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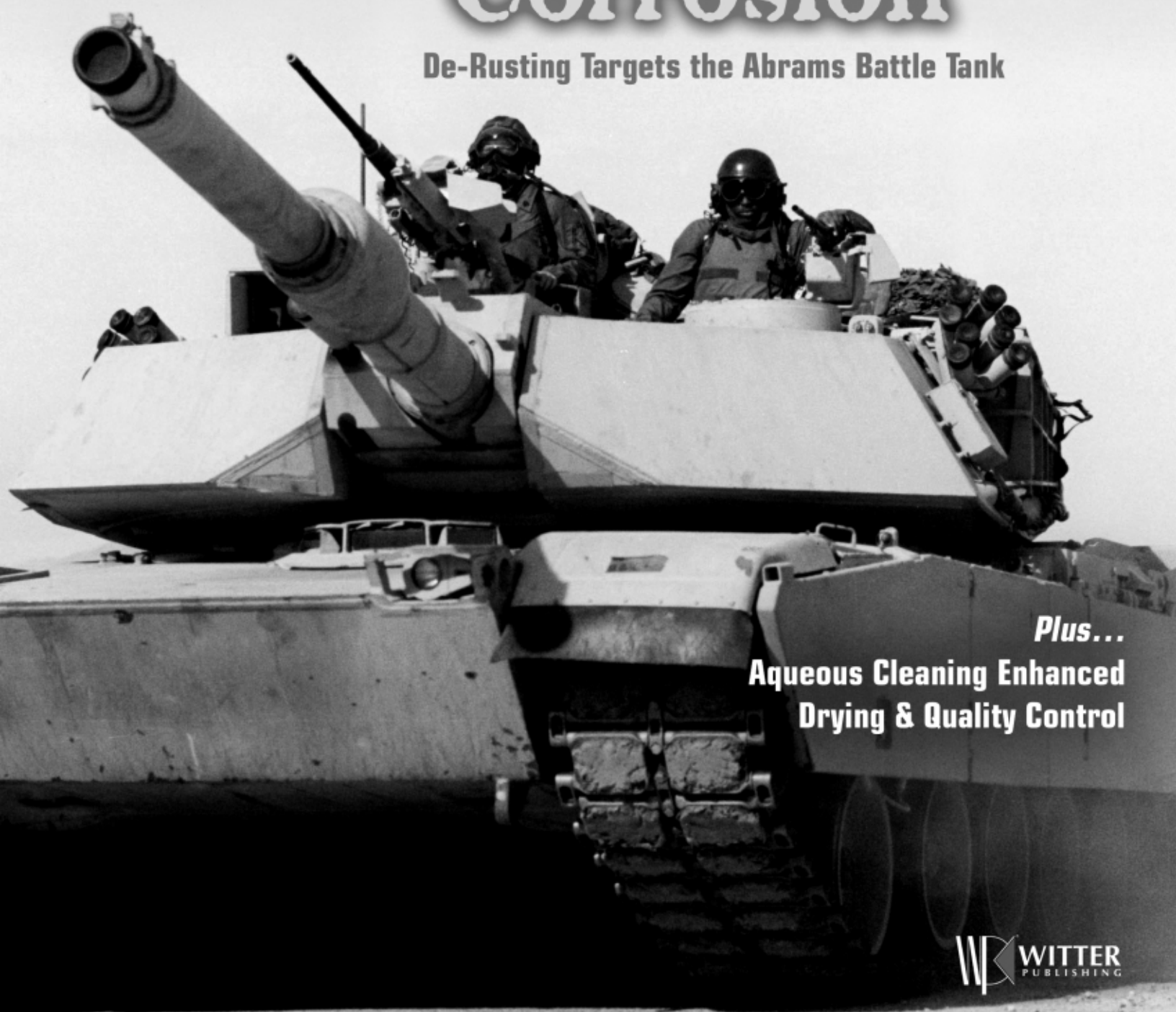
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## Combating Corrosion

**De-Rusting Targets the Abrams Battle Tank**



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**Aqueous Cleaning Enhanced  
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# Combating Corrosion

