Double Submerged Arc Welded line pipe.

Tool speed depends on gas by-pass, tool dynamics, drag, the extent and lubricity of the liquids, the extent and mass of debris, pipeline configuration, slope or elevation changes, internal wall conditions, coated or uncoated pipe, girth weld or spiral weld caps and spiral welded pipe. Drag also depends on the tool weight, the number, design, physical dimensions, stiffness and hardness of cups, discs and brushes and the extent of cup, disc and brush wear. Drag is calculated using the recorded pressure differential

across the tool. Black Powder in the pipeline, particularly when very dry, can cause a high coefficient of friction which can change drag, tool dynamics and speed behavior and cause excessive cup and disc wear which can further exacerbate irregular tool movement.

The SCP tool was closely tracked by Enable field crews and the SCADA system as it travelled from launcher to receiver.

The SCP tool speed was controlled to an average of 7.85 mph. The tool demonstrated excellent speed control over the full gas flow volume range for the duration of the run.

The actual amount of gas bypassed by the SCP tool will depend on pressure differential across the tool, drag and the other factors affecting tool dynamic behavior. It is estimated that 64% of the natural gas was by-passed by the SCP to achieve a uniform cleaning speed in this pipeline section.

The tool was safely brought into the trap at less than 7 mph and was received in excellent condition.

Cleaning results: the SCP tool brought in approximately 30 gallons of liquids measured into the Vernon storage tank. When the trap was opened, additional liquids were present in the trap which could not be measured. It could also be seen that some liquids had exited through the side opening 12" receiver by-pass line. There was also significant magnetic debris on the tool's high strength magnets.

