Trouble in Paradise

A deep-sea vehicle helps a contractor stop effluent leaking from a treatment plant's outfall into the Caribbean Sea

By Scottie Dayton

An annual inspection of the Ponce Wastewater Treatment Plant outfall in Ponce, Puerto Rico, identified effluent leaking from shallow and deep-water joint failures. The 48-inch pipe extends 3.5 miles offshore and ends in 400 feet of water. The U.S. EPA ordered the owner to repair the joints.

Divers, working through manholes, installed internal spot repair liners in the shallow sections. However, for reasons of safety, cost efficiency, depth (376 feet), and distance from the nearest access point (1,060 feet), the same approach was inappropriate for the deepwater leaks.

Plant engineering consultants contacted Bob Clarke, senior operations manager of the Marine Services Group of ASI Group Ltd. in St. Catharines, Ont., to develop repair options. Using spot repair liners, a proprietary cementitious mix, modified packer, workboat, and remotely operated vehicle (ROV), the team repaired the leaks to the EPA's satisfaction while battling hurricanes and high temperatures.

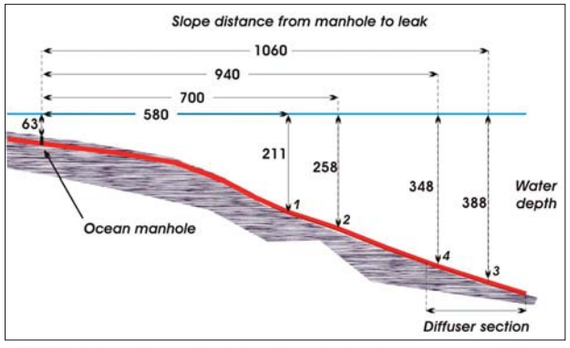

FIGURE 1: Locations of leaking joints in the deep ocean outfall. Number 4 was discovered during a preliminary repair inspection.

FIGURE 2: The ROV with modified packer from Logiball (upper) and a grouting sleeve from Link-Pipe (lower).

Initial repairs

The concrete and weight-coated, spun-concrete-lined steel pipe lies in a backfilled trench. Running down a 20-degree slope near the offshore end, it breaks through the ocean floor and rests on specially designed cradles. Concrete mats provide additional ballast. Leaks at locations 1, 2, and 4 (Figure 1) required repair. The only access to the joints was a manhole in 65 feet of water and nearly 4 miles offshore. ASI hired *Kruger B*, a 90-foot tugboat, as its work platform.

"Daytime temperatures hovered around 100 degrees, and the water was a constant 84 degrees," says Clarke. "Because the divers were in a contaminated environment, they wore rubber suits that seal to the diving helmet and gloves. Overheating and dehydration were constant challenges."

Dive durations were limited for these reasons and to eliminate decompression before surfacing. Divers were washed with water and a bleach solution, then rinsed before removing their equipment.

The pipe at the manhole inverted 10 feet down. Divers installed an upstream bulkhead to isolate the effluent, then flushed out the downstream section with a Flygt pump. They fitted a ring of brushes to a Phantom HD2 deep ocean survey vehicle from Deep Ocean Engineering to clean the pipe walls, reducing the amount of material that could obscure the vehicle's cameras.

"We modified the HD2 by adding a wheeled carriage so it would travel the pipe more easily," says Clarke. "We also added a water pump with remote valving, and a digital stills video camera," ASI also modified the mainline packer from Logiball by adding floatation devices (Figure 2).

The HD2 was loaded, piloted, and propelled through the pipe to the repair location from the surface (Figure 3). Using multiple cameras to ensure placement, a flexible Grouting Sleeve spot repair liner from Link-Pipe Inc. was locked in place by inflating the packer using the vehicle's water pump. Once the locking tabs engaged, the packer was deflated and the ROV removed.

The liners formed a seal against the leaking joints with spring pressure and elastomeric gaskets. During this repair, the site was abandoned for Hurricanes Frances, Ivan, and Jeanne.

