

Project Overview

Onyx Special Services, Inc was retained by Enbridge Energy Company Inc. to inspect and repair 1 each, east and west, 24 inch diameter steel pipelines crossing the Straits of Mackinac. These lines run parallel to each other and are separated by approximately 1000 feet along the 4.6-mile length of the crossing, and are situated in water depths ranging from 0 to 250ffw. Both lines are buried out to water depths of approximately 50 feet, and then lie uncovered on the bottom.

The focus of this project is to inspect, identify existing conditions and repair areas which could potentially compromise the safety of the lines. Examples of these conditions could include exposed or unsupported areas of pipe, severely degraded or missing coating, or damage caused by impact. In past surveys, it was determined that the exposed pipelines are now unsupported in many areas along the crossing.

Inspection and diving services mobilized to Mackinaw City July 19, 2004 and were de-mobilized to Cheboygan August 8, 2004. The inspection services were conducted with a remote operated vehicle (ROV). Acoustical tracking, along with video records indicated that numerous spans exceeded the design tolerances of the line. As such, Onyx was mobilized to place designed supports within these problem spans. This report includes data on this repair operation as well as the initial inspection.



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Operations

Onyx Special Services, Inc. and Durocher Marine completed the inspection vessel and diving operations barge equipment mobilization at Durocher Marines yard on July 19, 2004. At that time the inspection vessel (Timmy V) mobilized. Also mobilizing, the primary tug and diving operations barge to Mackinaw City dock, where the vessels would dock for the entire job. From Mackinaw City, the inspection vessel, diving operations barge, equipment and personnel would mobilize to repair affected areas along Enbridge Energy's east and west crude oil pipelines crossing the Straits of Mackinac. Onyx Special Services, Inc. would provide the navigation, positioning, remotely operated vehicles (ROV) support and diving operations. While Durocher Marine would provide the tug boat, barge, anchors and crane.

In planning the repair operations of the pipelines, the east pipeline would first be filled with NGL and then be shutdown for the entire survey and dive repair work. As the ROV survey proceeded, affected areas of concern were determined by Enbridge Energy management viewing documentation from the Remotely Operated Vehicle (ROV) inspection videos and reports. The ROV inspection was working a day or two ahead of the diving operations along the one designated pipeline. Given the length of the spans, spans that were over 195' in length, which require the pipe line to be shut down, and spans over 140' in length, would be repaired. The west pipeline would then follow the same procedure as the east.

Diving operations for the east line repairs began on July 21, 2004 and went through July 30, 2004. Spans on the east pipeline were:

- East Line – Spans that would require repairs: E-49 north, E-49 south, E-61north, E-61 south, E-74, E-13 north, E-13 south and E-01B not in specific order. (Also, see span table.)

Diving operations for the west line repairs began on August 1, 2004 and went through August 7, 2004. Spans on the west pipeline were:

- West Line - Spans that would require repairs: W-35, W-18, W-23, W-31, W-72 north, W-72 south, W-41, and W-63. (Also, see span table.)

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Summary of Methods / Equipment Limitations

Remote Operated Vehicle



The Phantom ROV is equipped with a remote pan and tilt video camera with auto focus controls, as well as 1000 watts of total lighting. For this inspection, the vehicle was also fitted with sector scanning sonar, which enabled the operator to see objects out of the visual range of the video camera. Navigation was provided by the Link Quest tracking system in concert with RTK tracking and a stand-alone computer with Coastal Oceanographic's Hypack software. In use, the ROV is fitted with an acoustic transponder, which sends out a sound signal to be picked up by a hydrophone mounted on the side of the surface support vessel. The offset of the vehicle (calculated by Link Quest) is fed to the navigation computer that plots a corresponding XY position based on RTK information. Video from the on-board camera is recorded in VHS format, with the operator entering position information to the on-screen display.

Once data has been gathered as acoustic records, video documentation is encouraged in order to provide definitive ground truthing of the indications on the sonar record. The ROV is a free-swimming vehicle tethered to a surface support vessel and controlled by personnel on-board. Navigation and positioning is provided by Real Time Kinematics (RTK) with an acoustic link to the ROV, all plotted out on a separate computer screen.



The main limitations to this equipment are related to water clarity (visibility), water current, and surface weather and wave conditions. Obviously, in highly turbid water conditions, an acceptable video record is impossible to generate. Fortunately water clarity for this project

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was exceptional, allowing for a very clear video record. Higher water velocities (current) can pose difficulties in keeping the vehicle on station, or even getting it to the target. Currents of 1 to 2 knots were encountered during this project, which did pose challenges.

The most prevalent limitation of this equipment is imposed by weather conditions. High winds/waves make for difficulties in keeping the vessel on station (dragging anchors) as well as degrading the accuracy of the acoustic tracking system (due to the pitching and rolling of the vessel and hydrophone combination). Throughout the survey period we encountered periodic weather delays and equipment set-backs.

In operation, the vessel crew positions the support vessel over the pipeline utilizing a 2 and in some instances a 3 point anchoring system. With evidence of a strong fix RTK lock on the RTK as well as a solid return from the vehicle tracking system, the vehicle is launched from the surface to begin its descent to the bottom. Once on bottom, the operator utilizes the navigation system to guide the vehicle to the pipeline. With the pilot free to fly the vehicle, the survey supervisor takes notes with further direction given by the client representative on site. "Parking" the vehicle at the desired location attains accurate location of anomalies, while the Link Quest tracking and RTK stabilize and update the position. This position is noted in the inspection log for future reference.

