

Methodology for the Evaluation of Batch Corrosion Inhibitor Films and their Integrity

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ABSTRACT

Proper maintenance of pipelines reduces the occurrences of failures due to internal corrosion to a remarkable degree. Primarily, the two methods employed in maintaining a pipeline are mechanical cleaning (pigging) and chemical treatment, (corrosion inhibitors & biocides) often used in combination. The technique known as batch filming uses a “pill” of concentrated chemical contained between two pipeline pigs; a lead pig and a filming pig (referred to as a pig “train”). In theory, the filming pig allows a small volume of chemical to continuously bypass the rear of the filming pig as the train moves down the pipe. This method is intended to coat the inner surface of the pipeline in a uniform layer of protective corrosion inhibitor. In practice it is very difficult for operators to determine the consistency of the coverage, and the thickness of the film deposited by a batch filming procedure. It is also very challenging to determine how long the chemical film can remain effective after it has been applied, especially if subsequent cleaning pigs are used as part of the maintenance schedule. To replicate the batch filming process at a pilot scale, a flow loop was modified with the capabilities of launching multiple 4” (10 cm) diameter pipeline pigs. The discussed methodology enabled researchers to batch film a pipe and analyze the thickness/coverage of the coating while varying specific parameters (contact time, pig design, chemical type and dilution ratio). The method also allowed for the observation of the effect of various cleaning pigs on the integrity of the applied film. The test scheme may provide valuable information to pipeline operators and chemical vendors about the use of batch filming and its reliability, as well as providing design insight to pig manufacturers.

Key words: Pigging, pipeline integrity, pipeline maintenance, inhibitors, Filming pigs

INTRODUCTION

In previous studies, InnoTech Alberta has explored the effectiveness of various cleaning pig designs through a devised test method involving the use of a flow loop.⁵ Following successful development and application of the test method, more challenges involving pigging practices were explored. As stated in previous works,⁵ maintenance pigging and inhibitor application are the two main methods to prevent internal corrosion of pipelines. Inhibitor application typically comes in one of two forms: continuous injection, and batch filming.⁶ With continuous injection, the chemical is dosed at a controlled rate into the pipeline and travels downstream with the fluid. This method is sometimes used when bottom of the pipe corrosion is the main issue. In this case the chemical should be denser than the carrier fluid, allowing it to flow along the bottom of the pipe, reaching the problematic areas.

In batch inhibition, the concentrated corrosion inhibitor chemical is filled between two pigs that move together contacting the full inner surface of the pipeline. Several companies promote the use of specially designed leading and filming pigs as designated sets for inhibitor film application. As with cleaning pigs, specific designs are often sold based on the recommendations of the suppliers and standardized third party validation of pig designs is not typically pursued.

When batch filming corrosion inhibitors between two pigs, the intention is to leave a thin but sufficient layer of chemical adhered to the internal surface of the pipe. A downfall of this form of application is that there is little indication that the layer was applied uniformly down the length of the pipe, also there are no clear signs identifying when that layer must be reapplied. From an economic perspective, the operator also has difficulty in determining if too much chemical (unnecessary expenses) or too little chemical (increased chance of corrosion incidences) was purchased for application. In the event that the chemical required infrequent reapplication, cost savings could be realized by lengthening the time between batching operations. There are also other cost reducing variables such as manipulating contact time (chemical volume dependent) and increasing the chemical dilution ratio when mixed with diesel or condensate.

There is currently no standard method to measure applied inhibitor film thickness in a working pipeline. Despite this, the industry often cites chemical application targets in terms of a film thickness measurement. The amount of chemical being purchased is often related to this intended film thickness and the dimensions of the pipe being inhibited. Operators looking to both decrease their maintenance expenses and gain confidence in their corrosion mitigation strategies would benefit from the pilot scale studies described in this paper. In order to gain insight into how the film coating is applied for a given set of variables, a standard test method must be created. The complexities of the batch filming application such as filming pig design and the effect of passing cleaning pigs over the applied film require no less than a pilot scale flow loop test to perform.