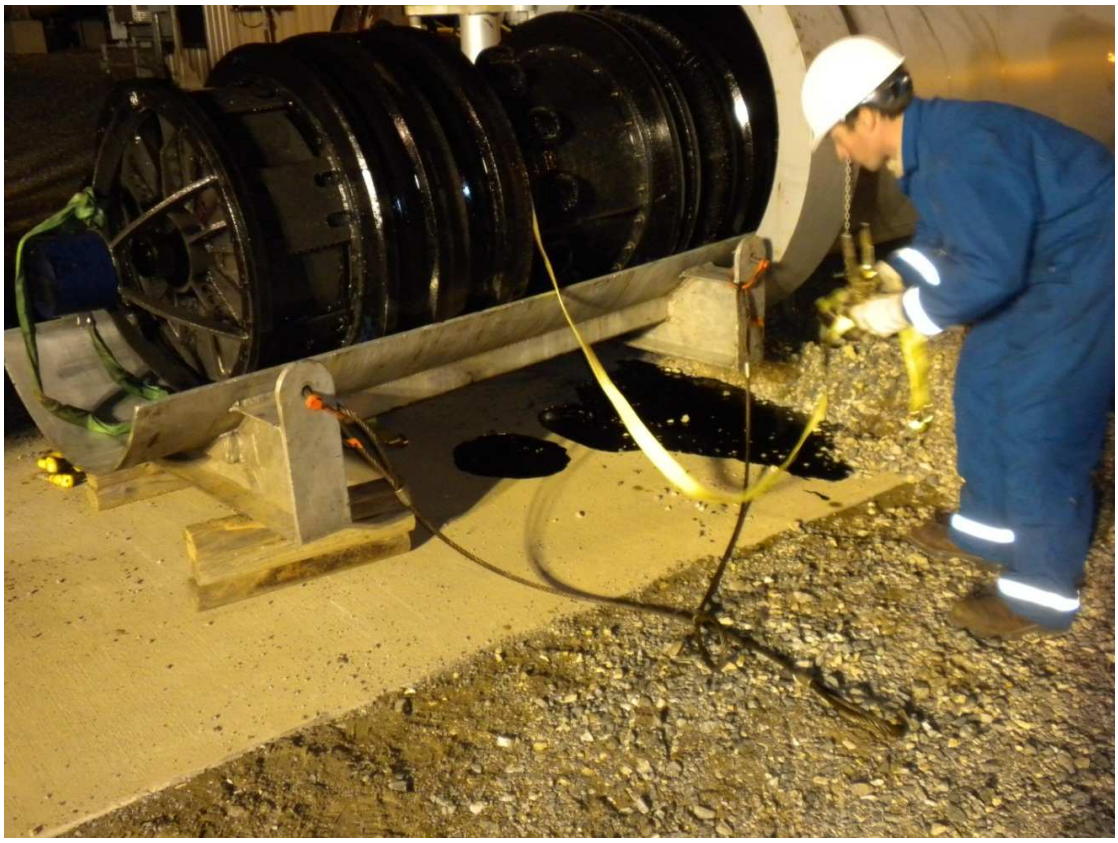

Figure 4: SCP tool at the Vernon Receiver

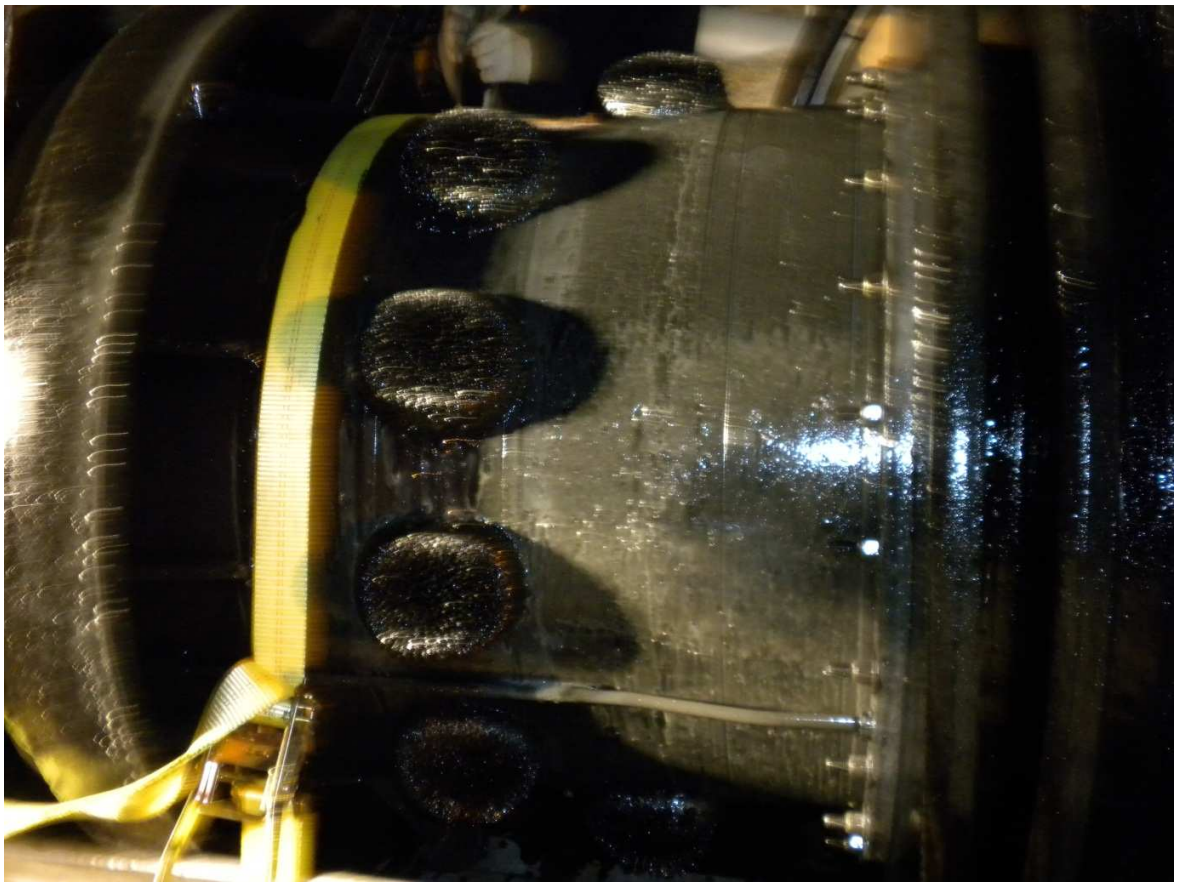

Figure 5: Debris on the SCP tool