Equipment Overview (Inspection Operations)

For the inspection, Onyx mobilized the Remote Operated Vehicle (ROV), a vessel and additional equipment from Cheboygan, MI to Mackinaw City, MI. This package consisted of the following:

- 40' crew vessel "Timmy V"
- Phantom HD2 remote operated vehicle
- Sector scanning sonar
- TSS Standard Gyro
- Motion Reference Unit (MRU)
- Link Quest tracking, short base line acoustic tracking system
- Real Time Kinematics (RTK) (centimeter accuracy)
- Computer navigation system
- Video recording equipment
- Comprehensive field spares kit
- Offshore safety package

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Diving Operation and Equipment









- The project superintendent is in contact with immediate personnel on treatment gas stores, equipment and equipment start-up. In turn, the tug boat captain is in contact with the USCG for shipping traffic concerns, weather reports and will report this information to the project superintendent. At this point, the project superintendent and client representative will make the determination of project location and a decision to sail.
- Span coordinates identified from the ROV survey used to plot anchor and mooring locations.
- Barge is positioned over anchor locations identified by the Hypack navigation system. The Hypack navigation program, located on the dive barge, brings in information provided from the Vector Sensor, Motion Reference Unit (MRU) and Link-quest tracking, which is then relayed to a monitor on the tug for the tug captain to follow. The anchors are then dropped approximately 750` from the pipeline and 1000` apart. Once both anchors are in position (2 anchor spread off the stern of the barge) the barge is towed into position and held in place with a constant speed and heading from the tugboat.
- The ROV is launched so that a specific repair procedure and location can be selected. Locations were selected based on their proximity to the center of the span, type of bottom encountered (smooth or irregular, hardness) and span height.
- The dive bell is then lowered to the work site, guided by the ROV. Adjustments are then made for barge positioning.
- When positioning of the barge is finished, the hydraulic drilling tool is then lowered to the work area and is held by the crane approximately 25` away from the pipeline. Also guided by the ROV.

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- The screw anchor and saddle support, which is a prefabricated design, is designed to drill along both sides of the pipeline. Extensions can be added, for adjustment with sub-bottom material or span height. When drilling into the sub-bottom, a specified hydraulic pressure must be met. At that time, the upper and lower saddle supports are installed. Placing the support over and under the pipeline and then all-thread bolts bring all the support saddle together.

- Dive operation begins and bottom time starts when the diver leaves the surface.

- Once on bottom, the diver will bring the drilling tool over the pipeline and lowers the drilling tool into place. Once in place, drilling to proceed. Diver will monitor drilling process until complete. When drilling is complete, the 3-pin assembly is disconnected and the hydraulic tool is lifted off the screw assembly and safely placed off the East Side of the pipeline to prevent dragging back into the pipe.

- Diver will then assemble the anchor and saddle into place.

- A repair (as detailed in above) is completed.

- The final inspection and position of the pipeline repair is recorded from the ROV. Diver was brought to the surface and decompressed.

This process usually entailed multiple dives to complete.

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Equipment Overview (Diving Operations)

The following equipment was mobilized to Durocher Marines yard in Cheboygan, MI for setup on barges.

- 1 - Mixed gas control Trailer
- 2 – 54" deck decompression chambers
- 4 – Hot water machines
- 2 – Quincy 5120 divers air compressors
- 150kw Multi-quip generator
- Class 2 diving bell and Handling system
- 2 – Underwater video and lighting systems
- Remote Operated Vehicle with all equipment and spares (Observation Class)
- Imagenex sector scan sonar
- Link Quest tracking Plus tracking system with 5 beacons
- 2 - Hypack navigation computers
- Vector Sensor GPS System
- 3 – 600' Divers umbilical
- Mixed gas stores
    - 100% Oxygen (Decompression gas)
    - 8416 HeO2 (Bottom mix)
    - 8614 HeO2 (Bottom mix, emergency gas)
    - 6040 HeO2 (Decompression gas)
    - 6040 Nitrox (Treatment gas)
- Miscellaneous diving and construction equipment (Hoses, extension cords, torches, tools, etc.)
- Helical Screw Anchors and Supports

    - Due to space and weather considerations, the above equipment was setup in storage containers stacked and sea fastened to the barge. The Hypack navigation equipment was centralized in the dive trailer, tracking the barge heading and position, ROV position, bell position and anchor drilling tool position. With the primary navigation being controlled from the dive trailer, a monitor was installed in the tug boat for navigation.

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Findings

The Remote Operating Vehicle (ROV) survey inspection took place July 20, 2004 through August 7, 2004 on the east and west pipelines. The diving operations followed 1 to 2 days behind the ROV inspections. Data obtained by the ROV survey inspection closely followed past findings and data obtained in the 2003 survey. During this time, Enbridge Energy made the determination that the east pipeline would be surveyed and repaired. The pipeline would have NGL placed in the line and then be locked out of service. When the inspection and repair work was concluded, the pipeline would then be placed back into service. The same procedure would be done to the west pipeline. Both the east and west pipelines show intermittent suspension over their entire length. Previous grout bag repairs were noted on the east and west lines where the pipeline no longer rested on the bag. The exposed portion of the pipeline is heavily covered in zebra mussel growth, making a detailed analysis of the coating and actual pipe condition impossible. Additionally, areas of debris encroachment as well as cables lying over the pipeline were noted.

The attached span logs identifies repaired spans, location of all spans, spider locations and current meter deployments, with northing / easting coordinates to each. Also included with this report is a CD with a very detailed informational spreadsheet of each span. Some of the information included in this spreadsheet: 2004 / 2003 span numbers, length, height, video tape number, DVD copy number, northing, easting, longitude, latitude and description.



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