

# THE USE OF CLEANING PIGS TO INSPECT PIPELINES

**A basic introduction to what can be achieved using cleaning pigs to inspect operational hydrocarbon pipelines**

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## **Abstract**

Cleaning pigs have been used successfully for over a hundred years to remove debris deposits from the internal surfaces of hydrocarbon pipelines. Recently, with the advances in miniaturisation of electronics and improvements in data processing techniques, companies such as RST Projects Limited have pioneered their use as inspection tools. This paper summaries how traditional cleaning pigs can be used to inspect pipelines.



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## **INTRODUCTION**

Pipeline cleaning pigs are used routinely within operational pipelines. In oil pipelines they are used to manage the build-up of deposits such as wax. In gas pipelines they can be used to control liquid inventories. In new lines they can be used to remove construction debris. Depending upon the severity of the application their deployment can vary from every few hours in the worst cases, through to weekly, or monthly, in waxy crude pipelines. In the case of dry gas pipelines their deployment may be only every year or so, and in some cases never.

In 1990 a major joint industry research and development program was established to examine in more detail exactly how cleaning pigs work. This revealed the importance of factors such as the differential pressure across a pig and how this varies depending upon the pig speed, type, disk material and other factors. This work also demonstrated that pig behaviour could be dependent upon the environment within which it was travelling.

In the mid 1990's this was developed further. Companies, such as RST, invested heavily in developing cleaning pig based tooling which could be used to inspect pipelines. The idea went;

*“if the behaviour of a cleaning pig is effected by the pipeline environment, and if changes in this behaviour can be measured, then this provides a means of identifying features which are present within the pipeline”*

It is this idea, which has resulted in the development, and subsequent successful use of tools such as RST's SAAM™ pipeline inspection system.

## **DATA LOGGING AND PIPELINE INSPECTION**

It is important at this point to make a very clear distinction between data logging and pipeline inspection. These two terms are regularly confused by many within industry. A data logger is a device which captures data (whatever it may be). It has no intelligence and puts the onus on the end user to develop any meaning whatsoever from the data acquired. Pipeline inspection, whether it be by Intelligent Pig or Cleaning Pig, involves the analysis and interpretation of data acquired from the survey. By this, the inspection provider takes the data from the inspection tool and interprets it. The end user is then presented with findings which details the results of the survey in a meaningful and comprehensive way.

## **THE THEORY**

To understand how a cleaning pig can be used to inspect a pipeline, it is firstly necessary to understanding something of how a pig actually travels along a pipeline. When this pig travels along a pipeline a number of things will occur. The first thing that will happen is that it will support a certain amount of differential pressure. This means that the pressure at the rear of the pig will be greater than that at the front. When this pressure differential is sufficiently great to overcome the static frictional forces between the pipe wall and seals of the pig, then the pig will move. The running friction will be

significantly less (typically a factor of 2 or 3). With the pig moving, the next thing that will happen is that the contact between the seals and pipe will generate noise and will cause the pig to vibrate. The pig will then acquire a certain attitude within the pipeline, typically with its nose pointing slightly downwards.

Therefore, a pig travelling along a straight clean pipeline will support a certain amount of differential pressure, make a certain amount of noise, vibrate in a particular way, and travel with its nose in at a certain angle.

So what happens when the pig passes a bend or say, a girth weld. Well, in the case of bend the differential pressure will increase markedly. In the case of a girth weld it will cause the pig to vibrate differently.

Of more interest, would be its behaviour when it passes, say, a dent. As the pig hits the dent the differential pressure across it increases significantly. Virtually at the same time the pig momentarily slows down as it hits the dent and then speeds up. The pig also vibrates significantly as it passes the dent. So, in effect a signature for a dent within the pipeline has been developed. This approach can be extended to any other feature which causes the pig behaviour to change.

Instrumentation packages (such as RST's SAAM™) have been developed to specially log this type of data, much in the same way that a flight data recorder does on an aircraft. Subsequent post processing of this data can then be used to reveal the presence of features within pipelines.

## **CAPABILITIES**

As this type of technology is still relatively new it is often difficult to differentiate between what an inspection provider claims to be capable of doing and what has actually been proven. Summarised below are some of the known capabilities:

### **Position Fixing**

Accurate positioning of features within a pipeline can be achieved. Systems such as RST's SAAM™ tooling work on the basis of identifying girth welds. These are readily identifiable from the unique vibration signature generated at each weld. KP along the pipeline is then derived from the weld count and features located relative to each weld. Not all systems are capable of doing this. The Impact logger (marketed by Copipe and others) cannot detect every weld by virtue of limitation in terms of its sampling frequency (only 1Hz max) and method of measuring shock. Tools such as these rely upon the use of odometer wheels. These can have problems of accuracy particularly in waxy crude lines.

### **Component Identification**

Individual component parts of a pipeline can be identified. The behaviour of a Cleaning Pig through a tee, wye, bend, valve, etc, will produce an unique signature. These signatures can be compared with a database of known features. This means that a simple data book of pipeline parts can be produced.

