THUMS
PIPELINE INTEGRITY
MANAGEMENT PROGRAM

Thums Long Beach Company, which operates the Long Beach Unit, lies in the East Wilmington Field of Southern California. The Long Beach Unit utilizes subsea pipelines to transport produced oil and gas from four man-made islands in the Long Beach Harbor. Each island produces oil and gas that is shipped to shore in the subsea pipeline system. Islands Chaffee and Freeman ship production to Island White. At Island White, the production streams are co-mingled and shipped to Island Grissom where production is again co-mingled and shipped to the Pier J facilities for final processing prior to sale. In addition, Thums operates land based oil and gas pipelines, JBM, JL1 and the J6" Emergency Oil pipeline that transports produced oil to the Broadway and Mitchell (B&M) custody transfer point. In addition, the BMP-2 pipeline transfers hydrocarbons from the Power Plant to the B&M site. Thums operates approximately 25 miles of pipeline capable of oil service. Because of this, we are considered a Category 2 operator.

Each island maintains five categories of subsea pipelines: oil, gas, reserve, emergency reserve and idle. Each pipeline is capable of handing either oil or gas. The lines range in length from 3950 feet to 8450 feet with diameters from 6 inches to 14 inches. The majority of the pipelines were installed in 1966 and 1967. An additional pipeline was installed in 1988 and two more installed in 1993. All the subsea pipelines are operated and maintained under U.S. Department of Transportation (DOT) regulations.

Thums pipelines are located within the Long Beach Harbor or on adjacent pier facilities that drain to the harbor areas. The Long Beach Harbor is a commercially navigable waterway and by definition, a High Consequence Areas (HCA). A loss of containment along any of Thums pipelines could result in the release of oil to these waterways.

Pipeline Assessment Methods

A combination of assessment methods are used to determine the integrity of Thums oil and Gas regulated pipelines. These assessment methods include the following and a discussion of each is presented below.

- Internal inspection surveys
- Pressure Testing
- Guided Ultrasonic (GUL) Surveys
- Cathodic Protection (CP) Surveys
- Excavations
- Pipeline Pigging
- Chemical Inhibition
- Facility Controls for Leak Detection
- Emergency Flow Restricting Devices ESD's
- Unavailable Technology (Dual diameter Pipelines, cement coated)
- Other (notification requirement)

Internal Inspection Survey

Internal inspection surveys or smart pigging has been conducted since 1971 to identify corrosion areas. In 1992, ultrasonic technology was used as a best available technology (Magnetic Flux surveys were conducted up to 1991). The Long Beach Unit has run internal inspection surveys on all of the active and reserve submarine pipelines every three years since 1992 utilizing ultrasonic technology. The fourth ultrasonic inspection was completed in December 2001.

Annual magnetic flux surveys have been run from the late 1960's through the early 1990's. The 1990 survey indicated that the severity of some previously documented corrosion areas had actually decreased. Another magnetic flux log was run for comparison. The comparison log results indicated significant differences in some pipelines. Several pipeline sections were excavated, removed and compared for accuracy. Actual pipe wall thickness measurements were recorded and compared with the two magnetic flux logs. The comparisons yielded mixed results.

In early 1992, a decision was made to use what was considered the best available technology at the time, to survey the Subsea pipelines. Ultrasonic technology was used in an attempt to get a more precise survey of the pipelines. Pipetronix was contracted to perform the survey. They were the first to develop the necessary tools and are regarded throughout the world as the best in the ultrasonic inspection business.

To complete the ultrasonic surveys, additional pipeline preparation was required to optimize the results. This included the following:

- The pipeline had to be clean and free of deposits. The cleaning consists of running a series of bi-directional cleaning scrapers with oversize discs down the line until they arrived without debris at the other end.
- The pipeline was free of dents and ovalities in excess of 5% diameter reduction. A caliper tool was run prior to the survey to measure and locate all dents and ovalities.
- The tool was run in liquid to act as a coupling between the ultrasonic energy and the pipe wall. Wall thickness measurements cannot be made without the liquid coupling.
- The speed of the tool was held as closely as possible to 1 m/sec as long as it was actively measuring.