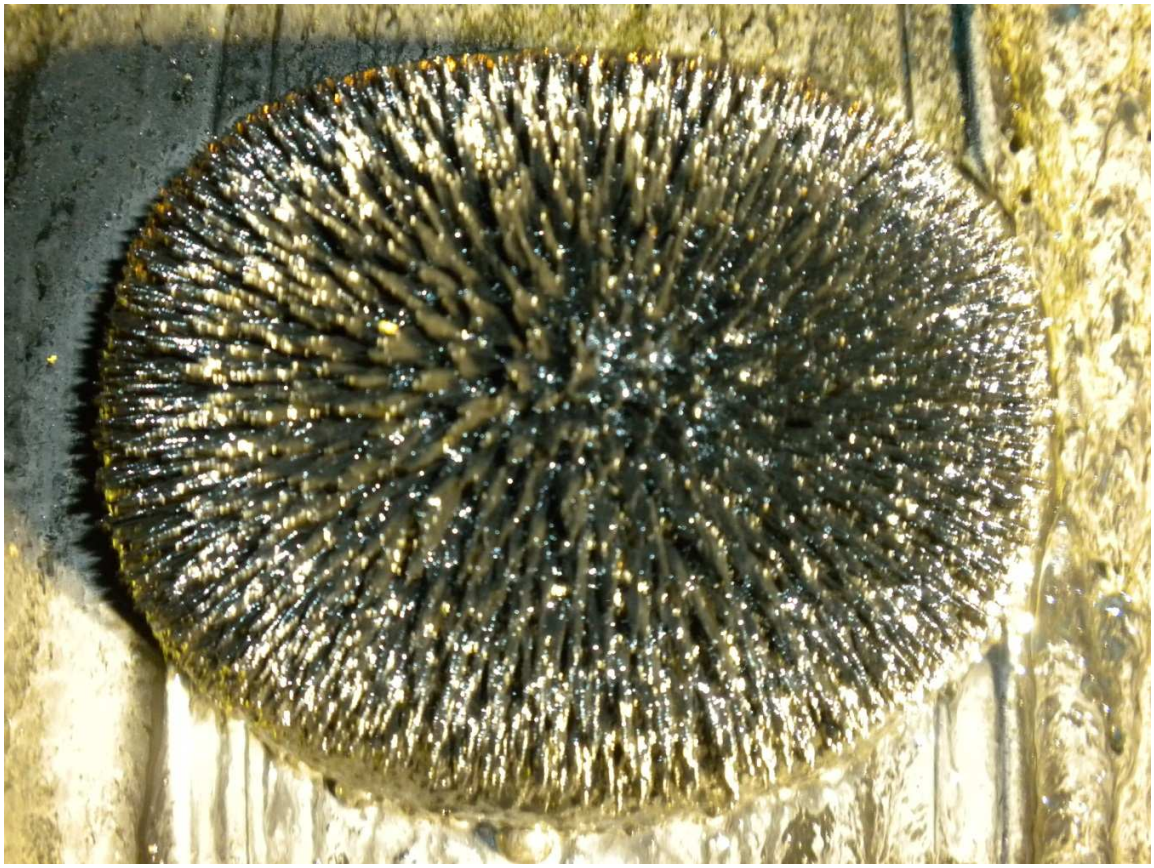

Figure 6: Metallic objects, welding debris and Black Powder buildup on the high strength magnets

