CASE HISTORY

Effective Rehabilitation Planning for a Natural Gas Transmission Line—Part 2

Carlos Moreno and Marianella Ojeda, Promigas, Barranquilla, Colombia
Michael Ames, SAE, Inc., Houston, Texas

This article outlines the results of a long-term pipeline integrity plan that was used to rehabilitate large segments of a natural gas pipeline over the past eight years. Part 1 of this article (June 2008 MP, p. 44) discussed the details to be followed in an effective rehabilitation plan to accomplish the goal of a well-maintained pipeline system.

This Promigas pipeline extends from production sites in northeastern Colombia, South America to the Jobo Terminal in northwestern Colombia. The following activities were carried out to fulfill the effective rehabilitation plan (ERP):

- Selecting a coating
- Repairing pipeline sections
- Prioritizing work zones
- Completing legal, environmental, and other permits
- Defining safety conditions
- Redesigning cathodic protection (CP)
- Testing CP
- Increasing CP reliability

Selecting a Coating System

Under controlled experimental conditions in the laboratory, all coating products normally present good or optimum results. Nevertheless, under real field conditions, where sometimes there is no control over environmental variables such as humidity, wind, temperature, etc., not all products may present optimum results. This is especially true in the tropics where the environmental conditions are difficult. Having that in mind, a careful selection of a coating system was done. Through a series of studies and specific criteria, each coating product was put to the test. The following aspects were evaluated:

Technical Specifications of Each Product

Because the company has gas transmission volumes that it has to provide to its customers, it was necessary to select a product that could be applied under normal gas flows. Gas flow cools the pipe’s outer surface, leading to issues with condensation in tropical areas. Outer surface temperatures of the pipeline are seldom at least 5 °F above dew point as
needed. The presence of humidity during coating application drastically reduces the coating’s life span and causes early failure to the coating no matter how excellent a product is. To provide a solution, gas flow could be suspended for short times for coating application. The coating selected had to cure in a very short time.

**Equipment**

The pipelines that required a recoating application were located in zones of difficult access; therefore the equipment to be used in the application was evaluated with preference for those easily transported.

**Cost**

The costs for the cleaning and preparation of the pipeline surface and coating application itself were combined for comparison. Surface cleaning and coating application in relation to productivity figures were also evaluated.

**Environmental Effects and Health Hazards**

The selected product had to be user and environment-friendly. Environmental impact had to be as low as possible, especially in any way that could harm the health of the personnel involved in the coating application.

**Curing Time**

Very short curing times for coating products were considered. From a safety point of view, it is not desirable to leave a ditch with a pipeline in operation uncovered for long periods of time. Also, external factors such as insects and dirt particles are very common in the pipeline location. Curing time was considered the most important variable for product selection.

**Investigation Results**

As a result of the coating application investigations, a hot-applied microcrystalline wax coating product and non-shielding fabric-backed tapes were selected. For specific pipeline sections such as those located at the exit of compressor stations, epoxy products were selected.

**Repair Method for Pipeline Sections with Defects**

Repairing 182 metal loss defects in the pipeline would involve high costs if Type B sleeve installations (welded to pipe) or composite sleeves were used. With these costs in mind, testing for the use of epoxy-filled mechanical sleeves not welded to pipe was done with excellent results. This sleeve is shown in Figure 1. According to the company’s analysis, composite sleeve repair for a metal loss is 175% more costly than using an epoxy-filled sleeve; Type B sleeve repair for a

![Epoxy-filled sleeve installation.](image)
metal loss is 250% more costly than using an epoxy-filled sleeve, and pipeline segment replacement under gas flow operation is 5,500% more costly than using an epoxy-filled sleeve. In some cases, however, it became necessary to apply other repair methods such as pipeline section replacements or Type B sleeve repairs. Nevertheless, ~95% of defects were repaired with epoxy-filled sleeves.

Prioritizing Work Zones

The criteria used to establish priorities for work zones were the risk index directly related to a populated area, and the potential impact area of the pipeline. The potential impact radius, calculated with the process hazard analysis software tool (PHAST®) in a zero lethal level, along with the class location criterion, determined the pipeline sections that could affect people or identified sites in case of failure.

A long-term work program was established and the execution of one work over another depended on the following:

a) Urban zones (class locations 3 and 4) first

b) Possible impact areas with specific identified sites in class locations 1 and 2 followed

c) Class location 1 and 2 zones without possible effect on identified sites last

Paperwork, Permissions, and Other Legal Considerations

Administrative functions required for the execution of work, environmental, state, legal, and private permits were completed. For pipeline coating application work, it is necessary to have environmental permits or licenses that are formally issued by the environmental authority. In addition to those permits, it is also necessary to have government or state permits as well as permits from the land owners.

