Pretreatment for Portable Purification

U.S. Army deploys a new generation of water purification technology

By John McArdle

The U.S. Army utilizes state-of-the-art membrane water purification technology to support highly mobile military operations and humanitarian missions. Mechanical Equipment Co., Inc. (MECO), of Sugar Land, Texas, has designed a lightweight water purifier (LWP) that can be easily transported to remote locations to produce safe drinking water from almost any available raw water, including surface water with high turbidity, brackish water and seawater. The LWP is also capable of purifying water contaminated with nuclear, biological and chemical warfare agents.

The LWP is light enough to be carried by four soldiers and simple enough for two operators to assemble and begin producing water from a source such as a river, lake, pond or ocean in just 45 minutes. The entire system can be transported in the cargo space of a HMMWV and by a single haul of a medium-lift utility or assault helicopter such as the UH-60 Black Hawk.

In the past, desalination systems had been designed for conventional seawater salt concentrations of 35,000 ppm; however, the salinity is much higher in the Middle East. It is 45,000 ppm in the Arabian Gulf, and in desert waterholes it can reach 60,000 ppm. MECO specifically tests each LWP to verify that it meets the 60,000-ppm requirement, enabling the systems to treat any water, anywhere in the world.

The compact LWP unit produces 125 gal per hour (gph) from fresh or brackish water and 75 gph from seawater—sufficient production levels to support company/battalion-sized units in the field. The exact number of people that the LWP unit can sustain in the field is proportional to the water consumption scenario. If the unit is used solely for drinking water, for example, it will be able to support more soldiers than if it is used for purposes such as cooking, cleaning, showers or laundry.

The LWP combines UF membranes that pretreat the water prior to processing by RO membranes.

Portable Water Treatment

Water filtration technology has evolved significantly since MECO began designing and manufacturing transportable water treatment systems for the U.S. military more than 60 years ago. In fact, the original thermal desalination systems used by the Marine Corps in the invasion of Iwo Jima employed MECO's patented vapor compression technology.

The new LWP combines two types of membrane filtration: ultrafiltration (UF) membranes that pretreat the water prior to processing by reverse osmosis (RO) membranes. This design replaces the Army's previous generation of portable water processing equipment, which pretreated the RO feedwater with multimedia filters (MMF) and disposable cartridge filters.

The MMF and cartridge filters posed several problems. Fundamentally, they were only capable of removing suspended solids between 1 to 5 microns, allowing some particulate breakthrough and causing quick fouling of the RO membranes.

The other problem was that the cartridge filters required frequent replacement, as often as every half hour in some cases. This problem extended beyond the labor involved in replacing the filters. More importantly, the continual resupply of consumable items can be a logistical challenge—and dangerous—in remote locations and under combat conditions.

Pretreatment of Feedwater

The UF membrane process in the new LWPs eliminates the need to replace and resupply disposable filters. Each system employs three Romicon Romipure UF cartridges from Koch Membrane Systems, Inc. (KMS).

The 5-in.-diameter cartridges contain hollow fiber membranes with

an internal diameter of 35 mL. The membranes and the cartridge housing are both composed of polysulfone, a high-strength polymer thermoplastic noted for its chemical stability under a wide range of temperatures.

The UF membranes have a 100,000 Dalton nominal molecular weight cut-off that consistently produces filtrate water with turbidity of less than 0.1 NTU, a more than 10-fold improvement compared to MMF and cartridge filters. The UF membranes remove turbidity, suspended solids, bacteria and other microorganisms from the feedwater that can foul the downstream RO membranes. The higher quality filtrate water prolongs RO membrane life and dramatically extends the time between RO cleanings, regardless of the feedwater conditions.

The UF pretreatment not only serves to limit fouling of the RO membranes, but the Romipure cartridges also have important features that limit and counteract their own fouling.

The hollow fiber cartridges operate from the inside to the outside during filtration, and the feedwater (retentate) flows through the center of the hollow fiber, and the filtered water (permeate) passes through the fiber wall to the outside of the membrane fiber. The tangential flow of the retentate sweeps across the membrane surface and continually acts to limit membrane fouling.