## **Pipeline Mapping**

Cleaning pig deployed inspection system can be used to develop vertical profiles of the pipeline. This is achieved by taking the gravitational component of an accelerometer, combining this with the known local velocity (either taken from the weld count or from an odometer wheel), and using a simple numerical integration to generate the shape. More recent developments have resulted in the ability to add these localised profiles together to produce strip maps. This type of approach is remarkably accurate and will produce vertical profiles to a similar quoted accuracy as other mapping tools such as the Geopig.

## **Dent Detection**

Changes in the internal diameter (or bore) of the pipeline can be readily detected. For example, heavy walled pipe sections (such as risers) which have a narrower bore, show up clearly as an increase in the drive differential pressure. Bore reductions of as little as 0.4% of the pipe diameter have been detected. Also, the presence of dents induce clear and readily recognisable signatures. Rough approximations of the size of dents can then be prepared.

## **Wax Detection**

The presence of a wax formation zone shows up clearly. As the oil cools wax will drop out of solution and form a layer on the internal pipe surface. This will occur at the wax formation temperature. At this point the behaviour of the pig will change dramatically. It will begin to pitch quite significantly, its differential pressure will fluctuate and it will begin to vibrate. So, when deployed on-board a cleaning pig changes in position of this zone can be monitored and tracked.

## **Condition Assessment**

Subtle changes in the behaviour of pigs can be identified. These changes are known often to relate to some form of localised change to the internal condition of the pipeline. For example, it is known that the presence of features such as an increase in surface roughness or the presence of a coating (such as a hard wax or scale), will cause such changes. Analysis of survey data will result in the pipeline being broken down into every single pipe spool and tagged. These local changes can then be tied-in with a pipe spool. Subsequent surveys of the pipeline will enable monitoring of these spools to be carried out to identify any subsequent changes.

Another use of this type of survey is in developing an overall Condition Histogram of the pipeline. This histogram presents graphically a statistical spread of the size of local pipe spool anomalies relative to a moving average of the 25 pipe spools either side of it. In effect it presents the severity of local changes in the pipeline condition. The shape of this histogram gives an overall assessment of the condition of the line. For example, it has been found that pipelines in good condition with few genuine significant anomalies will produce a profile with approximately 6% of the pipe spools generating a response greater than +2 standard deviations for the mean. For old lines in generally poor

condition this percentage will increase. Conversely for relatively new, well maintained lines this percentage will be less.

## **Trend Monitoring**

The ability to easily deploy inspection tools on-board cleaning pigs in an inexpensive and low risk way means that it becomes *'practical'* to inspect and monitor changes in the pipeline over relatively short time scales. For example, it is feasible to deploy a system every 6 months or even more frequently, should the situation so require it. This means trends associated with all of the previously defined detection capabilities can be quickly established.

## **HOW CAN IT BE USED?**

The beauty of this type of technology is that it is very easy to use. As it is deployed on-board cleaning pigs, it means it can be incorporated within a routine pigging programme. In fact, often when these tools are used, once they have been approved by the client, the operators in the field are not aware that the cleaning pig has the inspection tool on-board. Some of these tools operate via a pressure switch. This means that for routine surveys the tool can be set up and installed within the pig onshore. The unit can be shipped and run through the line without the need for an operator to set up the tool on site. This negates the need for costly platform beds and helicopter space. At the end of the survey the pig can be returned to shore where the data can be offloaded and analysed.

An alternative use of this type of inspection technology is its deployment on-board gauging pigs either in newly laid lines or older lines which are being made ready for an Intelligent Pig survey. In such cases analysis of the data can provide invaluable information of the status of the pipeline, including details of what components are present within the line, the radii of bends and the location of features which may make the deployment of the Intelligent Pig problematic.

## **BENEFITS AND LIMITATIONS**

The main benefits with using cleaning pigs to inspect and monitor pipelines are:

1. Easy of deployment
2. Relatively low cost
3. Field proven, 000's of Km's having been surveyed
4. Virtually no additional risk over and above the planned cleaning pig run.
5. Trend monitoring capabilities
6. Assist in prioritising the use of IP's
7. Provide early warning of formation of serious problems.
8. Deployed in less strategically important pipelines.
9. Deployed to fault find and diagnose problems.

The main limitations with using cleaning pigs to inspect and monitor pipelines are:

1. No measure of wall thickness is currently possible.

2. Not as accurate as Caliper tools.
3. The results are only as good as the company doing the interpretation.
4. Currently best in oil. Experiences in gas and multiphase lines are limited.

## **CONCLUSIONS**

The use of Cleaning Pigs to inspect pipelines offers the pipeline owner operators with an alternative to existing inspection technologies. They can provide information on many features within a pipeline. The cost and ease of deployment makes them attractive for use in lines which have never been inspected. They can also be used in strategically important lines to ensure that no significant changes have occurred between the deployment of Intelligent Pigs.

However, there are a number of important points to remember. Their use should not be treated as a 'DIY inspection'. Maximum value can only be obtained from a Cleaning Pig survey if the appropriate analysis is carried out. This involves high level data processing and is best carried out by the inspection company. Also, make sure the right instrumentation is specified. If this is not done then the precise features which the survey is looking to find may be missed.

To sum up. The use of Cleaning Pigs to inspect pipelines is a new technology. The full limits of what can be achieved have yet to be established. However, it is clear that it does represent a useful addition to traditional pipeline inspection means and one which will develop further in the coming years.

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