The data from the 1992 ultrasonic survey proved to be exceptional in quality. Several repair recommendations were made based on the data. The survey data proved to be accurate as it correlated very well with actual pipeline thickness data that was obtained from visual assessments of removed pipe sections.

In 1994, the Long Beach Unit re-evaluated pipeline inspection technologies. While many advances had been made in magnetic flux technology, the decision was made to use the Ultrasonic tools again. The primary reason was the ability to directly compare two high quality survey data sets.

Ultrasonic tools were again used to survey the Long Beach Unit's Subsea pipelines during June and July 1995. The data obtained from the survey was also considered to be of exceptional quality with very good repeatability between the 1992 survey and the 1995 survey. The survey logs helped to:

- Identify important features
- Identify areas of potential repair
- Assess corrosion rates (both internal and external)
- Estimate remaining useful life for each pipeline
- Estimate the appropriate survey frequency

The 1992 and 1995 Ultrasonic surveys were completed to determine internal, external and overall pipeline corrosion rates. Two data analysis methods were used. The first method examined how the deepest pit in each pipeline had changed between surveys. This analysis provided insight to the maximum wall loss area of each pipeline and how it changed between the two surveys over the past three years.

The logs obtained from these surveys are of exceptional quality, providing excellent repeatability, while identifying critical pipeline conditions. The surveys have been used to identify pipeline defects and corrosion anomalies, as well as determine pipeline

maximum allowable operating pressure (MAOP). Repeatability of the surveys allows Thums to determine any changes in the rate of corrosion, both internal and external.

The Survey frequency is determined based on the condition of the pipelines. Based on the results of past surveys and the corrosion rate of the pipelines, the survey frequency has been determined to be every 3 to 5 years.

Pressure Testing

Thums regulated pipelines are also pressure tested to determine the MAOP of the pipeline. Pressure tests are conducted initially upon pipeline commissioning. Additional pressure tests are conducted following repairs involving any replacement of a portion of the pipeline.

Guided Ultrasonic Surveys (GUL)

The GUL surveys are usually run on Thums land based pipelines. This technology is used for the detection of both internal and external corrosion. The low frequency ultrasonic waves propagate down the pipe and reflect off pipe features, such as welds, supports, etc. These reflections are then interpreted by using a computerized analysis program. These surveys have proven to be accurate at locating pipeline anomalies, but cannot distinguish between internal and external corrosion. This technique was used in conjunction with CP surveys and verification excavations to determine the condition of Thums JBM and JL1 pipelines. Both these pipelines are multi-diameter pipelines and cannot be smart pigged.

Guided Ultrasonic Surveys are performed on an as needed basis on areas of a non-Subsea pipeline (JL1, JBM, J2/J6 pipelines, BPM-1, BMP-2) that may be exposed by excavations.

Cathodic Protection (CP) Surveys

CP surveys are designed to evaluate the level of external protection on a pipeline. The most significant corrosion that could affect the integrity, is the loss of metal due to external soil side corrosion. The use of over-the-line surveys to evaluate the level of cathodic protection over the entire external pipeline length on a yearly basis is an accepted method to determine the integrity of a pipelines protection. The main factors that contribute to the integrity of a pipeline are defects in the coating, an active EMF corrosion potential and aggressive soil conditions. Pipeline locations where external corrosion may be present as a result of one or more of the above factors would have the highest risk of impacting pipeline integrity. Thums utilizes one or a combination of the following CP surveys to evaluate pipeline integrity.

- Close Interval Pipe to soil survey
- Over-the-Line Surveys (Offshore)
- AC/DC voltage gradient (ACVG) surveys
- Electromagnetic Coating evaluation survey

Locations where coating defects are present, where the EMF potential (close interval survey) levels are active and where existing CP "off" levels may be below the -850Mv standard are the highest risk areas. All the information above is used as input to identify the highest risk integrity locations on a pipeline.

