Military Vehicles and Equipment

Tribology plays a huge role in ensuring that tactical machinery can go from land- or sea-based storage to combat readiness almost immediately.

by Maurice E. Le Pera

CONTINUED ON PAGE 30
Prepositioning requires that a "partial preservation" be done, as the particular vehicles and equipment have to be nearly or fully operational when needed for immediate deployment.

**The January issue of TLT featured** an excellent article titled "Mothballing Equipment" that describes the processes and systems for shutting down plants and equipment and then restarting them month, years and, in some cases, even decades later.

These and possibly more stringent preparations are needed when prepositioning large numbers of the military’s vast fleet of vehicles and equipment. The Department of Defense (DOD) maintains stocks of vehicles (both wheeled and tracked), equipment (wheeled and stationary) and supplies called war reserves that support military units during a war or periods of mobilization. These war reserves are stored within the continental United States and are distributed as needed by air and sea.

Additionally, war reserves are also prepositioned overseas on land and on ships near areas of potential conflict. Prepositioning is a variation of forward basing and defines the staging of vehicles, equipment and supplies in a forward location for use by a force at some future time. In this way, the time it takes to transport large quantities of vehicles, equipment and supplies in responding to a crisis is significantly reduced.

The process of prepositioning differs somewhat from mothballing. In the case of mothballing, vehicles and equipment undergo a more complete preservation process, as the periods for storage can last many years. Likewise, to reactivate mothballed equipment, many man hours are needed to remove protective materials (like vapor corrosion-inhibited wraps), install and replace components and tend to such maintenance tasks as flushing systems, replacing fluids and lubricating oils, refueling, etc. All of these functions are needed to restore the vehicles and equipment to full operational service.

On the other hand, prepositioning requires that a “partial preservation” be done, as the particular vehicles and equipment have to be nearly or fully operational when needed for immediate deployment. In other words, as soon as the items are removed from their prepositioning location, be it a ship or a land-based storage facility, they have to be fully functional and capable of operating under their own power from the facility or ship to designated staging areas.

Further, with the global demands being imposed on DOD that originated since the 1940s, prepositioned vehicles and equipment have to be capable of satisfactorily operating in all types of environmental conditions regardless of the geographical area in which they are to be deployed.

**BACKGROUND/CHRONOLOGY**

Prepositioning began in 1961 with the Department of Army directing the prepositioning of vehicles and equipment for two divisions stationed in Europe that included 10 support units. Then, in 1964, the Combat Equipment Group-Europe (CEG-E) was established to store, maintain and issue vehicles and equipment to units from the continental United States deployed in support of the European General Defense Plan. This plan was tested annually during the Return of Forces to Germany (REFORGER) exercises that began in 1968 and continued each year until formally ending in 1990.

In REFORGER, forces were deployed from the states to Europe where they were issued their forwarded-deployed vehicles and equipment called “pre-positioned organizational material configured to unit sets” or POMCUS. These forces would undergo training as part of their annual exercises, return the vehicles and equipment to their CEG-E sites when finished, and then return to the states.

To illustrate the magnitude of such operations that occurred during these REFORGER exercises, nearly 9,000 soldiers were deployed in 1983 to Holland (i.e., one of the CEG-E POMCUS sites), drew their prepositioned vehicles and equipment, then moved to a staging area and conducted exercise “Certain Strike” on the plains of northern Germany. At the completion of the exercise, the 9,000 soldiers returned back to the states with the vehicles and equipment being returned to their POMCUS locations.

During the time when Army materials were being prepositioned, the Marine Corps came up with the idea of floating warehouses for prepositioning vehicles and equipment. Focused, even during the Cold War, on
responding to brushfires around the world, the Marines stationed cargo ships called Maritime Prepositioning Force. These retrofitted cargo ships, initially referred to as Near-Term Prepositioned Ships, were stationed in the Mediterranean, the Indian Ocean, and the Western Pacific. Each of the three squadrons held enough weapons, vehicles, and other equipment to outfit a Marine Air-Ground Task Force consisting of about 15,000 troops, pilots, and support personnel.

With the advent and success of the Maritime Preposition Force, the Army since 1991 has also adopted use of ships for prepositioning some of its material assets with the result that it now has a fleet of some 15 or more ships to accommodate this requirement. The bulk of the Army fleet (i.e., the Army Preposition Afloat) is eight Large Medium-Speed Roll-On/Roll-Off ships (LMSRs) anchored off the British territory Diego Garcia in the Indian Ocean. Each 1,000-foot-long ship has decks reinforced to hold the 70-ton tanks and includes ramps that allow them as well as other tracked and wheeled vehicles and equipment to be directly driven off with a minimum of time and labor.