Shawn McGlothlin and Michael Jago

*Extreme Weather Plagues  
Fort Hood Armor Units, Quickly  
Oxidizing Parts. De-rusting is a Vital  
Part of the Abrams  
“Tank Recovery” Process.*

**N**o soldier, sailor or marine relishes extreme weather conditions, however an armor unit is especially susceptible to the impacts of Mother Nature, where the constant enemy of a mechanized division is the elements. In fact, of the approximate total annual corrosion costs for the Department of Defense (DoD) — 20 billion dollars — about 10 percent, or two billion dollars, is directly attributable to the Army ground vehicles, including the M1 Abrams Tank Systems, the Bradley Fighting Vehicle, Carrier and Fire Support Systems, the High-Mobility Multipurpose Wheeled Vehicles (HMMWV or Humvees), and Light Armored Vehicles.

At Fort Hood, Texas the ground vehicles of the 4th Infantry Division (Mechanized) are under constant training and field maneuvers, where the terrain reflects what an armor division could face nearly anywhere in the world – streams, mountains, valleys, heavily wooded areas and semi-desert grounds. The weather conditions run the extremes – rain, sleet, snow, hail, desert sun and high humidity, with the temperature ranging from 10° F to 115° F. Needless to say, the tanks, howitzers, armored personnel carriers (APC's), Humvees and fire support vehicles, as well as the high-tech equipment are exposed to particularly aggressive environmental conditions; resulting in mass corrosion, thereby creating a maintenance bottleneck nightmare.

## The Hoffman Device

The 4th Infantry Division heads Task Force Ironhorse (see *Steadfast* sidebar), made up of more than 37,000 troops from 10 military installations. The 4th Division is a heavy-armor division that employs M1 Abrams tanks, Bradley fighting vehicles, 155 mm howitzers, anti-tank and anti-armor AH-64 Apache attack helicopters, and UH-60 Black Hawk helicopters in combat operations.

Immediate readiness is imperative to armored divisions, which is why Fort Hood trains under the most realistic conditions. In effect, a combat force of about 30,000 troops from the 4th Infantry Division and other units from Fort Hood were deployed to Iraq this past April, including cavalry and mechanized divisions.

To simulate tank gun firepower, the 4th Division uses a Hoffman Device. The Hoffman Device is a Multiple Integrated Laser Engagement System (MILES) manufactured by Hoffman-Werke (Lintorf, Germany), or the set of nine fluted steel tubes attached to the Abrams Tank's 120mm main gun. The tubes are loaded with a black powder charge from the muzzle, primed and fired just like a fireworks mortar. The Hoffman Device (Figures 2a, b) is used during field training to give the feel, sound, smell and flash of a real cannon firing. It allows the tank operators or "tankers" to perform live, realistic maneuvers, without the cost and safety issues of firing live rounds. A



