

2014 Straits of Mackinaw Pipeline Inspections and Maintenance Project

Enbridge Energy
Superior, WI

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Prepared By:
Ballard Marine Construction, Inc.
Chris Bauer
Chris.Bauer@BallardMC.com
866.762.6750

BALLARD MARINE CONSTRUCTION

www.BallardMC.com

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Thomas Prew
Enbridge Energy
1320 Grand Avenue, Second Floor
Superior, WI 54880-1726
(715) 398-4703 Office
(715) 394-1405 Fax
(715) 817-8125 Cell
Thomas.Prew@enbridge.com

Re: 2014 Straits of Mackinac Pipeline Inspection & Maintenance Project

Dear Mr. Prew,

Attached you will find the job overview report. This report will contain detailed information from the Enbridge Energy, Straits of Mackinac pipeline inspection and maintenance project. Included with this report is an excel spreadsheet detailing current span information and anchor locations.

Autonomous Underwater Vehicle (AUV) data collection services took place July 12, 2014 – July 16, 2014. Remotely Operated Vehicle (ROV) and video inspection services took place August 2, 2014 – August 3, 2014 and diving remediation & maintenance services took place on August 8, 2014 – September 8, 2014 for Enbridge Energy's Straits of Mackinac line 5 pipelines, both east and west legs. An additional diving campaign took place September 29th and 30th for the collection of invasive mussels that accumulate on the pipeline throughout the crossing.

Thank you for allowing Ballard Marine Construction, Inc. (BMC) to perform the services stated above. If there are any questions, please don't hesitate to contact me be which means you deem necessary.

Sincerely,

Chris Bauer
Sr. Project/Operations Manager
Ballard Marine Construction
2395 American Drive
Neenah, WI 54956
(360) 844-6868 Office
(920) 257-9938 Cell
chris.bauer@ballardmc.com



Project Overview

BMC was retained by Enbridge Energy Inc. to inspect and maintain the east and west, 20 inch diameter, steel pipelines which cross the Straits of Mackinac near Mackinaw City, Michigan. These two pipelines, located in water depths that range for 0 to 260ffw, run parallel to each other and are separated by approximately 1200 feet along the 4.6-mile length of the crossing. Both lines are buried at the shoreline out to water depths of approximately 60 to 70 feet and then lie primarily uncovered on the lake bottom.



The focus of this project was to inspect, identify existing conditions and remediate any areas which could potentially compromise the safety of the pipelines. Examples of these conditions could include but are not limited to; exposed or unsupported areas of pipeline, items such as fish traps or cable lying on or next to the pipeline or damage caused by an impact. Past surveys and historical data have determined that intermittent areas of exposed pipeline have become unsupported along the crossing.

AUV inspection services mobilized to Mackinaw city on July 11, 2014, while ROV inspection services mobilized on August 1 2014 and diving services mobilized on August 4, 2014. All services were de-mobilized from the project prior to or on October 15, 2014. Inspection services were conducted with a combination AUV, ROV method that included Multi-beam survey systems, acoustical tracking system and video recording devices indicating that there were unsupported spans exceeding Enbridge Energy's goal for this project. As such, BMC was mobilized to install mechanical supports to reduce the unsupported span lengths to the goal of 75 feet or less.

Operations

BMC completed mobilization of the AUV and ROV inspection vessel at the Mackinaw City Dock. From the Mackinaw City dock, the inspection vessel would mobilize to the work site where BMC went through a series of equipment calibration procedures to insure accurate data collection

AUV inspections began on July 12, 2014 and completed data collection on July 16, 2014. ROV inspections began on August 2, 2014 and completed video survey data collection on August 3, 2014. One day after the completion of the ROV video collection survey the diving operations barge and equipment began mobilization at Durocher Marine's yard in Cheboygan on August 4 2014. On August 7, 2014, mobilization of the primary tug and diving operations barge to the Mackinaw City dock occurred, where the vessels would dock for the project. From Mackinaw City, the diving operations barge, equipment and personnel would mobilize to repair or reduce affected areas along Enbridge Energy's east and west crude oil pipelines crossing the Straits of Mackinac. BMC provided the navigation, positioning and diving operations while Durocher Marine provided the tug boats, inspection and diving barges, anchors and a crane.

In planning the repair and reduction operations for the pipeline spans, affected areas of concern were determined by Enbridge Energy management reviewing documentation supplied by BMC. The BMC supplied documentation was created by reviewing the AUV survey data collected in July of 2014 as well as the ROV video inspection that was completed days prior to diving operations. Unsupported spans of pipeline that were near or over 75' in length were targeted for reduction. All repairs and reductions were performed while crude oil was flowing in the pipelines.