The proposed test method is expected to benefit the industry by providing insight into

- Applied film layer thickness
- Coverage and consistency of the film layer
- Assessment of the influence of variables such as contact time, flow velocity, chemical type, pig design, chemical dilution ratio
- The persistency of the film layer once applied versus flow and the use of cleaning pigs

EXPERIMENTAL APPARATUS

Pipeline Pigs

Batch filming pigs were selected based on their providers' descriptions and bought in sets including a lead pig with a tight seal against the internal pipe wall, and the filming pig designed in such a way as to allow some bypass of chemical as it travels down the pipe. The design of the filming pig is based on the hypothesis that as the pair of pigs (train) containing the chemical (pill) travels down the pipeline, chemical will bypass the filming pig and the two pigs will slowly come together as the chemical is applied to the pipe wall (Figure 1). It is believed that to achieve this, the rear pig must be either sized appropriately or have features that allow for fluid to slip around the pig in a controlled manner.

This test method allows for the use of any reasonable pipeline pig design to be either a lead pig or filming pig and provides results to determine if the design is satisfactory for its intended function.

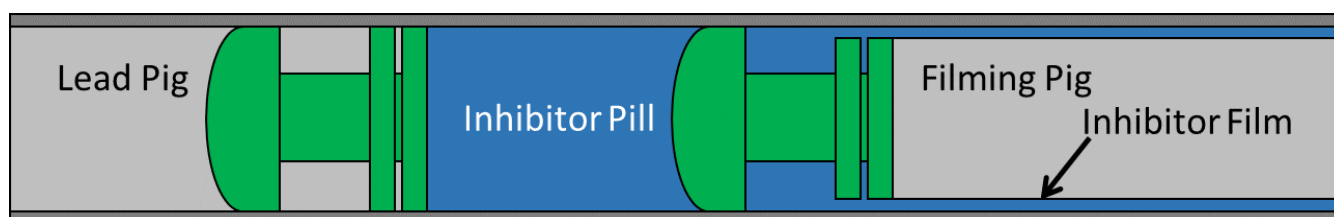


Figure 1: Cartoon representation of the intended application of inhibitor film within a pipe via the use of pigs.

Flow Loop

A recirculating flow loop capable of launching 4" diameter pigs previously developed at InnoTech Alberta Devon Facility, was modified to allow for the launching and trapping of multiple pigs within a single operation. The flow loop had been designed originally for corrosion monitoring studies pertaining to under deposit and microbial influenced corrosion (UD/MIC) and is fully instrumented with control of flow rate, safety interlocks for over-pressure, low/high flow prevention etc. (Figure 2, Figure 3).

The flow loop length was extended to allow for the possibility of running filming trains with a 10 second contact time (time between lead and filming pigs at a given point in the pipeline) while moving at a steady manageable velocity (4-12 in/s or 10-30 cm/s).

