CLEANING OF OIL & GAS PIPELINES
ON-LINE & OFF-LINE

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Summary:

The outcome of the last Pipeline and Pigging Conference in Houston, February 2003, could be summarized in one major topic "Pipeline Integrity Management", also in Europe this issue will be most important, especially regarding all the legislation and governmental regulations which are applicable or will be applicable in a short period of time. Pipeline owners and operators have to be aware of the integrity of their lines, because in case of a failure they have to prove that their line was "fit for purpose"!

Knowing this, in-line inspection of the pipeline has to be applied, and before such inspection is executed, the line has to be clean. During the above mentioned Conference there was concluded "The cleaner, the better"!

So, the deviated topic for this presentation is "The cleaner, the better" and the central question during the whole presentation is "do pipelines need cleaning?" After the presentation, all of you could answer this question and I already know what it will be.

Total Cleaning	>>	the right conditions for in-line inspection
In-line Inspection	>>	correct readings and data collecting
Pipeline Integrity	>>	Interpretation of the data, resulting in acceptable or not
Safeguarded Production	>>	Operator/owner can anticipate on the future in time!

Every day there is a considerable amount of time and money spent on making mechanical pigging runs in pipelines, typically they are run for more than one reason:

- Cleaning the internal pipe wall surface;
- Removing free solids and debris;
- Gathering data about the integrity;
- Applying some sort of chemistry to the inside surface of the pipeline.

By adding special fluids to this process, the effectiveness of these runs can be enhanced:

- improving flow conditions;
- reducing differential pressures;
- removing more solids per run (more solids than 50 pig runs would achieve);
- reducing the risk of pigs getting stuck;
- optimizing chemical inhibition programs.

This paper will discuss the typical pipeline pig's design, this includes the different shapes of the components and materials used relate to the performance of the pig as it makes its journey through the line. Various limitations of pigs will be outlined due to their physical design versus the geometric shape of the surface to be cleaned. The limitations of commonly used solvents will be discussed along with what is required to make cleaning fluids more efficient.

Introduction:

Pipeline pigging has become an important part of pipeline maintenance programs since the first pigs were run to keep an opening in the pipeline. From the first simple pigs that were run, consisting of straw balls wrapped in leather, they have evolved to the interesting and complicated designs we see today. Specific pigs have been developed to perform different

functions such as drying, cleaning, batching, gauging, applying films etc. etc. The efficiency they perform these tasks has improved over time to a point where further improvement may be beyond the design of the pigs themselves.

During the pipeline cleaning runs a number of common solvents have been added and run in conjunction with the pigs to aid in the cleaning of these lines. These products help in certain aspects of the cleaning runs but were never designed to do more than dissolve some of the materials that were trying to be removed from the interior surface of the pipe wall. With special fluids that have been developed, which are designed to breakdown, suspend solids, and reduce surface tension, the cleaning programs can be enhanced.

Background:

There are generally three main reasons for cleaning an active pipeline. They consist of improving the line flow efficiency, improve or insure good data on inspection tool runs, and to improve the results of chemical programs to increase the lifetime of the pipeline.

The flow efficiency of a pipeline as far as cleanliness is concerned, is based on the internal diameter of the pipeline and the friction that the pipe wall surface applies to the product moving it through it. By pigging the pipeline routinely, the internal diameter of the pipeline can be maintained. However sometimes the mechanical force of the pigs to the pipe wall surface is not enough to remove the materials that have build

up on the walls. A fluid to break down the contaminant and carry it out of the line is required. Also the presence of a contaminant on the pipe wall can create a reduction in efficiency even though the ID of the

pipe has not been substantially reduced. The surface roughness of these materials can tend to apply friction to the product being transported through the pipeline and create a backpressure.

The cleanliness of the pipeline is a big concern when it comes to running In-line Inspection Tools, due to the high cost of a miss-run or damage to the Inspection Company's equipment. The safe passage of these pigs and insuring the best possible data is recorded is very important. Debris on the pipe wall surface can cause sensor lift-off, which can have detrimental effects on the tool being able to accurately measure an anomaly in steel. It can also pack into the ILI tool mechanical components causing problems in it, being able to navigate through various components of the pipeline system.

Contamination in the internal pits, which cannot be cleaned out easily if at all by pigging alone, will have a negative effect on the ILI tools ability to accurately measure the size and depth of the pit. By introducing a fluid designed to disperse these solids from the pipe surface and pits, a clean metal surface can be established. This can be accomplished by reducing the adhesive characteristics of the deposit allowing it to be flushed from the system with fluid.

Chemical inhibition programs can be a very expensive part of a pipeline integrity program. Whether a batch or continuous injection method applies the chemistry, if the chemical cannot get to the metal surface it is trying to protect or the colony it is designated to kill, you could be getting a false sense of security thinking these programs are working. Properly cleaning of the pipe wall surface prior to applying any chemistry will insure that the products are actually getting to the problem you are trying to treat.

Some other reasons to enhance a pigging program include: removing more solids per run, reduce the differentials per run and to reduce the chances of getting pigs stuck on runs with heavy debris in the pipeline.

General characteristics of cleaning pigs:

Cleaning pigs are generally designed to push any loose material through the pipeline and to apply a mechanical force between the pig and the pipe wall surface to remove debris that can be easily removed. They typically will be composed of a combination of a wiping/sealing surfaces made up of discs, cups or foam with brushes mounted on them made out various materials. Some pig designs will have controlled by-pass to try and keep some solids in suspension.