Over-the-Line Surveys to determine the effectiveness of the CP are conducted once per year on Thums Subsea Pipelines. A Close Interval Survey is conducted annually on Thums JL1 and JBM pipelines. All survey results and corrective action information can be found in Thums' DOT files.

Cathodic protection (CP) is maintained on the Subsea pipelines using an impressed current system. The protection on these lines originates from rectifiers, supplying current to the subsea and pig trap areas or a combination of both. These rectifiers are monitored in accordance with 49CFR, part195.416 and 195.416.

An Over the Line Close Interval Potential Survey is performed each year in accordance with 49CFR part 192.465 and 195.416 on the Subsea pipelines as well as JBM and JL1, to determine the effective protection on each line.

In 2002, Thums conducted an extensive survey of the JL1 and JBM pipelines, conducting over-the-line surveys on both. These surveys included close-interval potential surveys, coating attenuation surveys and AC/DC voltage gradient (ACVG) surveys. The purpose of the surveys were to identify locations where the probability of corrosion occurring would be the highest. Portions of both lines were found with potential more positive than the NACE -850 criterions. As a result, rectifier outputs were increased on both.

The coating evaluation survey indicated that sections on both pipelines have areas where the coating has dis-bonded from the pipelines. Based on the results of both surveys, areas of pipelines were identified, excavated and inspected.

The pipe that potentially had the worst corrosion and the highest risk were those locations where the level of CP was low and where the coating was found to be in poor condition. In addition, Guided Ultrasonic Surveys were performed on the exposed areas of the pipelines.

The coating was found to be dis-bonded where the pipeline was excavated. However, the pipe was found to be in good condition. In all cases, the coating was removed and new coating (armor plate and/or heat shrink-wrap) was applied.

Excavations (Dig Inspections)

Excavations are performed at areas where active corrosion may be indicated. Corrosion areas are exposed, the condition of the pipeline is documented and the pipeline is repaired accordingly.

Pipeline Maintenance Cleaning

Wiper and brush cleaning pigs are run every two weeks through the in-service oil and gas lines from each island. The JBM, JL1 and JL2 pipelines are pigged on an as needed basis only and normally associated with service changes. Electronic reports are maintained to document any operational problems during the pigging as well as the condition of pigs. Any unusual liquids and/or solids generated from pigging are analyzed to determine any potential problems. The information gathered from pigging is used to determine the effectiveness of the corrosion inhibition and any changes in the system processes.

Facility Controls for Leak Detection

Under normal operating conditions, the Subsea pipelines require very little day-to-day monitoring and/or work. Each line is monitored for both high and low pressures. A high pressure will alarm the respective island and if pressure continues to rise, will shut down the island production and isolate the pipeline. A low-pressure alarm will automatically shut down the island production and on the oil service pipelines, isolate the pipeline.

Likewise, high flow situations such as high Free Water Knockout (FWKO) levels, Oil transfer pump vibration shut downs and high FWKO vessel pressures will automatically shut down the respective island and isolate the oil service pipeline. As an additional back-up system, each line is also equipped with a ‘vent line’ leading to a vent scrubber in the event there is a failure in the shutdown system.

Corrosion Inhibition

Corrosion inhibitor is continuously fed into the in-service subsea pipelines. The chemical rates are monitored monthly to ensure that adequate protection is maintained.

A batch treatment is also used in conjunction with bi-monthly maintenance pigging on the oil and gas lines. Inactive lines are protected with a pickling solution of corrosion inhibitor, biocide and oxygen scavenger mix.

Emergency Flow Restricting Devices (ESD’s)

A fully automated sub-sea pipeline safety control valve shut-off system (ESD’s), which consisted of a series of 8 control valves on the oil product lines from each island, was installed in 2002. A PLC automated control program system to actuate the ESD valves on low-pressure signal from the oil production lines was also implemented.

