

Overview of Corrosion Prevention Programs

Corrosion is the natural degradation of a material like steel pipe that results from a reaction with its environment. On the North Slope, causes of pipeline corrosion include carbon dioxide, water, sediment and bacteria. The age of a piece of pipe is not a critical factor in corrosion.

While corrosion cannot be eliminated, it can be managed through a combination of monitoring and mitigation. The goal of corrosion mitigation programs is to control corrosion rates to acceptable levels.

Corrosion rates are not static, however, and they can dramatically increase or decrease depending on fluid properties or changes in conditions that affect the efficacy of corrosion inhibitors. For that reason, locations that are prone to corrosion damage, or where damage has been identified, are inspected as often as every three to six months.

Monitoring and Inspections

BP Exploration (Alaska)'s [BPXA] overall annual inspection program consists of conducting inspections of about 100,000 locations on pipelines in Prudhoe Bay. Of these inspections, approximately 60,000 were for internal corrosion inspection and approximately 40,000 were for external corrosion inspection.

BPXA runs approximately 370 maintenance pigs per year on the North Slope. In addition, we utilize coupon monitoring, smart pigging, leak detection systems and surveillance by personnel to provide integrity assurance and maintain safe operations.

The State of Alaska annually reviews the adequacy of the BP corrosion inspection and prevention program.

BP Corrosion Prevention Program for the North Slope

BPXA's corrosion inspection, monitoring, inhibition and repair program on the North Slope is one of the largest and most comprehensive in the world. On a given day, the program teams 25 BP corrosion engineers and technical specialists with approximately 100-200 contract employees who are part of an alliance of world-leading suppliers for inspection and chemicals.

BP's North Slope pipeline monitoring and inspection program incorporates combinations of state-of-the-art ultrasonic, radiographic, magnetic flux, guided wave and electromagnetic inspection techniques. The program did not routinely run maintenance pigs or smart pigs in the oil transit lines because North Slope pipelines are above ground, allowing for direct inspection of pipeline sections where corrosion is most likely to occur. Ultrasonic and Radiographic testing are used as a leading indicator to trigger further action and is sound for pipelines that are accessible above-ground.

Two significant internal corrosion factors within Prudhoe Bay are water and carbon dioxide (CO₂), but exposure to both is minimized in the lines in question. Water content in the transit lines is very low and CO₂ is removed from processed fluids in the processing facility before it enters a transit line.

Given these factors, and data showing no appreciable corrosion from the inspection and monitoring program already in place, frequent scraper pigging operations were not indicated for Prudhoe Bay oil transit lines.

BP's program was designed to control corrosion, extending the useful life of valuable North Slope infrastructure. The 2006 annual budget for BP's corrosion monitoring and mitigation program is \$71 million, an increase of 15 percent from 2005, and 80% from 2001. Additional funds are also budgeted for repair and replacement of damaged pipe that is no longer fit for service.

Lines are pigged in Prudhoe Bay either because of mechanical issues or because corrosion monitoring suggests it. The frequency of pigging is specific to each pipeline and varies significantly across the North Slope and the industry. For example, the Northstar oil pipeline is pigged every two weeks to prevent paraffin buildup.

The unexpected results from a recent smart pig inspection that indicated greater corrosion than predicted, as well as the discovery of an oil leak on the same line, have called into question the condition of oil transit lines across Prudhoe Bay. As a precautionary step, BP began an orderly and phased shutdown of the Prudhoe Bay oil field. We are also undertaking testing and repair efforts that will ultimately provide us the assurance necessary to resume operation of the field once we and government regulators are satisfied that the lines can be operated safely and pose no threat to the environment.

Background

Coupon monitoring is a method that involves exposing a sample of the pipeline material (the coupon) to conditions within the pipe for a given duration, then removing the specimen for analysis. Material loss observed over the exposure period is expressed as corrosion rate.

Maintenance pigging is the term for using a mechanical tool to clean the inside of a pipeline. The tool comes in various configurations depending on the application (e.g. foam, disc, cup or brush). Typically the tool is used with fluids remaining in the line. The pressure of the fluids (oil, gas and/or water) acts as the drive mechanism for moving the pig from point to point. Maintenance pigging removes undesirable material, debris (liquid or solid) e.g., wax, paraffin, scale, sediment and water, corrosion cells from accumulating.

For mechanical integrity, specialty tools like “Smart Pigs” rigged with Magnetic Flux Leakage (MFL) and Ultrasonic Thickness testing (UTT) modules are used for accurate inspections of the wall of pipelines. Smart pigs can also perform mapping with GPS technology and detecting cracks from stress corrosion. Smart pigs and other automated techniques are helpful in identifying locations that should be more closely monitored using one of the point inspection methods (e.g. visual; ultrasonic; radiographic).

Another technology is ultrasonic testing (UT) which involves the use of a high frequency sound wave to produce a precise measurement of the thickness of a material. The technology is a well proven diagnostic tool routinely used for weld and flaw detection, as well as corrosion monitoring.

Important components of pipeline inspections also include regular visual inspections and the use of Forward Looking Infrared Radar devices (FLIR). FLIR technology is used to spot heat signatures of crude oil and is especially useful during winter months.

Mitigation of Corrosion

In the design of pipelines, many corrosion mitigations methods are considered. The selection of material from which to manufacture pipe, such as corrosion resistant alloys like stainless or low carbon steel, is one consideration. Another option is the use of various coatings and linings that provide pipelines protection against corrosive agents.

Technology used to protect metal structures from corrosion includes cathodic protection, a technique that is usually used in buried pipelines and takes advantage of electrochemical properties that reduces a metal structure's corrosion potential, particularly to address stress corrosion.

Mitigation also involves the application of corrosion inhibitors and biocides in conjunction with preventative maintenance such as pigging and physical rehabilitation of external damage.

External corrosion is mitigated by removal of the source for the water, drying, cleaning and buffing of the damage area and application of water resistant tape wrap or coatings. If external corrosion limits the integrity of the pipeline, then repair techniques will be used such as sleeves, clock springs, clamps and or composite wraps.