WINMAR
consulting services, inc.

PERFORMANCE OF OFFSHORE PIPELINES
(P.O.P)
JOINT INDUSTRY PROJECT

FINAL REPORT

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2000 – 2003

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SECTION 1

EXECUTIVE SUMMARY

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WINMAR Consulting Services, Inc. (WINMAR) has organized and executed work under a Joint Industry Project (JIP) entitled P.O.P. (Performance of Offshore Pipelines). The Scope of work was ambitious in attempting to perform predictive and destructive testing of aged out of service pipelines offshore Gulf of Mexico. The initial project concept and scope of work are described in Sections 2 and 3 of the report.

The initial project team consisted of WINMAR, University of California at Berkeley (UCB) and Stress Engineering. Kiefner & Associates were added at a later date to complete an additional research task.

The initial field test candidate was identified and approved in early 2001. Plans were made and crews mobilized to the field May 31,2001. Desired time in the field was estimated to be 5 days. The field implementation experienced major technical and weather problems during the testing of the pipeline segment. Problems were encountered due to Tropical Storm Allison and technically in running the smart pig prior to testing, pumping the pipeline up to burst pressure and in locating and retrieving the failed section. The initial plan and actual durations were as follows:

Days to Run Smart Pig	3 planned	6 actual
Days to Burst Segment	1 planned	4 actual
Days to Locate & Retrieve	1 planned	2 actual
	5 planned	12 actual

Details of the field effort can be found in Sections 4 and 5 of the report. In addition to all the technical and operational difficulties, Tropical Storm Allison occurred during the project offshore. Allison adversely affected both time onsite offshore as well as logistics/communications with the damage inflicted on Gulf Coast Region.

The resulting cost over run was detailed in a project meeting on November 9, 2001. The results of that meeting are detailed in Section 9 of the report. It was decided at that point to discontinue any further field testing or bench testing on retrieved sections of the initial pipeline. It was decided to engage Kiefner & Associates to complete a data research task with the balance of the JIP funding. The results of this study are included in Section 8 of this report. The analytical and predictive work performed by UCB is included in Section 6. The interpretive work on the failed pipeline section was performed by Stress Engineering and is included in Section 7. The results of the smart pig inspection were not provided by Rosen and could not be included in this report.

In conclusion, the proposed efforts were ambitious but failed to achieve any meaningful results. Attempting to perform research in an offshore operational environment with high dollar per day equipment spreads is not viable. Funding resources are easily consumed when encountering delays due to weather or technical problems. The predictive capability of the smart pig was not realized in this project. There was not sufficient results to validate a single predictive analytical model.

SECTION 2

INTRODUCTION

INTRODUCTION

WINMAR proposed to execute a Joint Industry Project (JIP) to assess the integrity of aging offshore pipeline systems. The name of the project is Performance of Offshore Pipelines (POP). The study consisted of multiple main components:

- Development and validation of analytical assessment models
- Field testing of out-of-service pipelines
- Testing and validating the performance of "smart pigs"

WINMAR Consulting Services, the JIP project prime contractor, decommissions over 30 pipelines a year - these disused pipelines give the project team a unique opportunity to test corroded pipelines in-situ. WINMAR was assisted by the Marine Technology & Management Group at the University of California at Berkeley (analytical model development and verification) and by Rosen Engineering and PII (inline instrumentation). Other consulting services were provided in-kind by consultants. Some of the services included:

- Risk assessment models and systems
- Pipeline leak detection and location
- Materials testing and failure analysis
- A project technical advisory committee composed of representatives from the participating organizations that provided technical guidance for this JIP.

OBJECTIVES:

- Validate existing pipeline integrity prediction models through field testing multiple pipelines
- Validate the performance of inline instrumentation through smart pig runs
- Assess the actual integrity of aging pipelines.
- Pipelines with external damage (dented, gouged)
- Internal damage (corrosion, weld defects) were studied and tested.

These objectives were accomplished by the testing of aging out-of-service lines using "smart pigs", followed by hydrotesting of the lines to failure, recovery of the failed sections, and determination of the pipeline characteristics in the vicinity of the failed sections.

BENEFITS:

The results of the study are to aid the participants in better understanding the in-place, in-the-field capacities of their aging and damaged pipelines. This knowledge will help participants better plan pipeline IMR (inspection, maintenance, repair) programs. The results of this JIP will give the participants a better understanding of how to approach analyzing and studying pipeline failures in a safer and more controlled manner.

SCHEDULE:

We proposed that the scheduled, the study would take 24 months to complete. The proposed start date was January 15, 2000.