The paperwork must abide by all laws and regulations and include the development of investigations or studies in which all potential impacts are identified, and therefore all measures to control and handle such environmental impacts are shown.

Most of the pipeline system crosses through private property fields. A critical factor in programming any work is directly related to the ability to obtain permits from the property owners and to have economic agreements with the parties.

Safety Conditions

Having in mind that nearly all work was to be executed while the transmission line was operational, it was necessary to define special safety precautions to guar-
Cathodic Protection

Redesign of the System

For the new CP design, the whole infrastructure was analyzed. It was determined that rectifiers had to be relocated to have a better current distribution. Groundbeds were also designed to guarantee the protection levels required along the transmission line.

Operational Follow-Up and Cathodic Protection Reliability

In the past, areas with poor electrical service could cause a depolarizing effect on the system. The relocation of rectifiers and the installation of hour meters allowed prompt follow-up actions to improve power service.

Increase in Cathodic Protection Reliability

To guard against suspensions of electricity from the power systems, battery backup banks were installed. In some cases, thermoelectric generators were installed to ensure the CP system’s effectiveness.

Conclusions

The ERP has been satisfactorily applied for eight years. This is shown by leak rates, low corrosion rates, and CP current requirements, as well as in the overall CP system’s reliability figures provided by the maintenance department of the company. Though the overall historical leak rates of the company are very low, the ERP was initiated to guarantee total reliability of the system. It was implemented because the system grows older every year and conventional maintenance programs may not be enough guarantee of reliability.

The company has achieved the goals it set forth to accomplish in 1999. To the present, nine operational leak-free years for the main transmission line have been achieved.

With ERP development, CP current requirements have been lowered substantially. CP current requirements have been lowered 51% on the 10-in (254-mm) pipelines after changing coatings on 73% of these pipelines.

As can be observed in Figure 3, CP current requirement comparisons during the last few years show that after ERP, the requirements have dropped considerably. Operational reliability of the CP system rectifiers increased to more than 98%. Electrical consumption is at its lowest in all the history of operation.

In 2007, the company started a second high-resolution, smart-pigging internal inspection program; no metal losses due to corrosion have been found that could compromise the system’s pipeline integrity.

To have better utilization of all data, a pipeline integrity management system was executed. This was done to comply with standard ASME B31.8S.1 Today, 21% of the transmission line system could cause impact to high-consequence areas, and continuous work is needed to reduce risk levels of this system and guarantee pipeline integrity and reliability of natural gas to the customers. All the concepts related to pipeline integrity have been reinforced via several strategies, to all personnel at all levels of the organization. All of the pipeline integrity concepts are being applied in each and every activity or task in everyday work.

The rehabilitation was achieved at a reasonable cost. If costs per kilometer of rehabilitation vs. costs per kilometer of construction are compared, we found that rehabilitation with this process saved well over half the cost of new construction for 10- and 20-in pipelines. Furthermore, it is true that any of the costs are negligible when confronted against the cost of a failure of the system.

References

Atlántico (Barranquilla) and has taken postgraduate courses in chief executive management and production management from the Universidad de los Andes (Bogota). He is an expert in gas pipeline design, operation, and maintenance, with 27 years of experience in pipeline engineering.

A member of NACE International since 1985, Moreno has given talks at various maintenance planning conferences and is a member of the Colombian National Chemical Engineering Association.

MARIANELLA OJEDA is a maintenance engineer at Promigas. She has a degree in civil engineering from the Universidad del Norte (Barranquilla) and has taken postgraduate courses in structural analysis and design, metallic structure design, and environmental engineering at the Universidad Politecnica de Cataluña (Barcelona, Spain). She is a NACE-certified Coating Inspector and Cathodic Protection Technician. She has worked on smart pigging and recoating projects for the past eight years.

MIKE AMES is vice president of SAE, Inc., Houston, Texas. He is an electrical engineer with more than 30 years of experience in the gas and liquid pipeline industry. A NACE member for 23 years, he is a NACE-certified Cathodic Protection Specialist and Senior Corrosion Technologist. He was the senior technical director of the processes established at Promigas as part of its pipeline integrity program used over the last eight years. He received the Eben Junkin Award for excellence in promoting corrosion technology and training, and has made many presentations at NACE conferences. He is a member of numerous NACE technical committees.

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