These ESD valves are designed to activate when the pressure on the oil product pipelines falls below the low-pressure alarm setting or the pressure exceeds the high-high pressure shutdown.

The low-pressure shutdown is set to alarm with no prior warning and will cause the Oil shipping line ESD valves to close. The high-high pressure shutdown has a high pressure alarm that will notify the Operator before the high-high pressure level is reached. In either event, systems will trip and all producing wells will be shutdown. Activation of an ESD valve will also automatically shutdown all upstream locations.

Unavailable Technology (Dual diameter Pipelines, cement coated)

Thums has two pipelines that are multi-diameter, JBM and JL1 pipelines. In addition, the JBM pipeline is internally cement coated. Currently there is no available technology for accurately surveying both cement coated and dual diameter pipelines. These pipelines are pressure tested at 3 year intervals.

Leak/repair history

Thums has incurred no leaks or spills resulting from a regulated pipeline. External repairs and pipeline segment replacements have been made to the Subsea Pipelines. These repairs are usually completed the year after a Smart Pig Survey is completed. Past repairs or pipe replacements to the land-based pipelines have mainly included moving an existing pipeline for Port of Long Beach Land Improvement Projects. In 2002, a repair was completed on the JBM oil pipeline. An adjacent operators pipeline ruptured and the JBM pipeline was exposed during excavation. Corrosion was found under the coating and the pipeline was repaired.

Local factors that could affect pipeline integrity

Current assessments and surveys are based on existing pipeline conditions. Changes in the age of the pipeline, rate of corrosion, soil conditions, additional new pipelines in the area, etc. will affect the frequency of pipeline assessments. An original corrosion study conducted on the JBM and JL1 pipelines concluded that these pipelines are subject to corrosion based on the soil potentials and other underground metallic structures are prevalent at this particular site.

Field data also substantiated the fact that corrosion can be mitigated by the use of cathodic protection. However, past experience with coatings such as installed on these lines, indicates that as the coating deteriorates, the current requirement will increase in the years to come. Cathodic protection designs should reflect this possible increase in current requirement. In order to compensate for this affect, an additional rectifier was installed in order to support the cathodic protection on the two new pipelines installed, BMP-1 and BMP-2. Continual monitoring of pipeline conditions is needed to ensure adequate pipeline integrity

Each pipeline assessment performed is compared to the previous assessment. Changes in the pipeline, both improvements and deteriorations are documented. Any deterioration that may affect the integrity of the pipeline will trigger process changes to stop the decline.

Criteria for repair actions

Most repairs associated with the pipeline integrity program have been in the area of splash zones and pipe to soil interfaces at each island resulting from external corrosion. Internal corrosion has been minimal.

Pipeline service configuration is determined based on the most recent pipeline survey information. The pipelines with the highest integrity are used for oil service. Pipelines with the second highest integrity are use for gas service. A line is contains severe corrosion (greater than 50% wall loss) in the tidal or Subsea zones and will not be used for transporting oil or gas under any circumstances.

Methods of Repair

Repairs are initiated on pipelines that exhibit active corrosion. For example, an oil pipeline indicates an area of corrosion that shows a 40% wall loss. A follow-up survey then indicates that the area of corrosion has grown to 49% wall loss. If the area of corrosion is located anywhere on the landside of the pipeline, the corroded area would be repaired. If the corrosion was located on the Subsea portion of the pipeline then the oil pipeline would be downgraded to one of the following, gas service, reserve service or emergency reserve service. Inactive or "slow areas" of corrosion growth may be monitored only. However, if the area is again in an accessible portion of the pipeline, the pipe may be exposed, the coating removed and the pipeline re-wrapped.

Repair of active corrosion areas would be as follows:

Internal Corrosion	Pipeline replacement
External Corrosion	Pipeline Replacement or Armor plate wrap.

Armor Plate wrap can be used to restore the pipeline to its original integrity. However, it is recommended for use only on pipelines with less than 80% wall loss. Thums has used this method of repair successfully on the JBM pipeline in 2001.