COSTS:

The U. S. Minerals Management Service funded approximately 30% of the project. It was determined that the DOT-OPS and GRI would most likely contribute matching funds equivalent to the MMS' 30%. In addition, Rosen Engineering and P.I.I. provided inline instrumentation services for the project. Other services, such as leak detection and location were also provided as services in-kind. Ten additional participants each contributing approximately $30,000 were required to initiate the project and perform the basic scope of work. Estimated total budget for the project was $1,000,000.

DEFINITION OF THE PROBLEM

Pipeline operators and regulators need information about the performance of aging and damaged offshore pipelines. Prior to the onset and completion of this JIP project, and to our knowledge, a test had never been performed in-place to determine the actual strength/capacity of an offshore pipeline during its service life. Mathematical models existed for predicting the burst strength of dented, gouged, and corroded pipelines, but they had not been validated with field tests. The hydrotesting of both piggable and non-piggable lines could yield important data and information that could aid pipeline owners and operators in developing more effective and efficient inspection, maintenance, and repair (IMR) programs, help industry and regulatory bodies that develop design and requalification guidelines, and help owners/operators determine if their existing lines can handle higher pressures and throughputs. In addition, data gathered from "smart pig" runs could be compared to actual pipeline conditions, through recovery of aged pipeline sections.

OBJECTIVE

The objective of the project was to validate existing pipeline integrity prediction models through field testing multiple pipelines, validate the performance of in-line instrumentation through smart pig runs, and finally, to assess the actual integrity of aging damaged and defective pipelines. The objectives were accomplished by the testing of aging out-of-service lines using "smart pigs", followed by hydrotesting of the lines to failure, recovery of the failed sections, and determination of the pipeline characteristics in the vicinity of the failed sections (failure analysis). This gives JIP participants a unique opportunity to observe and study pipeline failures SAFELY.

As stated above, one objective of the project was to validate the dented, gouged, and corroded pipeline burst strength prediction models currently in existence, such as ASME B31-G, R-Streng, and DNV 99 for pipelines. Another model was being developed as a joint international project sponsored by the U. S. Minerals Management Service, Petroleos Mexicanos (PEMEX), and Instituto Mexicano del Petroleo (IMP) titled RAM PIPE REQUAL and an associated JIP identified as PIMPIS (Pipeline Inspection, Maintenance, and Performance Information System), this would be tested and validated as well.

The validation was provided by hydrotesting in-situ pipelines to failure. Sustained and rapidly applied hydro-pressures were used to investigate the effects of delayed and dynamic pressure related failures. After testing, the pipelines were scheduled for decommissioning; with the failed sections located, and brought to the laboratory for testing and analysis. Class A predictions were made before the pipelines were hydro-tested to failure based on results from in-line instrumentation (instrumented) and from knowledge of the pipeline products and other characteristics (not instrumented). Based on the results from the testing, the analytical models were to be revised to provide improved agreement between the measured and predicted burst pressures.

Since the pipelines were inspected with smart pigs before the hydro-tests, it was possible to compare the smart-pig data gathered during pig runs to the actual condition of the pipeline. This was accomplished by recovering sections of the pipeline that were identified by the pig as having pits or metal-loss areas.

BACKGROUND

Prior to POP, research had been conducted at UC Berkeley (UCB) to develop analytical models for determining burst strength of corroded pipelines and to define IMR programs for corroded pipelines. The PIMPIS JIP, which concluded in May1999, was funded by the MMS, PEMEX, IMP, Exxon, BP-Amoco, Chevron, and Rosen Engineering. A parallel two-year duration project was started in November 1998 that is addressing requalification guidelines for pipelines (RAMPIPE REQUAL). This project is sponsored

by the MMS, PEMEX, and IMP. These projects have relied on laboratory test data on the burst pressures of artificially dented and gouged pipelines, and naturally and simulated (machined defects) corroded pipelines.

Recently, very advanced guidelines were issued for the determination of the burst pressure of dented, gouged, and corroded pipelines. While some laboratory testing on specimens with machined defects to simulate denting, gouging, and corrosion damage had been performed during this development, most of the developments were founded on results from sophisticated finite element analyses that were calibrated to produce results close to those determined in the laboratory. A recently completed evaluation of the guidelines based on predictions of the burst capacities of dented, gouged and corroded pipelines, were tested against laboratory test data in which the test specimens were 'naturally' damaged. The results indicated that the guidelines generally produced conservative characterizations of the burst capacities. The evaluation indicated that the conservatism is likely due to the use of specimens and analytical models based on artificially produced defects.