The following day on October 10th 2012, a standard Hard-Bodied Cleaning Pig was run in the same Panola to Vernon 42 inch pipeline section

The standard Hard-Bodied Cleaning Pig was difficult to track at the normal pipeline gas flow speed. Gas flow velocity during this cleaning pig run was reduced by Enable to an average of 16.9 mph. The highest calculated gas flow velocity was approximately 17.4 mph. The average speed of the Hard-Bodied Cleaning Pig for the run was 17.16 mph. The pig arrived at the receiver at speeds in excess of 17 mph. The pig was in good condition.

Cleaning results: the standard Hard-Bodied Cleaning Pig brought in approximately 1 quart of liquids and no debris.

Figure 7: Standard Hard Bodied Cleaning Pig as received at Vernon

Conclusions

1. **A standard Cleaning Pig when run at high gas flow volume and high velocity may not thoroughly clean the pipeline**

2. **SCP cleaning tool performance is proven when compared to regular cleaning pigs**

   - The SCP tool is a more effective pipeline cleaning and maintenance tool at elevated gas velocities/volumes
   - Demonstrated a superior ability to clean pipelines because it runs at speeds friendly to cleaning
   - Liquids and debris movement is enhanced by the lower speed of the SCP tool
   - Does not skate (aquaplane or hydroplane) over liquids consequently does not leave potentially deleterious debris/liquids to remain in the pipeline which may result in internal corrosion and reduce operational efficiency
   - Reduces the impact of cups or discs jumping over girth welds which occurs at higher speeds
   - More tool weight means the tool cleans better
   - The tight seal design of multiple cups, discs and brushes seal and clean better
   - Gas movement through the speed control by-pass vanes on the front of the tool creates turbulence immediately in front of the tool thus creating additional drag to help slow the tool speed
   - 100% of the by-pass gas flow is jetting out in front of the tool and aimed at the pipe wall. The resulting turbulence provides excellent entrainment velocities and keeps liquids and debris in suspension and moving out ahead of the tool to the receiver
   - Unwanted liquids are delivered to the receiver for sampling and analysis and not left in the pipeline
   - Powerful Neodymium Iron Boron (NdFeB) rare earth magnets gather welding debris and metallic objects

3. **Gas Flow Delivery**

   - It has been shown that the SCP tool allows the pipeline operator to maintain full gas flow volume and velocity while more effectively cleaning the pipeline
   - Typical gas flow delivery comparison can be shown in the above Enable 93.2 mile 42 inch natural gas pipeline project. When using a standard cleaning pig it would have been necessary to reduce the 22 mph gas velocity by reducing gas flow from 1.563 Bcf to approximately .667 Bcf per day in order to achieve the desired cleaning effectiveness at the reduced cleaning pig speed of approximately 7.85 mph. By using the SCP cleaning tool, it was not necessary to reduce gas flow in the pipeline to achieve optimum line cleanliness. The equivalent 7.85 mph tool speed was achieved without reducing gas flow. This resulted in the ability to continue to deliver the additional .896 Bcf per day for the duration of the pig run, or 11 hours and 53 minutes. Therefore, in this case by using the SCP tool an additional .443 Bcf was available to be delivered to the customer