The design of the wiping or sealing surface of the cleaning pig will have an effect on how efficiently it will be able to remove or carry debris down the pipeline. The properties that have an effect on the cleaning efficiency, which work in conjunction with each other, are:

- Diameter of the material. In order to propel the pigs through the pipeline, an effective seal must be maintained. The diameter of the sealing surface in relation to the inside diameter of the pipeline will have a great effect on the amount of pressure exerted on the surface to be cleaned.

- Hardness or type material. The hardness or how pliable the sealing surface is will have an effect on the force applied to the pipeline wall. The correct hardness is a balance between the effective cleaning that is desired to be accomplished during the run and being able to negotiate any deviations in the pipelines internal diameter that are normally encountered. The type of material the pig is made out, will have an effect on how quickly the material will wear out. This in turn will have a bearing on how efficient the pig is running near the end of longer runs.

- Thickness of the material. Effectively determines the amount of contact with the pipe surface the pig will make with the pipe wall during the run. The thicker the material the more cleaning surface is applied per run and the more rigid the material becomes.

- Shape of the contact edge. The shape of the leading edge of the cup or disc will have a role in the amount of material can be removed from the pipeline and how effectively it will remove loosely adhered material from the surface to be cleaned. The more perpendicular the edge of the cleaning surface to the pipe wall the more effective it becomes. As the edge becomes more conical, more debris will be run over and actually put back on the surface you are trying to clean.

- Velocity of the pig. The speed at which the pig travels through the line will have a large effect on how much material can be brought out of the line. In general the faster the pig travels the less efficient it becomes in being able to carry material in front of it. In filming applications you can actually control the thickness of the film you are applying with speed control. The faster the pigs run through the line the thicker the film is applied. Brushes in general are fairly good at keeping the pipe wall surface clean, but are not overly effective at cleaning into the pits. The effectiveness of the brushes are normally determined by:

- Shape and style of brush. There are many shapes and styles of brushes that have been run on pigs. The more common are the wire wheel, brushes fastened to plates mounted on spring arms and brushes embedded into the material the pig is made of. The number of bristles that comprise the brush will have a big effect on how much cleaning can be done per run. In most brushes the bristles are mounted in a curved plane so they tend to be fairly effective at cleaning the pipe wall surface they were designed for. However because they are on a plane, the individual bristles are unable

  to get into deep narrow pits to clean them out as they restricted by the adjacent bristles that hold the whole brush out.

- How brushes are mounted. The brushes should be mounted on the pipeline pig to insure full 360º wall coverage. The best place for the brushes to be mounted is on the rear of the pig with no sealing surfaces behind it. Once the material has been removed from the pipe wall surface, any sealing surfaces coming behind the brush will tend to put the contaminant removed back onto the wall and in the pits. Also brushes run behind the pig tend to clean themselves while brushes located between sealing surfaces can pack up if any volume of debris is encountered.

- Size of brush bristles. The size of the bristles will have an effect on the size of anomaly that they will be able to clean. The larger the bristle the more difficulty it will have getting into smaller pits. The smaller the bristle the more flexible it becomes making it difficult to apply much force to the material to be removed.

- Stiffness of material in brush versus material to be removed. The harder the material to be removed from the pipe wall the more aggressive brush is required for mechanical cleaning alone. Some of the material found in pipelines become so hard and tightly adhered that the brushes that would be required to remove it can cause physical damage to the surface that is trying to be cleaned. In cases like these developing a method to soften the material to be removed would be a better option.

Pipelines pigs can be very good when used properly at doing the things they were designed to do. There are a number of problems encountered while cleaning a pipeline that the pigs are not able to do that cleaning solutions can be designed for. They include:

- Penetrating solids. The pigs can only apply a mechanical force to the material trying to be removed and will have no effect on softening, dissolving or releasing and preventing the material from re-adhering to the pipe wall.

- Suspending large volumes of solids in fluid columns. Some pigs have been modified to have bypass ports built into the pigs or cup surface to allow a controlled liquid or gas flow through the pig. This is to help carry more solids in suspension or help reduce the differential pressure, should the solids begin building up in front of the pig. These ports will have some effect on the material directly in front of the pig but do not help suspend or reduce DP once the material gets very far in front of the pig.

- Getting deep into the pits. The pig cups/discs and brushes because of design are not physically capable of getting into deep narrow pits. In fact the material that has just been removed can be driven in tighter to these areas by the sealing surfaces.

- Coat solids to keep them from sticking to each other. The pipeline pigs running down a pipeline will have no effect on preventing some materials from packing up ahead of it due to its adhesive nature. It will tend to smear back onto the pipe wall surface and stick to itself causing increased DP's and pigs to become stuck.

- Brings solids out in a slurry. Other than a bit of bypass designed into the pig itself, they will not have an appreciable effect on making the material being removed into a slurry.

By adding pipeline-cleaning compounds that have been specially formulated to address each of these issues, the physical limitations of the design of cleaning pigs can be overcome. As an

added benefit these solutions can actually reduce the amount of friction on the pig allowing the pigs to have a longer effective life.

Conclusions:

Cleaning pipelines by using advanced chemicals with specific cleaning characteristics is preferred versus the mechanical cleaning, the benefits to be gained will far outweigh the cost, by improved flow, efficiency, inspection results and chemical programs.