### M1A1 Abrams Battle Tank

**Crew:** Four

**Armament:** 120 mm M256 smooth bore cannon, .50-caliber M2 machine gun, 7.62 M240 machine gun, 7.62 M240 machine gun

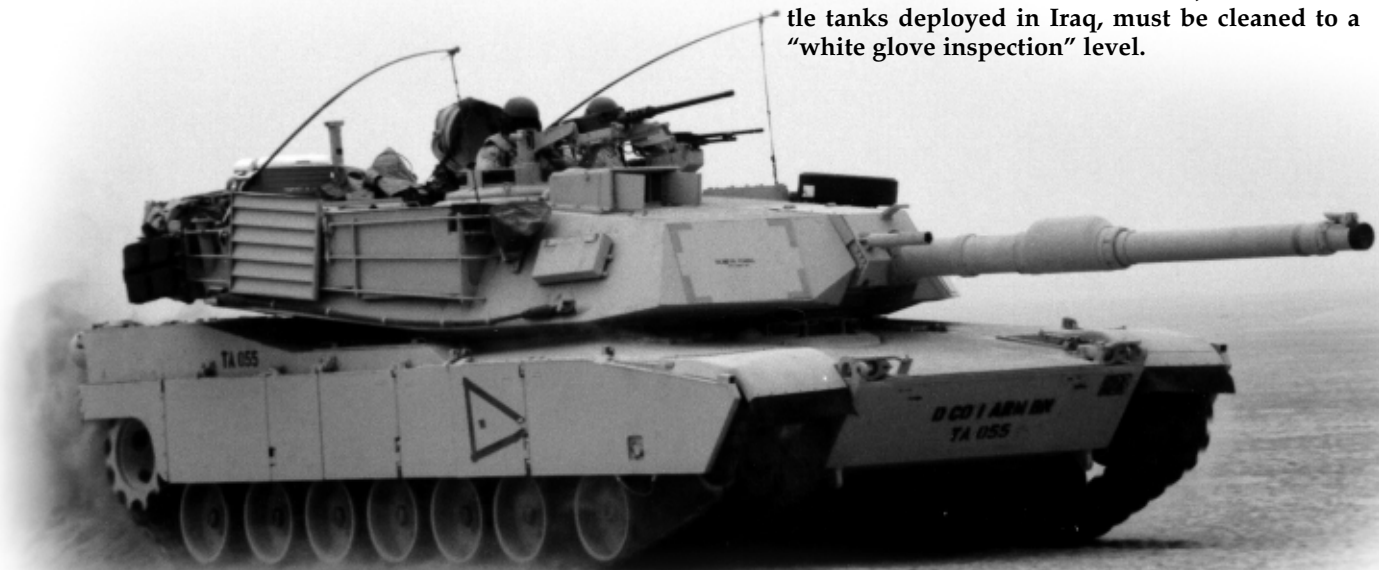
**Maximum speed:** 42 mph

**Range:** 265 miles

field training exercise will last about two weeks with the fully exposed Hoffman Device being fired and reloaded time and time again.

Upon return from the field maneuver, a work detail is handed out to clean the Hoffman Device. Cleaning the Hoffman Device is not regarded by the troops as a pleasant nor easy task. Each of the nine elongated tubes suffer from iron oxidation from the extended exposure in an aggressive environment

**Figure 1:** Upon return from field maneuvers, the Hoffman Device on the M1 Abrams, the main battle tanks deployed in Iraq, must be cleaned to a "white glove inspection" level.





and are fouled with black powder, which is corrosive. Iron oxide is the corrosion of iron and ferrous alloys, known most commonly as rust.

The quality assurance office inspects each device for cleanliness, not just to extend the equipment life, but also to avoid the dangerous combination of explosives and corrosion. The inspection is visual and described as a “white glove treatment”.

Historically, each of the tubes were first abrasively cleaned by hand or if the troops were lucky, they used a three-inch bore brush on an electric drill. It was then blown clean or rinsed, wiped out, and hand cleaned with emery paper. The process was repeated until each tube was clean. The final step was a light coat of oil.

One Hoffman Device, on average, will take a minimum of two men all day to manually clean, or a half-day with the aid of a bore brush on a manual drill. In either case, it is hours of heavy-duty “elbow grease” to remove the rust and carbon to specifications. A battalion, usually made up of three companies, coming in from the field can expect to have approximately 22 tanks. That means 22 Hoffman Devices being cleaned by

44 men with 176 hours of intense manual labor or 88 hours with a manual drill. There is a slight variation from company to company in the quantity of devices issued and cleaning process, but the effect and drudgery are about the same.

Manual labor has ruled in this cleaning task because the Hoffman Device is an explosive system. The soldiers must wear protective gloves and eyewear during manual cleaning. Alternative de-rusting methods can create dangerous situations. Acids, strong alkali and electrolysis are corrosive and toxic. Media blasting is out due to equipment set up and maintenance cost, the sensitive electrical component plug in, the odd shape of the tubes, the secondary cleaning required to remove media from tight spaces and blast hazards. All of these options require costly equipment, including a higher level of personnel protective equipment (PPE) and continued training as the personnel rotate. Even if these alternative methods could be employed, EPA reports and disposal issues would rapidly diminish the thought as Fort Hood has a tight and well-respected environmental program.

De-Rusting

Staff Sergeant Hejnal and Sergeant Castellano, of Fort Hood, were attending an on-post trade show and witnessed a demonstration by military supplier Orison Marketing



Figure 2a: The Hoffman Device with controller ready for service. Evapo-Rust does not adversely affect any electrical connections.