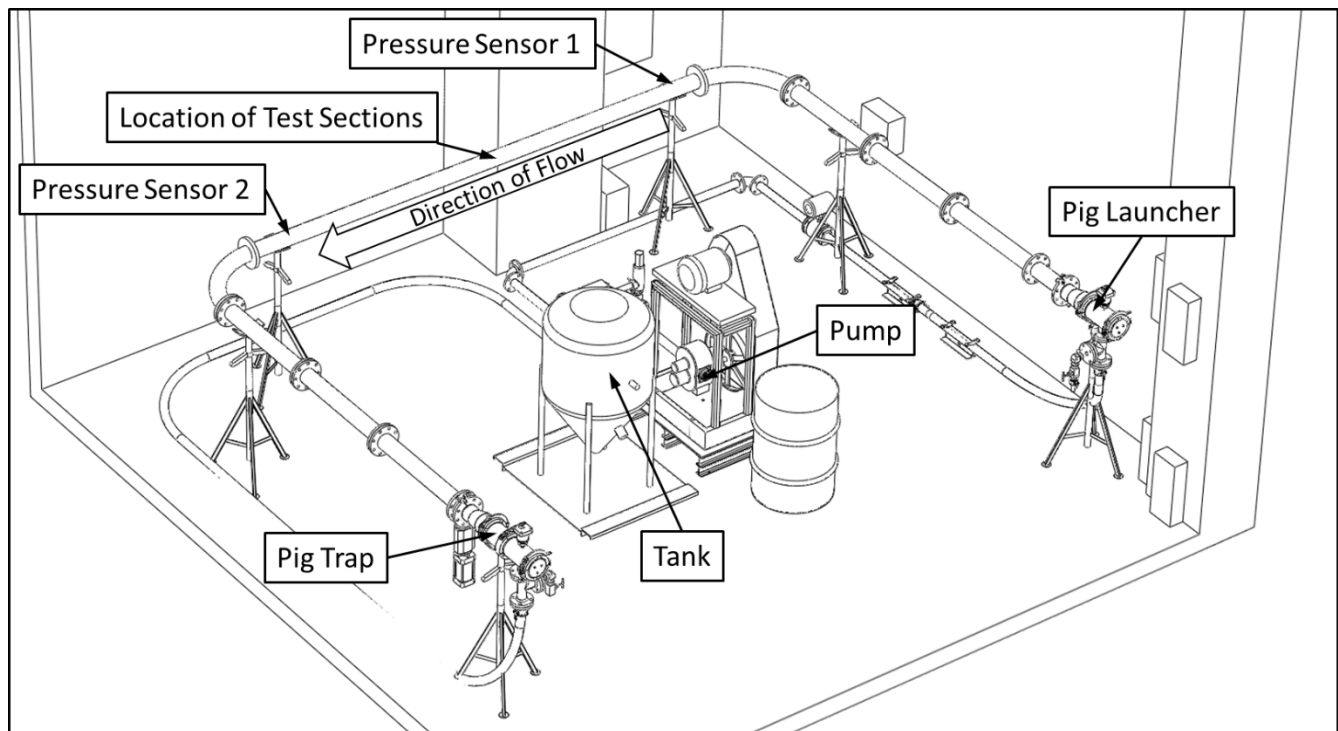


Figure 2: Schematic of the flow loop used for the development of the discussed test method located in Devon, AB (some parts omitted for clarity).

