Repairing an Underwater Pipeline

Divers followed these steps to repair a heavily corroded flange underwater in the Caribbean Sea

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During the annual inspection of the nonmetallic transfer hoses at a hydrocarbon unloading facility in the Caribbean, a heavily corroded flange (Fig. 1) on an 8-in. stationary steel pipe was discovered.

The hoses are part of a system in which two parallel 8-in. Schedule 80 pipelines of API 5L Grade B steel connect a tank farm onshore with the flexible nonmetallic transfer hoses on the bottom of the sea. The ends of the hoses are connected to tankers, moored during the unloading process on mooring buoys. Annual inspections of the hoses are required. This inspection process calls for divers to disconnect the hoses, which are then pulled out of the water for a thorough visual inspection on land.

In late 2008, major maintenance work was performed on the pipeline, including the removal and inspection of the hoses, as well as changing bolts and gaskets.

A routine inspection with a remotely operated vehicle (ROV) this summer revealed a heavy calcium layer on the flange of the stationary pipe on the south pipeline. Further investigation with the ROV confirmed heavily corroded and eroded material around the bolt holes in the flange of that pipe.

It was discovered that during the maintenance work performed in late 2008, stainless steel bolts without insulation were used on the mild steel flanges. Without insulated bolts, galvanic corrosion—an electrochemical action of two dissimilar metals in the presence of an electrolyte and an electron conductive path—could take place.

The owner of the facility contacted Miami Diver Inc., Miami, Fla., to remove the corroded flange from the stationary pipeline and replace it with a new flange.

After reviewing the pictures taken by the ROV and the original project specifications, it was decided to cut off the damaged flange and weld a slip-on ANSI Class 150 flange onto the pipeline. The flange material was ASTM A 105 with the bore to match the existing API 5L Grade B, 8-in. Schedule 80 steel pipe.

Welding Procedure Development and Welder Qualification

The first step for Miami Diver was to write a repair and welding procedure, which the client and a governmental organization had to approve. The procedure listed a step by step approach for the repair, including the welding procedure specification (WPS) and welder performance qualification (WPO) for the underwater welding work that would be performed.

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Once all the approvals were obtained, welder qualification took place at the Miami Diver facility in Miami. A PQR for welding fillet welds on pipe had already been established and approved by Lloyd’s Registrar. A WPS for the welder qualification was written, as is practice with the classification societies. Three diver
welders and the H. C. Nutting welding engineer retained by Miami Diver practiced for one day, prior to the tests being witnessed by the Lloyds surveyor.

The tests were performed in a 35,000-gal tank at a water depth of 18 ft on a 5-in.-diameter Schedule 80 pipe, welded to a 1-in.-thick base plate in the 5F position. The progression of the welds was downhill. The fillet weld between the pipe and the plate was a ⅜-in. multilayer weld containing three passes.

In accordance with AWS D3.6, this test qualifies the diver welders for welding pipe diameters between 2.5 and 10 in. (70 and 280 mm), with production weld sizes between 1.5S and a minimum production weld size of 0.5S (where S is the leg length of the qualification weld), with the SMAW wet process.

During the practice run, every welder was able to weld two test coupons under the test conditions — Fig. 2. The test pieces were tested as required per AWS D3.6: four fillet weld break tests and four macroetch tests — Fig. 3. At the end of the day, the welders and welding engineer were satisfied with the results and were ready for the surveyor to witness the tests the next day.

The tests witnessed by Lloyds Registrar occurred without any problems. The tests were welded in the tank and visually inspected. After acceptance under the critical eyes of the welding engineer and Lloyds surveyor, four fillet weld break tests and four macro samples were removed from every test assembly welded — Fig. 4. All three welders passed the tests on the first attempt.

Removal of the Damaged Flange

The repair procedure called for the damaged flange to be cut off underwater. To produce a quality cut, a very precise saw was needed. A split frame low clearance saw, manufactured by the E. H. Wachs Co., Lincolnshire, Ill., seemed to be the right tool for the job. E. H. Wachs agreed to send a technician to Miami to explain the saw to the team assigned to do the flange repair.