Dive repair and reduction operations, 40 in total, for both the east and west lines that were performed in 2014 are as follows:
E-71, E-25, E-23A, E-28A, E-30, E-35, E-34B, E-32B, E-40, E-45, E-47, E-48B, E-49B, E-49A, E-22, E-19A, E-19B, E-08C/D, E-3, E-02A, E-01A, E-04A, E-05A, W-01B, W-6, W-13, W-18B, W-28A, W-31A, W-31B, W-37, W-35B, W-51B, W-68A, W-71, W-57, W-61, W-65, W-64N, W-67

Additional miscellaneous repair, debris removal and dent inspection were also performed. These tasks included:

- One dent inspections located within spans (No dent observed however a small amount of coating damage was noted).
- Two pipeline ovality inspections. (No ovality observed)
- Tightening of a loose top saddle on three previously installed mechanical support anchor.
- Invasive mussel collection

Survey/Inspections Summary of Methods / Equipment Limitations

Autonomous Underwater Vehicle –Kongsberg "Remus 100" & Remotely Operated Vehicle – SeaBotix "vLBV 950"

The "Remus 100" is a shallow water Autonomous Underwater Vehicle. The technicians are able to preprogram mission topside for the AUV to carry out underwater after it is deployed. Through these missions the technicians are able to communicate with the vehicle to insure proper operations. Once a mission is complete the technicians are able to download the collected data of the AUV before redeploying for the next mission. Because the AUV is vehicle is free flying vehicle, weather constraints are minimal. In addition, because the AUV can collect multi-beam data within a couple of meters of the pipeline, these factors make this a more versatile and useful data collection system then previously used multi-beam data collection systems.

For the AUV inspection, the vehicle was equipped with a multi-bean system, side-scan system and internal positioning systems that included GPS, INS and DVL systems. AUV technicians were than able to deploy the vehicle for data collect of a portion of the pipeline, recover the vehicle to recover collect data and then redeploy for additional data collection. Approximately 4 separate missions were run on each pipeline to insure accurate and ample data collection.

The main limitations for this equipment are minimal. This is what makes this vehicle such a beneficial tool. Because the AUV is free flying and not dependent on top side support during operations weather is not a large factor. The largest concern is battery life however, because of the large amount of data being collected and the time needed to download that data from the system it was discovered that if charging was taking place during the download of the data the AUV's internal power supply would last a full day.

The "vLBV 950", is a Remotely Operated Vehicle (ROV) system, is extremely versatile ROV system and can be employed to carry out a variety of tasks including surveying, searching and inspections. A pilot on the surface controls the vehicle remotely by sending commands to the vehicle tether. The vehicle can be moved in any direction or by using the autopilot facility remain accurately on course and depth to provide a stable platform. The pilot can also control the vehicle's video system, lighting and any other equipment fitted to the unit.

For the ROV inspection, the vehicle was fitted with a Linkquest USBL tracking system in concert with an RTK GPS system and Hypack software. In operations, the ROV was fitted with a Linkquest 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 offsets of the vehicle as calculated by Hypack, is fed to the navigation computer that plots a corresponding XY position based on Real Time Kinematics (RTK) information from the GPS. Video from the on-board camera is recorded in a digital format, with the surveyor following position information from the Hypack navigational software.

In operation, the vessel is positioned over the pipeline using a live boat operation for the survey. With evidence of a strong fixed RTK lock 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. Different from years past, the ROV inspection services were used only to obtain video of the pipelines looks for visual anomalies, coating delamination, obstructions or items endangering the pipeline and inspections of previously installed anchors. 2014 was the first year that an AUV was used to collect all position information on the pipeline

The main limitations for this equipment are related to water clarity (visibility), water current, surface weather and wave conditions. In highly turbid water conditions, an acceptable video record is impossible to generate. Fortunately water clarity for this project 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. At times high currents hampered dive operations but never became a problem during survey operations

The most prevalent limitation of this equipment is imposed by weather conditions. High winds/waves make for difficulties in launch and recovery of the equipment. Throughout the survey period weather was ideal, however during dive operations weather played a large roll and a substantial amount of weather downtime was incurred.

Equipment Overview (Inspection Operations)

BMC mobilized the Remotely Operated Vehicle (ROV), Hydrographic survey vessel and additional equipment from Cheboygan, MI to Mackinaw City, MI for the inspection. This package consisted of the following:

- Kongsberg Remus 100 – Autonomous Underwater Vehicle with all associated equipment
  - GeoSwath Multi-beam system
  - Doppler Velocity Logger (DVL)
  - Inertial Navigation System (INS)
  - Global Positioning System (GPS)
  - Depth Sensor
  - Long Base Line (LBL) acoustic tracking system
- ROV LARS – Launch and Recovery System
- vLBV 950 - Remotely Operated Vehicle with all associated equipment
  - 2- Camera (1 Black and White and 1 Color)
  - Tilt Unit
  - Lighting
  - Compass
  - Depth Sensor
- Comprehensive field spares kit
- Linkquest tracking, Ultra short base line acoustic tracking system
- Trimble SPS 461 Heading
- Motion Reference Unit (MRU)
- Trimble R5-R6 GPS System - Real Time Kinematics (RTK) (centimeter accuracy)
- Computer navigation system
- Computerized and digital video recording equipment
- Offshore safety package
- Hydrographic Survey Vessel (Miss Geodesy)
- Hypack Hydrographic Survey Software

Diving Operation and Equipment

The project manager 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 manager. At this point, the project manager and client representative will make the determination of project location and a decision to sail.