Figure 2b: Closeup of MILES tubes with signs of powder residue and corrosion. With a recovery time of 30 minutes for four Hoffmans, there are less troops needed to clean the Devices using Evapo-Rust.

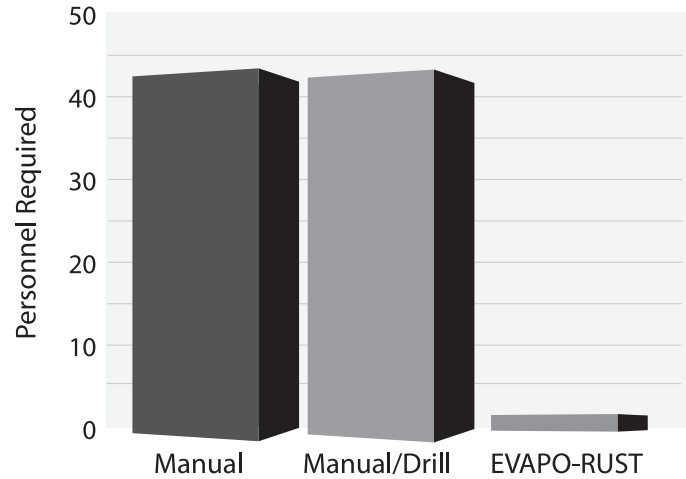


Figure 3a: Personnel required to de-rust/clean 22 Hoffman’s for each method.

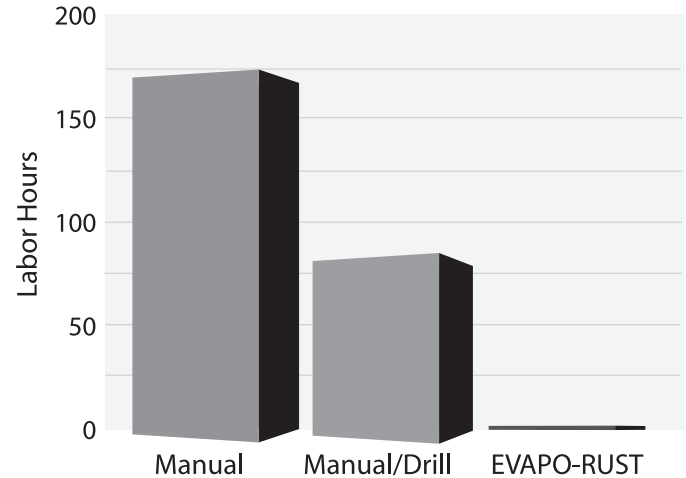


Figure 3b: Labor hours required to de-rust/clean 22 Hoffman’s for each method.

(Abilene, Texas, [www.orisonllc.com](http://www.orisonllc.com)) of Harris International's Evapo-Rust, an aqueous de-rusting chemistry. The demo was performed on gun barrels, tools, water pumps, engine heads, timing chains and other miscellaneous rusted parts. Features of the product that interested the sergeants included a pH range of 6.1 to 7, it was not an eye or primary skin irritant, non-toxic, non-corrosive, contained no acids or caustics, no volatile organic compounds (VOCs) or hazardous air pollutants (HAPs), no solvents, it was sewerable in neat form and biodegradable. But could such a "friendly" product meet the demanding needs of cleaning the Hoffman Device?

Skeptical, the sergeants retrieved a small rusted coupler from the Hoffman Device. They placed the coupler in the Evapo-Rust ([www.evapo-rust.com](http://www.evapo-rust.com)) and 15 minutes later removed it – rust free. Sergeant Hejnal purchased a gallon of the de-ruster to bench test on a Hoffman tube. He poured the Evapo-Rust into the tube and let it sit for 20 minutes. He then poured the solution back into the gallon container and cleaned the tube with VPW SC-1000 in order to remove the carbon. VPW SC-1000 (also available from Orison Marketing) is a low- to moderate-sudsing, concentrated organic soil remover. It is comprised of a ternary, non-ionic surfactant system that may be used for the removal of petroleum derivatives, fats, oils, greases, lipids, proteins and sugars. VPW SC-1000 is SCAQMD Clean Air Certified and does not contain VOCs, Chlorinated solvents, caustics, phosphates, silicones, acrylics, glycol ethers, or acetones, and is USDA Category 1A rated.