The saw features a ring that clamps around the pipe, and two cutting tools offset 180 deg from each other that rotate around the pipe and perform the cut. The hydraulically driven machine produces a high-quality cut. The machine can make a 90-deg cut, or it can produce any other joint geometry with any opening angle possible.

Upon arrival in the Caribbean, a
Fig. 6 — This concrete mat over the pipe prevented the use of lift bags.

Fig. 7 — Dive supervisor Peter Joenson dressing the diver.

Fig. 8 — A diver installs the saw on the pipe.

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Fig. 9 — The saw performing the cut underwater. A stingray came by to check everything out.

Fig. 10 — Diver Chris Mizener employs the wet SMAW process and a Hydroweld FS electrode to weld the slip-on flange to the pipeline.
meeting was scheduled at the client’s facility. The team split in two groups. The welding engineer and the dive supervisor met with the client to discuss the project and to receive a safety orientation. Two divers met with the rest of the crew, who had arrived with the dive boat, which was already waiting at the dive site — Fig. 5.

The nonmetallic hoses had already been disconnected and stored on land. The repair work was scheduled for three days, during which an inspection dive needed to be performed to evaluate the extent of the damage, and then the corroded flange had to be cut off and replaced. After welding the new flange onto the pipe, the hoses had to be reconnected, a pressure test performed, and finally a last inspection dive made. During that dive, video footage of the submarine facility would be taken for the client to view.

The Crew

The dive crew consisted of the dive supervisor, welding engineer, and two divers. The dive boat crew included the captain, one diver, and two deckhands.

The first dive was to inspect for and to videotape the extent of the damage. The diver also evaluated the work to be performed, including the space underneath the pipe. The information collected was important to the discussion on how to proceed with the repair. It was critical to have enough room underneath the pipe to install the saw and to allow the diver welder to weld in the overhead/6 o’clock position.

The object of the second dive was to create the necessary space underneath the pipe. The first thought was to raise the pipe at the end with lift bags, but that proved to be more challenging than initially thought, because the sand was so fine and kept slipping back into the jetted area. However, the diver (Fig. 7) finally removed enough material to create sufficient space to weld in the overhead/6 o’clock position.

Cutting the Pipe

It took two divers approximately 45 min to install the saw for cutting the pipe — Fig. 8. The saw was placed approximately 6 in. behind the weld joint. The old flange was a weld neck type. The entire cutting process was accomplished in less than 15 min, with excellent saw cut quality. The sound or the vibration created by the cutting process attracted a stingray — Fig. 9.

After the cut was completed, the damaged flange was brought to the surface, and the Wachs saw was removed from the pipe and brought to the surface as well.

Welding the Flange

Before welding began, the coating and marine growth needed to be removed from the weld area and the nearby heat-affected zone. The paint in the weld area and heat-affected zone of the new flange was also removed with a grinder. In addition, the paint in the flange’s inside hole was removed.

The completed weld was visually inspected and passed the acceptance criteria for Class B welds in accordance with AWS D3.6, Specification for Underwater Welding. The finished weld was also videotaped for the client to evaluate.

To protect the finished weld, underwater epoxy was applied to create a strong, permanent seal — Fig. 11.

Installing the Hoses

The four flexible nonmetallic transfer hoses on the north and south pipeline needed to be reinstalled. The hoses were capped to make them buoyant and floated on the surface to the approximate location where they needed to be connected. To sink the hoses, the divers removed the caps and flanged the hoses together, using insulated fasteners and new gaskets. The last hose on each side received a blind flange to seal the system prior to pressure testing.

Pressure Test and Final Inspection

The client requested a pressure test to be performed at 225 lb/in.². The pressure needed to be held for 15 min without any leaks. The leak test showed a pressure loss in one location. After the fasteners in the location in question were retightened, the pressure held.

The last task was an inspection dive along the pipeline and the transfer hoses, with the buoys reconnected at the ends. This dive was videotaped and witnessed by the client.