Span coordinates identified from the 2014 AUV survey were used to plot anchor and mooring locations. The barge was than positioned over anchor locations identified by the Hypack navigation system. The Hypack navigation program, located on the barge, brings in information provided from the RTK GPS, Heading Sensor, Motion Reference Unit (MRU) and Link-quest tracking system, 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 anywhere between 1,000'-2,200' apart. Once both anchors are in position (2 anchor spread off the stern of the barge) the barge was towed into position and held in place with a constant speed and heading from the tugboat.

The vLBV 950 ROV was launched so that a specific repair or reduction procedure and location can be selected. Locations were selected based on their proximity to the center of the span or as determined by Enbridge's on site representative, type of bottom encountered (smooth or irregular, hardness) and span height.

The dive bell was then lowered to the work site, guided by the ROV. Adjustments were then made for barge positioning. When positioning of the barge was finished, guided by the remotely operated vehicle, the hydraulic drilling tool was then lowered to the work area and held by the crane. When barge position was determined stable the crane operated, by use of the live video supplied by the ROV, and would capture the pipeline with the installation too. Next, the dive supervisor would begin the drilling process via controls located topside. Once drilling was complete a diver would enter the water to detach the tool from the anchor assemble and complete final installation.

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 were installed. Placing the support over and under the pipeline and then all-thread bolts bring all the support saddles together.

Dive operation begins and bottom time starts when the diver leaves the surface. Once on bottom, the diver removes the 3-pin assembly thus disconnecting the hydraulic tool from the anchor assembly. The tool is then lifted off the screw assembly and safely placed off the East Side of the pipeline to prevent dragging back into the pipe. The diver then assembles the anchor and saddle into place until installation is completed.

The final inspection and position of the pipeline repair reduction was recorded from the ROV and the diver is brought to the surface for decompressed if needed. This process typically took one dive to complete. The same ROV and equipment detailed above for video survey operations was utilized for dive support.

Equipment Overview (Diving Operations)

The following equipment was mobilized to Durocher Marine's yard in Cheboygan, MI for setup on barges:

- Mixed gas control Trailer
- 3 – 54" deck decompression chambers
- 4 – Hot water machines
- 3 – Quincy 5120 diver's air compressors
- 150kw Multi-quip generator
- 2 - Class 2 diving bell and Man Rated Handling system
- Hydraulic drilling tool
- 2 – Hydraulic hose reels
- 2 – Underwater video and lighting systems
- vLBV 950 - Remotely Operated Vehicle with all equipment and spares (Inspection Class)
- Link Quest tracking Plus tracking system with 4 beacons
- 2 - Hypack navigation computers
- Trimble R5/R6 RTK GPS
- Trimble SPS 461Heading
- 2 – 600' Diver's umbilical's
- 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, tools, etc.)
- Helical Screw Anchors and Supports

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

Findings

Data obtained during the 2014 AUV and ROV survey inspection closely followed past findings and the data obtained in the 2012 surveys. A second, an attempt was made to cross reference the hydrographic survey data of the pipelines with the most recent pipeline ILI data sets. The goal was to determine pipeline depth of cover information where the pipeline was not visible to the ROV or exposed. After resolving several ILI data set inconsistencies, mainly associated with the east pipeline, comparisons of the ILI data set to the AUV survey data along with depth of cover information where the pipeline is buried were achieved with positive results.

During the inspection process, Enbridge Energy made determinations as to which spans would be reduced. The pipeline would have crude flowing through the line during anchor installation which was consistent with the 2012 campaign but differed from years prior. Both the east and west pipelines show intermittent suspension over their entire length of exposed pipeline. Some of the previous grout bag that was used in years past for span reductions were noted on the east and west lines where the pipeline no longer rested on top of the bags. Mechanical anchor supports used in years past were stable and in good condition. The exposed portions of the pipelines are heavily covered in zebra mussel growth, making a detailed analysis of the coating and actual pipe condition difficult. However a few instance of a small amount of coating delamination was observed. Additionally, areas of small debris encroachment were noted but not of concern.

The attached spreadsheet identifying requested span information is included within this report. This spreadsheet identifies span identifiers, location of all spans, current span lengths, distance between spans, anchor locations, span touchdown point information including depth and bottom type.

Comment/Suggestions/Recommendations

Over the past 14 years, BMC (formerly Veolia Environmental Services, Onyx & Superior) has continued to work with Enbridge Energy to monitor, inspect, repair and reduce any issue or concerns with both the east and west pipelines that cross the Straits of Mackinaw. The continuation of that monitoring, inspecting, repairing and reducing of spans for the two pipelines is one of the many important steps taken to help prevent problems from developing in the future and should continue to be an ongoing process.

Because of all 40 span reduction operations BMC preformed in 2014, both the east and west legs of Enbridge Energy's line 5 crossing the Straits of Mackinaw, no remaining spans exceed 75' in length. Furthermore, the ROV video inspection and AUV data collection shows that the pipeline currently appears to be in stable condition with minimal coating delamination or nearby obstruction concerns. As stated above, BMC's believe that Enbridge Energy should continue its rigorous inspection schedule of the pipeline crossing to insure that the pipeline stays in the good operating conditions.