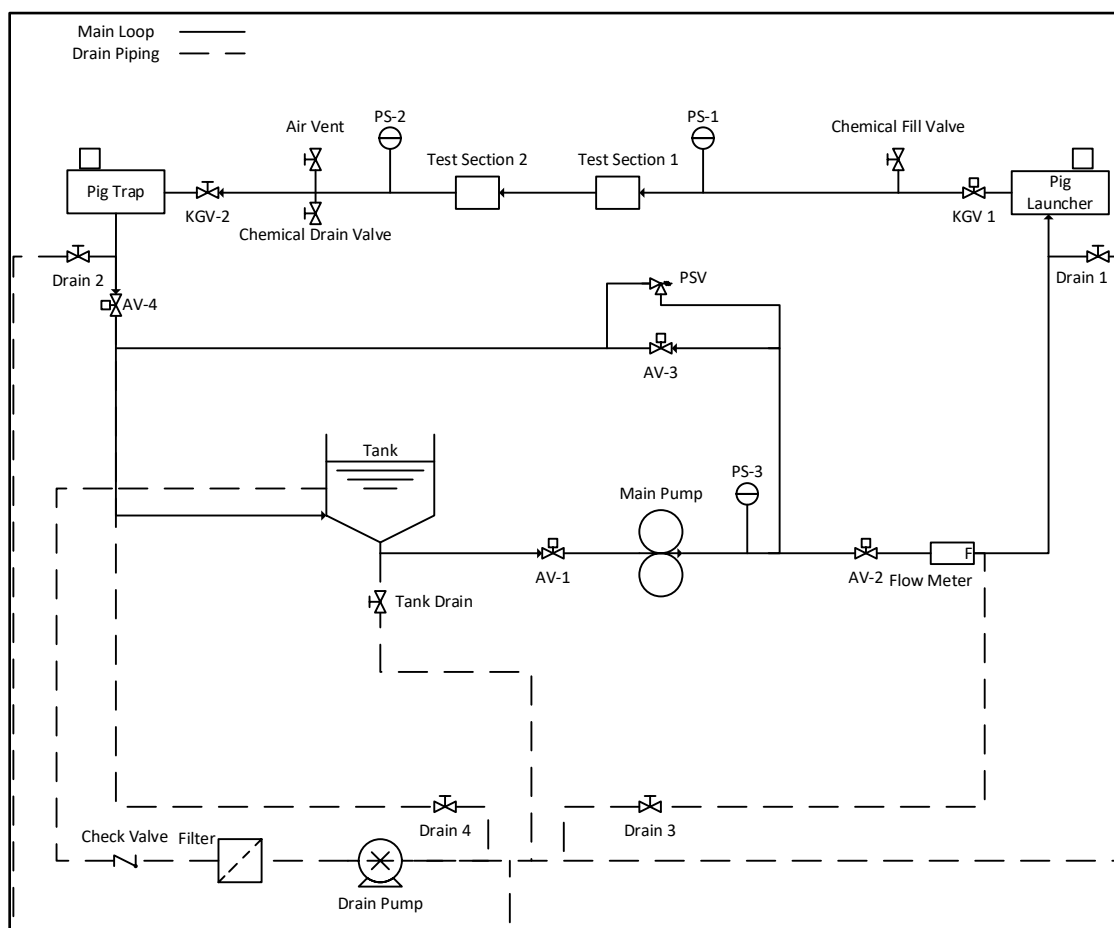


Figure 3: Simplified piping and instrumentation diagram for the flow loop shown in Figure 2.

During commissioning, the various pig configurations were run with different pump RPM set points to build velocity versus pump speed calibration curves. Although a positive displacement pump (gear pump) controlled with a VFD was used, each pig set was seen to travel at different speeds for the same RPM, possibly due to pressure and fluid bypass fluctuations (Figure 4). Since filming pig are intended to work on the premise of allowing some level of fluid bypass, it is important to note that the pigs will not move with the same velocity as the pumped fluid and may not move until a minimum driving pressure is achieved (different for each pig design/combination).

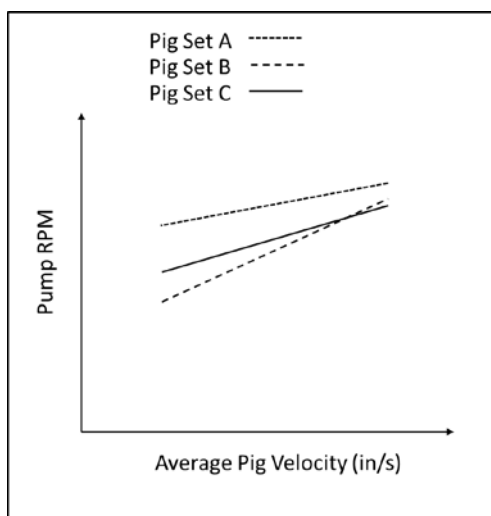


Figure 4: Example plot of pig velocity versus pump speed, demonstrated for various hypothetical combinations of pigs.

A segment of clear PVC piping was installed just upstream of the pig trap (Figure 5). This allowed for visual observation of the pigs as they approached the end of the flow loop and was also the location of a drain port (bottom) and an air intake valve (top). The use of these valves is discussed in the Setup and Filming section of this report.



Figure 5: Image of filming pig inside clear PVC pipe section during the commissioning phase of the project with sludge debris in front of the pig (travel from right to left).