**Pigging and chemical treatment for oil and gas pipe lines**

Combine the two to minimize corrosion damage, maximize operating efficiency and reduce chemical treatment costs


CHEMICALS USED in treating oil and gas pipe lines, such as sour point depressants, flow improvers, corrosion inhibitors, biocides and gas hydrate prevention products, are often applied using pigs to enhance their performance and efficiency, and to supplement their action.

Pigs are used to remove paraffin deposits, apply corrosion inhibitors, clean deposits from the line, and keep out accumulations of water where bacteria grow and corrosion occurs. Bacteria generate hydrogen sulfide, cause corrosion, and produce plugging slimes and solids in the fluids.

Of equal value is a pig’s ability to remove sand, chalk, rust and scale deposits from inside the pipe line, which can cause under-deposit corrosion, a major form of accelerated corrosion, similar to pitting.

**Paraffin treating.** Paraffin treating compounds are used primarily to reduce the viscosity of an oil, to minimize paraffin deposition on the pipe walls, and to minimize plugging of instrumentation and metering equipment. Two types of paraffin treating compounds are used in pipe lines:

- Crystal modifiers
- Dispersants.

Crystal modifiers function by changing the paraffin crystal shape and surface energy. This makes the crystals less likely to attach to the pipe walls, or each other. Also the crystal size remains so small that the crystals are less prone to sedimentation and agglomeration. For this reason, crystal modifiers are known as pour-point depressants or flow improvers.

Dispersants are surfactant compounds which alter the surface energy of paraffin crystals, again making them less attractive to each other and to the pipe walls. Both crystal modification and dispersion cause a reduction in the rate of paraffin fouling on the pipe walls. Typical use rates for both types of paraffin compounds range from 100 to 200 ppm.

Crystal modifiers must be added continuously at a temperature above the oil cloud point to be effective. The cloud point is that temperature at which the oil becomes cloudy due to precipitation of paraffin crystals, representing the solubility limit of paraffin in the oil.

The cloud point is not the same as the pour-point of the oil, which is the temperature at which the oil no longer pours out of a beaker under standard conditions. Oil below the pour-point is still pumpable.

Low flow conditions, with complete cooling, cause greater paraffin deposition. Once deposited, however, paraffin will not redissolve when the oil is below the cloud point, or solubility limit of paraffin in the oil. It must be removed either by solvent-dispersant chemicals, or by mechanical, and/or thermal methods.

**Paraffin control using pigs.** Pigs are routinely used to control paraffin formation on pipe surfaces. There are many different pig designs used for removing paraffin, such as Polly Pigs, spheres and mandrel pigs equipped with scraper and conical cups, discs or a combination of both. The pig has two functions in this application:

- To scrape the adhered wax from the pipe wall
- To remove deposits from the pipe line.

The interaction of a pig’s surface bearing area against the pipe wall causes a shearing or scraping effect. Bypassing the pig assists in suspending debris in the oil, which helps carry it out of the line. Hard wax deposits can be removed by pigs equipped with wire brushes, scraping discs and other cleaning devices. The pig’s ability to remove wax is not necessarily determined by its tight-sealing capability, as in a batching operation, but by its cutting, scraping or pushing characteristics.

**Combined pigging and chemical paraffin treatment.** Theoretically, a chemical treatment program or pigging alone could be adequate in controlling paraffin formation. But, in actual operating conditions, neither method can offer a complete guarantee. This is especially true in pipe lines that carry oil with high cloud points, low flow velocities and high paraffinic or asphaltene characteristics.

The rate of buildup can be so aggressive that the amount of chemicals necessary are cost prohibitive. In addition, some paraffins exist which are difficult to treat fully. The deposition rate can be so rapid that pig runs are not frequent enough to keep up with the growth.

A well developed paraffin control program combines pigging with chemical treatment, since neither treatment alone is likely to provide all the benefits of a combination program. The principles followed in paraffin control programs are:

- Paraffin deposition rates are greatest when chemicals are not used
- The cost for complete chemical inhibition of paraffins can be very high.

Pigs should be run periodically to scrape off accumulated paraffin deposits on the pipe walls, which the chemical program has not prevented. This should lead to reduced chemical consumption, since the goal is no longer complete prevention of deposits. Optimized programs for paraffin control in pipe lines combine chemical treatment with pigging to:

- Maintain the line in a clean condition
- Enable the line to be re-started in a cold condition
- Minimize the chances of sticking a pig, especially in offshore lines
- Prevent flow capacity reductions or pressure drop increases through the line
- Keep instrumentation and sampling equipment clean and in working order
- Keep operating costs to a minimum.

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When a pipe line has accumulated an excessive amount of paraffin buildup, either through improper or no maintenance at all, caution should be used when designing the rehabilitation program. When thick deposits are present, it may not be feasible or cost effective to use chemicals for wax dispersal, as very large volumes of chemicals would be needed.

It also can be difficult and hazardous to try to move huge volumes of wax with pigs through lengthy pipe lines. It is easy to create a blockage, which may require extraordinary pressures. Care must be taken to conservatively remove the wax in controllable amounts through use of progressive pigging techniques. Once pigs have removed all the wax that is physically possible to remove, chemicals can be used to economically treat the remaining paraffin.

**INTERNAL CORROSION CONTROL**

Corrosion is the most serious problem associated with pipe line maintenance. Substantial dollars are spent each year on prevention, monitoring, inspection and repair of corrosion related damage. Most internal pipe line corrosion problems are treated chemically with inhibitors, which are used to form a protective layer on the pipe walls. Corrosion inhibitors come in several basic types and each performs uniquely in different pipe line conditions.