- A further example of gas flow delivery comparison can be shown in another recent 71.1 mile 42 inch natural gas pipeline project. When using a standard cleaning pig it would have been necessary to reduce the 21.62 mph gas velocity by reducing gas flow from 1.455 Bcf to approximately .525 Bcf per day in order to achieve the desired cleaning effectiveness at a reduced cleaning pig speed of approximately 7.7 mph. By using the SCP cleaning tool, the equivalent 7.7 mph tool speed was achieved without reducing gas flow. This resulted in the ability to continue to deliver the additional .930 Bcf per day for the duration of the pig run, or 9 hours and 14 minutes. Therefore, in this case by using the SCP tool an additional .358 Bcf was available to be delivered to the customer
- In a third example in another recent 105.77 mile 42 inch natural gas pipeline project when using a standard cleaning pig it would have been necessary to reduce the 18.71 mph gas velocity by reducing gas flow from 1.430 Bcf to approximately .535 Bcf per day in order to achieve the desired cleaning effectiveness at a reduced cleaning pig speed of approximately 7.05 mph. By using the SCP cleaning tool, the equivalent 7.05 mph tool speed was achieved without reducing gas flow. This resulted in the ability to continue to deliver the additional .895 Bcf per day for the duration of the pig run, or 13 hours. Therefore, in this case by using the SCP tool an additional .483 Bcf was available to be delivered to the customer
- These are but a few examples of the typical significant Gas Flow Delivery comparisons when using the SCP. This higher available gas volume allowed Enable to maintain reliable gas delivery to meet the demands of the downstream client base while cleaning the pipeline

4. Fuel Costs

- A clean pipeline delivers natural gas more efficiently; less horsepower is required to move an equivalent volume of gas. More throughput is achieved in a clean pipeline per compression horsepower required thereby resulting in a considerable savings in fuel costs

5. Additional Savings

- If we assume that cleaning a pipeline has a certain real value or cost, and by comparison if cleaning the pipeline at normal high gas flow volumes and high velocity with a standard cleaning pig only achieves 50% cleaning efficiency, the pipeline operator would need to run the pipeline at least twice with a standard cleaning pig for it to come close to achieving 100% cleaning efficiency. However, the pipeline operator would never get to 100% cleaning efficiency at normal high velocity pipeline flow speeds with a standard cleaning pig. Therefore, real savings come in only having to run the SCP tool one time to achieve maximum effective cleaning
- Provides optimum customer satisfaction with higher quality gas delivered
- Reduces maintenance costs such as filter replacements
- Avoids potential ILI re-run Charges

6. Standards of Cleanliness and Assurance of ILI piggability

- There is no Standard for “when is a pipeline clean?”
- The SCP cleaning tool removes contaminants and debris - the ideal breeding ground for conditions leading to internal corrosion

- The SCP provides maximum assurance that the pipeline is clean enough for ILI Integrity Management Surveys
- The SCP not only cleans the pipeline but also helps to prevent failed ILI tool runs by finding problems ahead of time with unknown appurtenances, partially closed valves, pipeline operating problems, flow issues, operator error and Black Powder
- The SCP provides the assurance of optimum ILI run results and improves ILI run success

Figure 8: SCP 42 inch tool cleaned and ready for launch in the next pipeline section at Vernon

Summary Advantages of the SCP tool:

- Proven to be a more effective pipeline cleaning and maintenance tool for higher gas flow velocity pipelines
- Particularly justified for cleaning high gas volume pipelines without having to reduce gas flow
- Enhances pipeline integrity - having the cleanest possible pipeline avoids less than satisfactory ILI results and the risk of missed or miscalled pipeline anomalies
- Provides a controlled tool speed platform for add-on Pipeline Evaluation Tool options

- Provides a platform vehicle for alternative pipeline cleaning methods with either multiple cleaning discs and wire brushes or Prostran cleaning brushes for coated pipe
- Promotes Safety - provides cleaning tool movement and trapping at safe and manageable speeds
- Easy to launch, retrieve and clean
- Easy to track due to a predictable tool speed, on-board Transmitters, and Magnetic or Geophone tracking response
- Capable of long distance pipeline runs
- A tough, rugged and durable pipeline tool with proven survivability
- Provides a service based alternative to the pipeline operator buying and maintaining cleaning pigs
- Provides speed control for towing a broad range of maintenance or ILI tools
- A clean pipeline lowers risk and offers compliance with any regulatory cleaning requirements
- Peace of mind; a clean pipeline is safe and environmentally friendly

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