The hollow fiber geometry allows for a large amount of membrane surface area in a compact module. This high packing density means large volumes of water can be filtered while utilizing minimal space and power, both of which are critical advantages for the LWP application.

A high-pressure pump driven by a diesel engine draws water from a 40-gal filtrate tank on the UF module and feeds the RO module under pressures of up to 1,200 psi. The purpose of this filtrate tank is to provide backwash and fast flush capabilities for the UF membrane while allowing continued operation of the high-pressure pump.

Producing Pure Water

The RO module consists of seven Fluid Systems TFC spiral RO elements manufactured by KMS. The membrane elements feature a proprietary thin-film composite polyamide designed to increase efficiency and reduce costs. The pressure vessels are constructed of titanium.

The RO membranes remove dissolved and suspended materials including organics and salts. Only molecules in the range of 5 Angstroms (0.0005 micron) or 100 MWCO will pass through the membrane. Approximately 30% of the RO feedwater is recovered for use as drinking water, and the rest of the concentrate (or brine) is discharged as reject. The permeate from the RO module is passed through a chemical module, where it is metered and given a chlorine injection for residual disinfection.

The U.S. Army awarded MECO a multiyear contract for 380 of the LWP units, and about half of the units have been delivered and are in use in Iraq and Afghanistan. The systems are being used to support the U.S. Army field troops.

The 82nd Airborne Division is operating a number of LWPs in Iraq, specifically providing water for their mobile kitchens. The LWP provides a more practical and safe water solution compared to the older methods of using bottled water. In the past, providing bottled water required extensive logistical and security support to ensure that the water made it to the remote sites untainted.

Prior to field deployment, MECO and KMS built seven prototype systems

that were subjected to rigorous and exhaustive testing by the U.S. Army, including 5,000 hours of operating time and 1,600 miles of cross-country transportation testing in the back of a HMMWV. The design and testing process led to important system refinements and improvements. For example, MECO worked with KMS to address the challenge of designing a system that can sustain several freeze-thaw cycles, conditions that go well beyond the environmental requirements of most water purification systems.

"The KMS membranes have been remarkably resistant to fouling," said John Klie, government business development manager for MECO. "We worked closely with KMS engineers to develop and optimize an automated backflushing method that has practically eliminated the need for chemical cleaning operations. Of the various vendors that we researched and tested, KMS provided the only solutions that did not require the use of ancillary air scouring equipment to clean the membranes."

Kyaw Moe is the MECO LWP program manager who provides training and technical assistance to the Army specialists who operate the LWP units. He is not aware of a single instance of any LWP requiring a chemical cleaning for the RO membranes.

"I was recently in contact with members of the 10th Mountain Division headquartered at Camp Liberty, Iraq," Moe said. "They have been using the LWP in combat conditions for over a year, producing clean water without the need for a single chemical cleaning procedure."

On top of simplifying the process, fewer chemicals make for better-tasting water. "The water produced by the LWP is very palatable," Klie said. "We have found that the challenge with older conventional systems has been over-chlorination, which ultimately gives water a 'swimming pool' taste. The LWP's automated chlorine dosing system prevents this from occurring, and hence, produces a drinking water taste that is similar to commercially available bottled water."

An Economical Solution

The LWP has proven to be an economical solution in Iraq, where the cost of supplying bottled water to the troops can be as high as $5 per gal. Water produced by conventional first-generation purification systems costs approximately $1 per gal, including the cost of disposable filters, chemicals and fuel. The LWP can produce water at 7 cents per gal, which is primarily the cost of diesel fuel to operate the system and chemicals for minimal, periodic cleaning.

The MECO LWP, with UF and RO membranes from KMS, provides a self-supporting water purification method for the U.S. Army Special Forces and other remote military and humanitarian missions that eliminate the need for difficult, expensive and dangerous water resupply. *wqp*

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