Pipeline integrity and rehabilitation

Many factors can lead to the failure of steel pipelines and the root cause is not always obvious. Because of the high cost of repairs, detailed investigation of such failures is considered vitally important to ensure that the underlying cause is dealt with before carrying out costly rehabilitation. This paper, by ***Craig Botha*** *of Paradigm Projects, proposes an investigative methodology and explores failure including mechanisms such as operation, hydraulics and corrosion.*

The objective of this paper is to provide the methodology for pipeline integrity evaluation with meaningful results to support the approach. Furthermore, the methodology should be adaptable to pipelines carrying various products in very different locations.

INVESTIGATION

Site inspection: The site of failure should be inspected as soon as possible and samples of failed materials or components taken for evaluation. Specific procedures should be employed to ensure the failure site and samples are protected from damage or undue contamination.

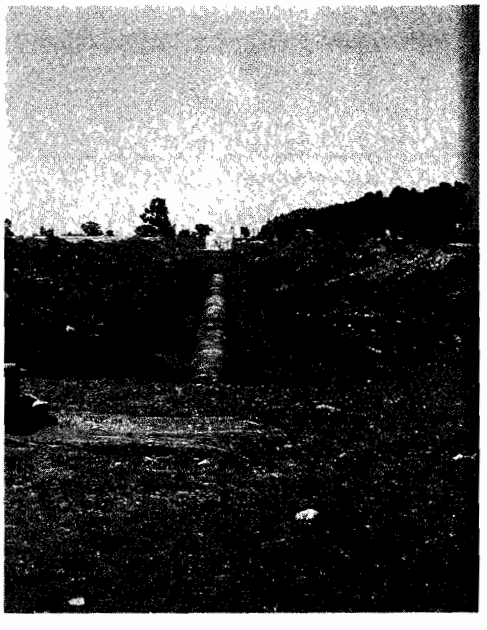
Construction records: The keeping of detailed construction records remains vital to any project. With poor records, it can be difficult to discover what was done during the simplest of pipeline constructions leading to high cost of discovery and the potential for making errors of judgment in respect of repairs and rehabilitation.

Construction material records: Many existing steel and ductile iron pipelines are constructed with coupled joints using some form of spiggot and socket connections or mechanical couplings and flanged fittings. Those connection systems do not assist with the making of electrical continuity of the pipeline system which can be expected to suffer from the effects of corroding agents such as stray currents. Further complications with coupled connections include the difficulty in repair of coatings and linings and protecting the couplings themselves.

Welded pipeline joints remove most of the problems associated with electrical continuity and anchorages. However, in practice there are always unwelded couplings in water systems, which require special attention. Many older steel pipelines were manufactured with longitudinal and transverse weld seams. With such pipe cross sections, full circumferential tension forces are developed across the longitudinal weld seams.

The fabrication of modern large-diameter steel pipelines for water transmission can involve spiral welding and stress relieving which reduce the risk of failure across welding. The selection of appropriate grade steel and plate thickness to deal with hydraulic loading and providing some allowance for the longer-term effects of corrosion is vitally important.

Coating and Lining Records: Many lining and coating systems of excellent ability fall short of practical application requirements under field conditions, particularly during application to pipeline and fitting joints where there is usually no guarantee of integrity regardless of how rigid application specifications might be. Many older raw and potable water pipelines were lined with bitumen which has gradually deteriorated through loss of plasticity and left pipe walls unprotected against the effects of microbial agents.

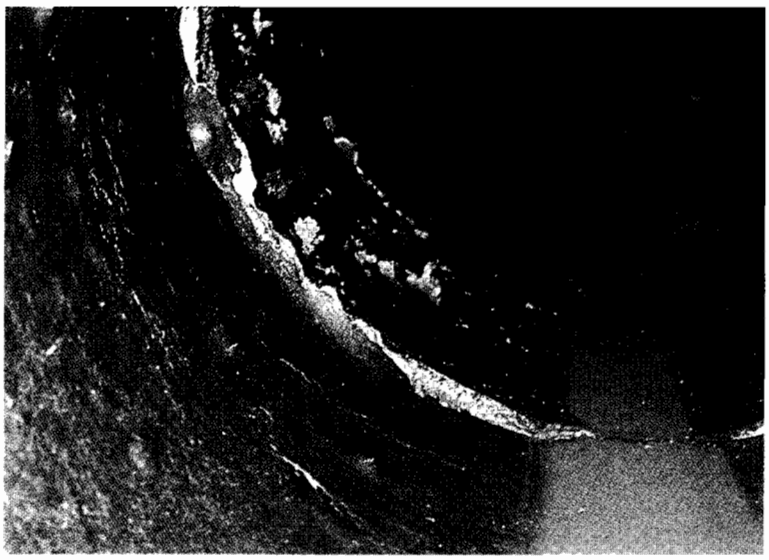


Upon identification of corrosive areas, the affected sections of pipe are exposed

Corrosion Protection Installation Records: The application of corrosion protection systems is not always well-documented and there is often much confusion about what was installed, how it was meant to be operated and where the responsibility of the maintenance should be.

Operation and Maintenance Records: These

records can usefully assist failure investigation by providing information on operating problems under various conditions of flow; how controls were applied; previous repairs, and some indication of the level of maintenance practiced.



Bacterial growth along a girth-weld

PIPELINE MATERIALS

Examine pipe wall: The grade of steel and method of welding are important indicators of the ability of the pipeline to withstand operating conditions. Representative samples should be cut from failed pipe sections and strength properties determined for comparison with the strength requirements of the pipeline under the range of operating conditions to which it has been subjected.

Examine internal linings: Potentially corrosive mechanisms active within pipelines require the application of protective internal linings. A variety of linings ranging from traditional bitumen, cement mortar, sophisticated epoxies and other exotic compounds are in use. Many aging pipelines were lined with bitumen which, over time, is susceptible to loss of plasticiser resulting in embrittlement, blistering and failure.

More modern linings are less susceptible to this mode of failure. However, the success or failure of any lining system is largely dependent on quality assurance during application. Every lining has a limited life span. Once the lining fails, the bare steel pipe surface is exposed to a potentially corrosive environment with consequences that may lead to failure.

Epoxy applied after removal of the failed bitumen lining

Examine external coatings: External coatings are applied to pipelines to limit the effects of corrosive agents and include materials such as bitumen fiberglass, epoxies, tapes and plastics. Examination of the coating at a site of a pipeline failure may give an indication of the failure mechanism. Coating defects pose a threat to the life expectancy of any pipeline, since a variety of corrosive agents are present in the surrounding environment. Cathodic protection is often mistakenly viewed as the only corrosion prevention strategy required and little or no attention is given to the coating that provides the first line of defence.

FAILURE EVALUATION

Hydraulic models can be prepared to evaluate conditions under which the pipeline may have operated before failure. Simplified models can be used for surge analysis to determine whether such operating conditions could potentially have resulted in failure of the pipeline.

CORROSION EVALUATION

A combination of several strategies can be applied to ensure an effective corrosion prevention system.