With both the Maritime Preposition Force and the Army Preposition Afloat, there are additional numbers of prepositioning ships that are designed to carry fuel, ammunition, and other supplies needed to support the forces. The numbers of ships given in this article only reflect those prepositioning ships that house combat and tactical vehicles and equipment.

CURRENT PROGRAMS

Current prepositioning programs involve both land bases and ships. The Army Prepositioned Stock (APS) program includes both land-based and ship prepositioning of vehicles, equipment, and supplies. The land-based sites are in central and southern Europe, northeast Asia, southwest Asia and within the continental United States. Facility support at these locations includes full maintenance capabilities and controlled humidity/temperature storage facilities.

In addition to these four land-based locations, the Army also maintains its Army Preposition Afloat force, which involves some 15 or more ships that can be anywhere at sea but have basing facilities on Diego Garcia. These ships can support operations requiring a large variety of vehicles and equipment. For example, one LMSR can carry an entire Army task force including 58 tanks, 48 tracked vehicles and more than 900 trucks and other wheeled vehicles in its 394,000 square feet of cargo space. An excellent example of this is shown in “The Army’s Floating Brigade” which can be viewed at www.army.mil/soldiers/nov2002/pdfs/float.pdf.

Prepositioning of vehicles, equipment and supplies for the Marine Corps is under the Maritime Preposition Ships program that encompasses some 16 or so LMSR ships configured in three squadrons. Each squadron is capable of supporting a Marine Expeditionary Brigade of 17,600 troops for 30 days. As of 2003, five ships were located in the Mediterranean Ocean, six ships in the Indian Ocean near Diego Garcia and five ships in the Pacific near Guam and Saipan. Since the 1991 Gulf War, the LMSR ships have undergone additional modifications, one being the need to increase their speed, from an average of 13 knots to an average of 24 knots. Further, these LMSR ships now can be loaded or off loaded within 96 hours (1).

PROCEDURES INVOLVED

The procedures governing prepositioning are covered in several DOD documents, one CONTINUED ON PAGE 32
being the Army's Technical Manual TM 38-470 (2) titled "Storage and Maintenance of Army Prepositioned Stock Material." These procedures are the result of many years of experience and have evolved during the past four decades.

Similar procedures cover the prepositioning of Marine Corps vehicles and equipment. Early on the problems resulting from corrosion during storage of vehicles and equipment in depots, as well as those in intermittent service, prompted the need for the development and improvement of fluid and lubricant products. These products had to be formulated (or reformulated) to provide adequate corrosion protection as well as allowing them to be used as an operational fluid or lubricating oil. Some examples include:

- A silicone automotive brake fluid (i.e., MIL-PRF-46176, Silicone Brake Fluid, Operational and Preservative) to correct serious corrosion-related problems occurring in brake systems.
- An engine oil that not only would combat extensive internal engine corrosion but also be a preservative and provide full operational use until the first drain interval (i.e., MIL-PRF-21260, Internal Combustion Engine Oil, Preservative and Break-In).
- A hydraulic fluid initially designed for preservation of hydraulic systems and components (i.e., MIL-PRF-6083, Petroleum Base Hydraulic Fluid for Preservation and Operation, or MIL-PRF-46170, Fire Resistant and Rust Inhibited Hydraulic Fluid, Synthetic Hydrocarbon Base) but which also eliminates corrosion-related problems occurring in ground vehicles and other machinery.

One of the initial obstacles in the prepositioning process not related to any component or engine lubrication (that is, not tribologically related) involved fuel. Since most of the vehicles and equipment were and continue to be mostly powered by compression-ignition engines, the diesel fuel being used was not a very storable commodity as it tended to undergo a gradual deterioration due to auto-oxidation. Several cooperative programs were subsequently conducted to demonstrate the viability of storing vehicles and equipment with fuel (3), (4).

This problem was corrected by either adding a stabilizer additive to the diesel fuel or substituting an aviation kerosene-base turbine fuel (either JP-5 or JP-8). This allowed vehicles and equipment to be stored either fully or partially fueled for periods of a year or more without encountering any of the fuel deterioration-related problems that had been occurring with the use of diesel fuel. Since that time, all prepositioning now mandates that aviation kerosene-base turbine fuels be used.

The vast majority of prepositioned vehicles and equipment are stored either on ships or in controlled-humidity storage facilities. In either case, the relative humidity is to be maintained at 40% and must remain in the range of 30% to 50%, with the temperature being maintained between 60 F (15.6 C) to 80 F (26.7 C). The majority of controlled-humidity storage facilities are traditional storage warehouses constructed of concrete, cement blocks or metal-clad panels that have been vapor sealed. Vehicles and equipment stored under these conditions do not require extensive preservation and exercising. However, all vehicles and equipment scheduled for sea or land-based prepositioning must meet minimum level maintenance requirements (at least 90% mission capable).

