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Review

Challenges to the integrity of old pipelines buried in stable ground

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ABSTRACT

A succinct description of the particular conditions that have led to failures and damage of buried pipelines in Argentina is given in this article. The particular characteristics of soil, demographic evolution, original construction standards and procedures, and specific damage conditions based in case histories, are taken into account.

The purpose of this review is to contribute in orienting the efforts by operators and regulation bodies in order to efficiently increase the reliability of onshore buried pipelines. The author has been involved in many failure analyses involving pipelines in this country, some of the latest being related to explosions involving natural gas pipelines and related equipment.

The Argentine high-pressure oil and gas transmission pipeline system includes more than 40,000 km of buried piping. Diameters range from less than 14–36 in. Construction dates of most of these pipes range from around 1960 to around 1980. Particular cases discussed are:

- Old pipelines in stable ground
- Failures by SCC in buried pipelines
- Dealing with low-frequency ERW seam pipe
- Unknown materials and historical conditions of operation
- Integrity of old repairs
- Influence of demographic changes along right of ways

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1. Introduction

South American countries are fast exploring and exploiting their oil & gas resources. Some are relatively newcomers to the industry; and therefore, not much experience is available as to what are the most important menaces to the integrity of the facilities. This is the case, most notably, of Bolivia, and to a lesser extent, of Peru, Colombia and Ecuador. Although Venezuela has been for a long time a large exporter of crude, not that much experience has been gained in terms of integrity of large pipelines. Pipelines and related facilities in Brazil are also relatively new.

Other countries have a long history of oil & gas pipelines, mainly for local energy requirements. Argentina, for example, used to have large state-controlled oil & gas facilities. Most facilities built as early as the late 50s are still being run; and so, failures due to environment, operation and third party damage have been relatively frequent and fairly well documented.

With the exception of failures initiated because of gross overloads, internal combustion, accidents or sabotage, pipeline failures initiate from previous damage in the pipe body or in the longitudinal and circumferential (girth) welds. There are a number of causes that have been found to produce in-service degradation in buried oil and gas transmission pipelines, all related to mechanical and environmental damage. Typical environmental in-service damage types are: corrosion, fatigue, hydrogen stress cracking, and stress corrosion cracking.

Corrosion and third party damage are by far the most frequent causes for pipeline failures. Characteristics of these mechanisms are well described in the literature. In this article we will give a succinct description of the particular conditions that have led to failures and damage of buried pipelines in Argentina, taking into account the particular characteristics of soil, demographic evolution, original construction standards and procedures, and specific damage conditions based in case histories [1]. The purpose of this article is to contribute in orienting the efforts by operators and regulation bodies in order to efficiently increase the reliability of onshore buried pipelines. The author and collaborators have been involved in many of the failure analyses involving pipelines in this country, some of the latest being discussed in a recent article dealing with failure investigations of explosions involving natural gas pipelines and related equipment [2].

2. Old pipelines in stable ground, Argentina's experiences

The Argentine high-pressure oil and gas transmission pipeline system includes more than 40,000 km of buried piping. Surface coatings are mostly of the tar and glass fiber type. Longitudinal tube seams are made with both Electrical Resistance welding (ERW) and Double Submerged Arc Welding (DSAW). Diameters range from less than 14–36 in. (350–900 mm). Construction dates of most of these pipes range from around 1960 to around 1980.

Until the 1990s, Argentina had a tradition of state-controlled companies designed to develop and apply technologies to provide energy for local use. This has been the case of YPF, an oil company that at a time provided 100% of the country's crude and refined oil needs. Similarly, Gas del Estado (State Gas) was responsible for the development of the natural gas (NC) pipeline network. A large portion of the energy, such as electricity generation and heating for industrial and household use derives from natural gas. Compressed NG fueled vehicles are also very common, especially in city transport.

The use of natural gas has increased to a point when the country is nowadays importing some of its natural gas needs, mostly from fast developing Bolivian fields. The increase in energy needs has not been matched by an increase in local oil & gas production, partly due to a poorly designed dismemberment and privatization of the state owned companies, in the 1990s. This was followed by restrictions in fares and revenues for the companies (mostly European) that operate upstream and downstream systems. Accordingly, these companies severely reduced investments. In 2012 YPF was re-nationalized, after the government retook control from Repsol [3].

Most facilities built as early as the late 50s are still being run. Gas pipelines San Martin and Norte, which run from gas fields down south and up north (respectively) to the industrialized central region of the country, have each several thousand kilometers of pipelines which are more than 60 years old. Pipelines from the oil and gas fields from the west date back to the 80s. The system is continually being upgraded, but still most of the oldest pipelines do not have alternative loops in case of failures or scheduled repair, for which it is necessary to close down a tract.

Most pipelines run through flat, stable, sedimentary land, called pampa. This pampa could be either dry (south and west) or wet (midland). Failures due to environment are mostly related to corrosion; as usual, third party damage is the most frequent cause for failures [1].

Over the last 20 years, interest of integrity managers have been focused in failures and damage related to the following conditions:

- Stress Corrosion Cracking (SCC).
- Electrical Resistance Welds (ERW) and old repairs.