The concept for the POP project was developed based on these recent models. The concept was to extend the knowledge and available data to determine the infield capacities of naturally aged and used pipelines; testing these pipelines to failure using hydrotesting; and recovering the failed sections to determine the pipeline material and corrosion characteristics. The testing involved pipelines in which in-line instrumentation indicated the extent of denting, gouging and corrosion and other defects. The testing also involved pipelines in which such testing is not possible or has not been performed. In these cases, predictions of corrosion were developed based on the pipeline operating characteristics and corrosion prediction analytical models. Thus, validation of the analytical models and engineering assessment processes involved both instrumented and un-instrumented pipelines, an assessment of the validity of the analytically predicted corrosion and effects of external damage (denting and gouging).

SECTION 3

SCOPE

SCOPE OF WORK APPROACH

- Reviewed pipeline decommissioning inventory and selected a pipeline candidate.
- Selected pipelines for testing.
- Conducted field tests with an instrumented pig to determine pipeline denting, gouging and corrosion conditions.
- Used existing analytical models to determine burst strength for both instrumented and non-instrumented pipelines.
- Hydrotested the selected pipelines to failure (sustained and rapidly applied pressures).
- Located and retrieve failed sections and other sections identified as problem spots by the "smart-pig."
- Compared "smart pig" data to actual pipeline condition.
- Analyzed the failed sections to determine their physical and material characteristics.
- Revised the analytical models to provide improved agreements between predicted and measured burst pressures.
- Documented the results of the JIP in a project technical report.

DELIVERABLES

The project deliverables were a kickoff meeting, an interim meeting to present data from the smart-pig runs and analyses, a wrap-up workshop, and a final project report.

SCHEDULE

The study and field tests took 24months to complete. The 24-month schedule covered an offshore summer work season, allowing for the pipeline tests. The project was initiated on 15 January 2000.

ORGANIZATION

WINMAR Consulting Services was the prime contractor. UCB, Rosen Engineering and PII were project sub-contractors. A Project Technical Steering Committee (PTSC) was formed with representatives from the sponsoring organizations. A chairman of the PTSC was elected by the sponsoring organizations. The PTSC chairman was the direct interface with the JIP manager for WINMAR.

PROJECT TEAM BACKGROUND

WINMAR

WINMAR is the industry leader in managing the decommissioning of offshore platforms. The WINMAR team has managed over 250 removals in water depths ranging from 15' to 380'. WINMAR managed a 1999/2000 Decommissioning Campaign for nine clients that encompassed the removal of 45-55 GOM platforms and 60 pipelines in 1999. This represents almost 50% of the annual removals for the GOM. WINMAR has an ongoing working relationship with all removal contractors, specialty subcontractors and decommissioning techniques.

WINMAR has specific experience with:

- Total removal and abandonment in-place of offshore pipelines
- Piggable and unpiggable pipelines
- Cathodic potential surveys, including external and internal corrosion surveys
- Oil, gas, condensate, as well as bulk fluids pipelines
- Small and large pipelines.
- Flow lines, gathering lines, and transmission lines
- Producers, transmission companies, onshore processing and terminus facilities
- Recertification and reuse of disused pipelines
- Maintenance of aging infrastructure
- Safety systems for operating pipelines
- Building, operating and maintaining pipelines

WINMAR looks at lifecycle management problems as engineers and technical professionals, not as contractors. As such, we try to use and develop new technologies and techniques to lower costs and raise the efficiency of lifecycle operations, something that contractors do not often focus on. WINMAR is not trying to push existing marine equipment or techniques. Our lifecycle management experience is the industry benchmark.

UCB MTMG

During the past seven years, the Marine Technology and Management Group (MTMG) at the University of California at Berkeley (UCB) has performed a series of projects that have addressed the design, reassessment and requalification of marine pipelines. Reliability based methods have been a hallmark of this work. Reliability based design criteria have been developed for new pipelines that have addressed a wide variety of limit states and design conditions. The Pipeline integrity and performance information system (PIPIS) project focused primarily on reliability based criteria for the reassessment of corroded pipelines, for both instrumented and un-instrumented pipelines. The PIMPIS system was designed to interface with the pipeline performance information system that has been developed by the U. S. Minerals Management Service. Most recently, the work has addressed guidelines for the reassessment and requalification of marine pipelines (RAMPIPE REQUAL). This project has involved extensive testing and verification of alternative analytical models to evaluate the performance characteristics of damaged and defective pipelines.

ROSEN ENGINEERING

Rosen Engineering is one of the premier in-line instrumentation firms in the world. Rosen has performed pipeline instrumentation in most parts of the world, onshore and offshore and has developed a large database of information on the characteristics of these pipelines. Rosen's work has involved development of advanced in-line instrumentation systems, the verification of the results produced by these systems, and assistance in development of in-line instrumentation system specifications that can help pipeline owners and operators produce more reliable and uniform results from different in-line instrumentation systems and contractors.