**Corrosion inhibitor treating of oil and gas lines.** One problem area in treating gas lines is that stratification of liquids in the line may occur. Therefore, the flow patterns or regimes must be considered when applying corrosion inhibitors. When multi-phase conditions exist, liquids will stratify along the bottom of the pipe, with water forming a separate layer beneath the hydrocarbon liquids.

With these conditions, some types of corrosion inhibitors will not properly contact the upper walls of the pipe, leaving a good portion of the surface unprotected. Fig. 1 shows the changes in flow regime which develop due to changes in pipe line elevation, resulting in the development of stratified flow or slug flow when fluids start flowing uphill or downhill.

**Inhibitor application with pigging.** When inhibiting either gas or oil lines, pigs should first be used to sweep out water and remove any sediment from the pipe wall. If liquids alone are being displaced, a sealing pig would be sufficient.

Cleaning pigs equipped with wire brushes or scraping discs should be used if wax or scale deposits are evident in the line. A film of inhibitor should be applied using periodic batch treatments with sealing pigs. Batching keeps the chemical in a solid column ahead of the pig, as shown in Fig. 3, allowing exposure to the entire pipe surface.

If pigs are not used, the chemical slug will lose its column form, leaving portions of the pipe unprotected. Batching, followed by a continuous low-concentration injection program is recommended over an injection program alone, since an injection program cannot ensure that all of the pipe wall has been treated by contact with the flowing liquids.

**Biocide treatment of pipe lines.** Control of bacteria and bacterially induced corrosion in pipe lines is another area where chemical application is enhanced greatly when used in conjunction with pigging.

Anaerobic sulfate reducing bacteria (SRBs) and anaerobic acid producing bacteria (APBs), are two types of bacteria commonly found in oil and gas pipe lines. SRBs produce hydrogen sulfide...
while APBs generate acetic acid, both highly corrosive.

**Pipe line bacteria.** Bacteria live in water, but prefer to grow on metal surfaces. Once bacteria establish as viable colonies on the pipe wall, they protect themselves with a polysaccharide outer layer, which can effectively filter biocides and other chemicals. This protective layer can defeat routine bacteria control programs based upon simply batching bactericides through the line.

Using pigs in conjunction with a biocide program can dramatically improve its effectiveness. A pig should first be used to remove substantial buildups of water. Wire brush pigs then can be used to scrape and scratch the bacteria colony outer layer, and remove bulk bacteria growth from the pipe wall. This prepares the pipe surface for the application of biocides, enabling the biocide to penetrate and destroy the colony, and reducing the volume of bacteria to be treated. Nylon bristle brushes are available for coated and plastic lined pipe systems. Sealing pigs can then be utilized to batch a slug of biocides, enabling maximum exposure to the affected areas.

**Selection of pig design.** As in any pigging application, the best results are achieved when using a pig design suitable for the required procedure. Using the wrong equipment when combining a pigging and chemical program can waste expensive chemicals, leave pipe surfaces insufficiently clean and in the long term actually contribute to pipe failure. Nylon bristle brushes are available for coated and plastic lined pipe systems. Sealing pigs can then be utilized to batch a slug of biocides, enabling maximum exposure to the affected areas.

If a disc pig is used, it is recommended that the configuration be equipped with guide discs to support the mandrel weight and reduce the potential for bypass. Spheres can be inflated so that a tight seal is realized. However, spheres offer the least amount of surface bearing area and minimal wiping ability of any pig.

A cross-flow coated Polly Pig offers a good seal, but may not have as much usable life as offered by the other designs. When batching chemicals, it is advisable to use two pigs, one in front and one behind the slug of chemicals, to help contain the liquid in a full column form. A brush pig can be used as the front pig to help prepare the pipe surface for treatment.

In order for any pig to perform its task sufficiently, it must be in good operating condition. Parts such as cups, discs, springs, brushes and blades should be routinely inspected for wear and fatigue. Replacement of these parts should be made when it is determined that they are no longer useful in sealing and cleaning, or in supporting the weight of the pig.

Using a worn or insufficient pig can result in liquids and deposits being left in the pipe line, although frequent pigging is performed. It is possible also to lose costly chemicals when batching due to excess bypass around worn sealing parts.

**Recommendations.** Both chemical treating and mechanical pigging offer solutions to various pipe line operating problems. However, neither method alone is likely to provide the benefits of a combination program. Chemicals are most effective and efficient when used primarily to treat problems on the pipe surface, such as the formation of wax deposits, bacteria colonies and corrosion. Pigs are best used to prepare the pipe surface for the application of chemicals, to help distribute the chemicals evenly throughout the pipe line, and to minimize the volume of chemicals needed by removing bulk deposits and entrapped fluids.

If chemical treatment and pigging are combined in a well developed preventive maintenance program, it is possible to keep corrosion damage to a minimum, maximize the operating efficiency of pipe lines and reduce chemical treatment costs.

The following recommendations should be followed when developing a chemical treatment and pigging program:

- Conduct a thorough analysis of the pipe line’s operating conditions, identifying all possible flow, deposition or corrosion problems
- Identify the best chemical for the situation, the most effective dosage and method of application
- Start with a clean pipe line. Remove unwanted liquids, scales and wax deposits with the appropriate type of pigs
- Whenever possible, apply chemicals in periodic batch treatments
- Establish a well defined maintenance program using low concentration chemical injection between batching and frequent pigging
- Select pig designs that are well suited for the application and keep the wear parts in good, usable condition.

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