Vehicles and equipment being prepositioned are to be stored with their fuel tanks at least three-quarters full. All compression-ignition engines and transmission systems have their operational engine oil drained and replaced with the operational preservative engine oil (i.e., MIL-PRF-21260).

Likewise, gas turbine engines use the corrosion-inhibited version of their aviation gas turbine engine oil (MIL-PRF-23699, Aircraft Turbine Engine Lubricating Oil, Corrosion Inhibiting) or, if unavailable, a preservative additive (Brayco 599) is added. Antifreeze is tested for its Freeze Point and Reserve Alkalinity or Nitrite concentration and replaced with new antifreeze if the minimum levels are not met. Differential, transfer and power take-off, brake system and hydraulics are all checked for fluid levels and topped off if necessary.

All exposed lubrication points are coated...
with either the operation preservative engine oil or other preservatives available within the supply system such as MIL-PRF-32033 (General Purpose Lubricating Oil, Preservative, Water Displacing), MIL-PRF-3150 (Preservative Lubricating Oil, Medium Grade), MIL-PRF-10924 (Automotive and Artillery Grease), MIL-G-18458 (Grease for Wire Rope and Exposed Gear), and MIL-PRF-16173 (Solvent Cutback Corrosion Preventive Compound).

Once positioned in either land-based facilities or on ships, the vehicles and equipment undergo scheduled exercising and maintenance checks. The time intervals vary depending on whether the items are combat or tactical. For example, on land-based facilities, combat vehicles/equipment undergo maintenance checks at least once every 30 months whereas tactical vehicles/equipment undergo maintenance checks at least once every 48 months. However, exercising both combat and tactical vehicles and equipment (start-up, power up all systems and subsystems, etc.) occurs on a more frequent basis.

For their exercise requirements, vehicles and equipment on board ships, at least four times while afloat (approximately every five to six months), are to be started, engines brought up to normal operating temperature, gear boxes run through their gear range with the transmissions in neutral, and all systems and subsystems powered up.

If an engine is not in continuous or intermittent use, the oil film remaining on metal contact surfaces such as cylinder wall, piston rings, main bearings, connecting rod bearings, etc., will slowly diminish or disappear. When the engine is then started, before these metal contact surfaces become lubricated with the oil, metal-to-metal contact will occur, causing the onset of wear. To keep this wear to a minimum, engines are turned over without firing to ensure that the oil pressure is registering in the engine. As soon as oil pressure is shown, the engine is then started and operates for the exercising period specified.

**TRIBOLOGICAL IMPLICATIONS**

As mentioned previously, prepositioning of vehicles and equipment places them into an interim storage environment where they must have the capability to be fully operational in a very short time. This transition from essentially no activity to full operating activity certainly demonstrates the importance of tribology and its implications as an integral part of the prepositioning process.

The need for eliminating or significantly minimizing corrosion on metal contact rubbing surfaces due to moisture contamination is obviously very critical for engines, power trains and hydromechanical systems.

*Continued on page 34*
Corrosion and its byproducts would certainly generate serious wear problems to form in critical component areas that would quickly impact the operational readiness of the prepositioned material. As prepositioning mandates the use of packaged petroleum products that have been formulated to possess the necessary corrosion inhibitors and rust preventatives, the occurrence of corrosion during the interval of storage is kept to a bare minimum.

In addition to the need for adequate corrosion-protection control, the inactivity even during interim storage causes the removal of the residual oil films between the metal-to-metal contact rubbing areas. These residual films are needed to mitigate wear during engine start-up or when initially activating some hydromechanical component. Because of this potential problem area, prepositioning procedures have incorporated quarterly intervals of engine start-ups and exercise systems that allow for the replenishment of these residual oil films.

SUMMARY

The success of prepositioning is measured by the degree of combat readiness of the vehicles and equipment when needed. The high degree of engine reliability, fully functioning hydromechanical and other power transmission systems, absence of corrosion-related or fluid deterioration-related problems, etc., serves to highlight the tribological involvement and successes in this process. Thus, DOD is able to quickly respond in placing the needed forces with their vehicles and equipment wherever and whenever needed. This was more than demonstrated in the last two conflicts in the Middle East and in Eastern Europe.

Because of these successes, the Navy is planning to further evaluate the feasibility of having military bases at sea (5). This involves developing a new class of ships that will be called the Maritime Prepositioning Force Future. <<

Maurice Le Pera is a STLE member and also heads his own consulting company, Le Pera & Associates, in Harrisonburg, Va. You can reach him at melepera@aol.com.

References


