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Featured Projects

Navy Turns To The Sun to Protect Pipelines at Guantanamo Bay

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The naval station at Guantanamo Bay, Cuba, is America's first and oldest overseas base. The underwater fuel and water utility pipelines crossing U.S. Naval Station Guantanamo Bay (GTMO) are vital for day-to-day operations. A corrosion-induced leak on a fuel pipeline would dramatically curtail the base's flight operations, not to mention the negative effects on the environment. If a water utility pipeline were to fail, it would leave Navy personnel and their dependents without a supply of potable water.

Inadequate Cathodic Protection

When studies revealed that the cathodic protection (CP) system on the western side of Guantanamo Bay was not operable, the Navy had to act. The eastern CP system was adjusted to protect the pipelines on a temporary basis, but a failure of that system would have left the pipelines totally susceptible to the ill effects of corrosion. In many cases, correcting such a problem entails simply replacing the impressed current CP (ICCP) system to the bay's eastern side.

The Navy has installed a solar-powered cathodic protection system on its base at Guantanamo Bay, Cuba. Photo courtesy of Naval Facilities Engineering Command (NAVFAC).

An ICCP system generally utilizes an alternating current (AC) to direct current (DC) power source called a "rectifier." The rectifier drives DC through the seawater from an array of anodes (a group of metallic electrodes) to the steel pipeline along its entire submerged external surface. As the DC collects on the pipeline, the surface becomes immune to corrosion. The array of anodes, commonly referred to as an anode bed, basically "sacrifices itself" by undergoing corrosion rather than the pipeline, which is electrically the "cathode" in a simple DC low-voltage circuit. A pipeline under "cathodic protection" will no longer corrode and can sustain its structural integrity indefinitely.

Insufficient Alternating Current

At GTMO, the Navy lacked a key component for an ICCP system to work: a readily available AC power source. "Power availability would have required us to install an expensive voltage transformer and a very long run of secondary conductor," said Edwin Piedmont, CP Program Manager with the Naval Facilities Engineering Command (NAVFAC) Engineering Service Center.

Piedmont explained that the inoperable CP system used a defunct electrical distribution system that once served housing units in the vicinity. The housing, however, had become obsolete and was demolished along with the electrical distribution system. Rather than install a new power line and transformer and bear the approximate $50,000 cost for equipment and roughly $2,500 per year in energy costs, the Navy chose to harness one of GTMO's most abundant power sources—sunlight.

Plenty of Direct Current

"AC-powered units actually have to convert the AC to DC using a rectifier," said Piedmont. "Solar power provides a pure DC power source." Taking advantage of this fact, the Navy saw an opportunity to demonstrate a solar-powered CP system whose DC is regulated by high-efficiency electrical controls. These high-efficiency controls are critical because they match the solar and seasonal variations to the system's anode bed and battery storage capacity.

Because the CP system requires a constant source of energy, it is paramount that the energy collected on sunny days be stored to compensate for the lack of sunlight during nights and overcast/rainy days. "The high-efficiency units enable us to get more energy and require us to store less, reducing the need for both solar panels and storage batteries," Piedmont said.

Solar energy collected in this photovoltaic array provides power for a cathodic protection system that protects fuel and water pipelines at U.S. Naval Station Guantanamo Bay. Photo courtesy of Naval Facilities Engineering Command (NAVFAC).

To illustrate the energy storage capability of the newer solar CP systems, Piedmont pointed out they are designed to operate for three to four days without any light. On a clear night the units actually do receive power from the starlight, but the amount of power in that case is much lower than what the sun provides. Given GTMO's proximity to the equator (North 19.9 latitude), the system can operate year-round on nine (winter) to 15 (summer) hours of recharge time. Batteries power the CP systems at night.

Superior voltage control is a key advantage that newer photovoltaic technologies offer in relation to earlier generations of solar-powered CP systems. These newer devices have proven more effective at controlling voltage than their precursors. "The old way generated way too much power at times and too little at others," noted Piedmont, who oversaw the construction of a solar-powered CP research project for a Panama City seawall in 1990. "We had to spend that generated energy, and resistors had to be used in the summer to throttle the system." He added that the newer technologies control the power much more effectively. As a result they do not generate the extra energy and eliminate the need for resistors, which are prone to burn up if they collect too much current.

Shipping Challenges

According to Piedmont, the solar-powered CP system at Guantanamo has worked as well, and even better, in some cases, than an AC-powered system, since going online in February 2008. He said the biggest challenge was shipping the CP system's components into Guantanamo. "As far as the CP system itself, we have yet to have any unexpected surprises since we anticipated that it would work," he said.

Piedmont contends that solar-powered CP systems would be suitable for other Navy installations worldwide, particularly those in remote locations. The difficulty in getting the technology on-site, however, will likely continue to be an obstacle to installing it at other far-flung bases. "If we were able to ship materials easier, we could put them in many locations, but the materials are hard to get in these sites," he concluded.