One-off concoction

"The joint at location 2 was misaligned by 3 inches and beyond the tolerances of the repair sleeve," says Clarke. "The rough finish of the spun-concrete lining exacerbated the condition." Industry experts in Europe, Canada, and the United States agreed that no commercial product or technology would fix the problem.

Preferring a method that injected material into the joint to create a seal, ASI built a mockup of the offset and tested several commercial grouts mixed with various additives. "We plugged hoses or had excessive leakage," says Clarke. "We needed a mix close to the specific gravity of seawater to help prevent run-out."

This workboat carried equipment and personnel to the scene of the repair.

Tough Job

PROJECT:
Repair pipe joints leaking effluent 400 feet below the Caribbean Sea

CUSTOMER:
Ponce Wastewater Treatment Plant, Ponce, Puerto Rico.

CONTRACTOR:
ASI Group Ltd., St. Catharines, Ont.

EQUIPMENT:
HD2 deepwater survey vehicle from Deep Ocean Engineering, San Leandro, Calif; Grouting Sleeve spot repair liners from Link-Pipe Inc., Richmond Hill, Ont.; mainline packer from Logiball Inc., Québec

RESULTS:
Leaks stopped successfully

FIGURE 3: The ROV pilot (left) at the control consoles inside the tugboat uses three monitors. The one to his left is a multiple display, three for the ROV cameras and to display the positioning system for the boat. It shows the boat's location on a navigation chart and includes anchor positions. The middle monitor is the primary camera display and the one on top of the console is the permanent navigation display.

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>
> **Bob Clarke**

The team developed a proprietary mix that used a water-to-cement ratio suitable for high strength, a gel-forming organic polymer, and inert, inorganic microspheres for filler and to reduce specific gravity. Trials demonstrated a highly fluid mixture that pumped easily, even as the additive started to gel. The gel stabilized the grout, and the insoluble fiber and microspheres helped block leaks.

"We used a high-pressure pump, assuming we would encounter considerable resistance when pumping 1,000 feet through 3/4-inch hose," says Clarke. "However, we never reached 200 psi, the priming pressure of the pump, probably because of the gel's slippery nature and the microspheres' ballbearing-like action, which eliminated friction."

ASI then modified HD2 again (Figure 4) to include:

- More cameras and lights to help position the packer and monitor process.
- A pressure gauge to confirm inflation pressure at the packer.
- A return hose and valve to flush grout from the delivery hose during setup.

Based on the success of the Logiball packer, ASI used one of its collapsible mainline packers modified to fit around the HD2. The vehicle's umbilical, carrying power, video, and control cables, was bundled with two high-pressure grout hoses and a twin low-pressure hose for bladder inflation. A powered capstan was needed to deploy and recover the heavy bundle.

Back to Ponce

Kruger B again provided the work platform. A similar procedure was used to lock out and isolate the pipe, and clean the interior. To avoid midsummer heat, which surpassed the thermometer's 120-degree limit one day, divers worked at night.

"We also didn't know whether daytime highs would adversely affect the mix's flash setting," says Clarke. "Samples of the grout formed a cementitious gel with the consistency of a sponge ball within 10 minutes of incorporation."

The first grout injection was completed in less than two hours, including flushing of the lines. Divers left the packer in place for eight hours. When it was removed, the ROV cameras revealed a perfect repair, but on the edge of the joint.

FIGURE 4: HD2, the delivery system, with the modified Logiball packer as an external frame.

The team adjusted the camera system and added tell-tales to the packer at the injection ports. (Tell-tales are flexible plastic strips that ride against the crown of the pipe, but pop up once into the gap.) This time the grout went straight into the leaking joint and produced a perfect repair.

After the line was recommissioned, a final inspection confirmed that no effluent was leaking from the repaired joints. Grout stains were visible on the outside of the pipe, and numerous small fish were congregating under the grout mattress, an excellent indicator that the water was uncontaminated. ■

Doing the main repair at night meant cooler temperatures and calmer weather.

MORE INFO:

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