According to Sergeant Hejnal, after this process, "the tube was totally rust and carbon free." He showed the device to his commanding officer and received approval to purchase 10 additional gallons. The sergeant quickly set up a small dip tank and finished the entire set of Hoffmans in just a few hours, greatly increasing critical time for "tank recovery" – the task of readying the Abrams for its next mission. Today Sergeant Hejnal's crews use a 150-gallon plastic tank to de-rust four Hoffman Devices at once. Tables 1 and 2 show the impact Evapo-Rust has had in reducing labor hours and personnel required, while increasing tank recovery time.

"It was the first time the MILES [the Hoffman Devices] had passed, all first go," states Sergeant Hejnal. Explaining the significance of this he adds, "On first turn in I've seen two to three [Devices] get kicked back. It's the fact you spend all day cleaning a Hoffman when you could be spending time doing recovery on your vehicle. [The de-ruster] gives the troops valuable recovery time for the tank. With a recovery time of 30 minutes for four Hoffmans, there are less troops needed to clean the Devices."

According to Sergeant Hejnal, word of the de-ruster is spreading to other units that are now recovering parts that, "to the untrained eye, looks like it needs to be DX (thrown away). But after being in Evapo-Rust, you have a new part." The 4th I.D. change to Evapo-Rust as a cleaning process conforms to the Army future DoD Corrosion Prevention and Control Program. It helps cut costs, increases readiness and decrease maintenance burden by increasing personnel safety and equipment life, significantly reducing recovery time for the Hoffman Device, thus providing more time and personnel for actual vehicle recovery, it does not require the purchase of PPE or environmental permit modifications, no specialized training, and being re-usable it costs about \$0.04/pound to de-rust.

## How It Works

Evapo-Rust, invented by David Harris of Harris International Laboratories (Springdale, AR), works through selective chelation, a process in which a large synthetic molecule forms a bond with metals and holds them in solution. Most chelating



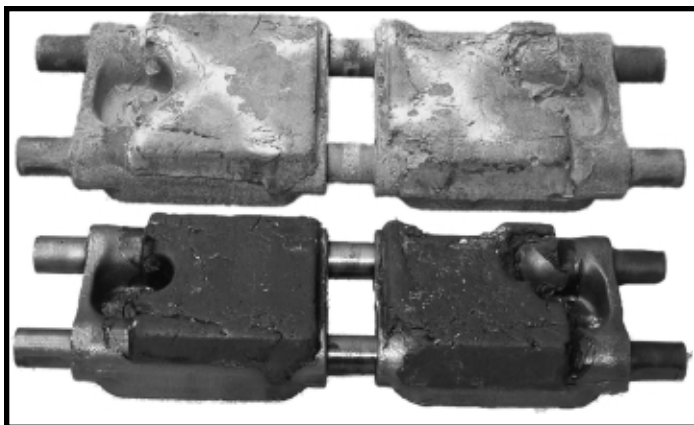
## Evapo-Rust Branches Out

When it comes to aircraft, corrosion is a serious issue. In fact, tools with rust are strictly prohibited on the flight line. An Air Force base tool room maintains hundreds of hand tools for use by the squadron's mechanics. At any time, up to 30 tool kits may be exposed to weather while on the flight line. Most tools are common commercial grade wrenches, which means they rust. At times each aircraft requires custom tools and adapters. These custom tools are fabricated from mild 1010 steel with no coatings to allow for periodic non-destructive inspection. Rust is a constant problem in small openings and on large irregular tool surfaces. Sanding accelerates wear and acid or caustics are not permitted.

Replacement costs due to corrosion can be excessive, especially on precision and custom tools. The 13th Bomb Squadron was the first to adopt the simple expedient of keeping a polypropylene "suit case" of de-ruster Evapo-Rust on hand to place tools into after a rain shower or as corrosion was noted. The tools are de-rusted, rinsed and then coated with an inhibitor. The 13th's initial purchase has been in use since March 11, 2002. As Robert D. Widger, Sergeant, USAF, Assistant NCOIC Sortie Support, Dyess, AFB states, "We [formerly] spent six to eight hours, per tool kit, cleaning and wiping down tools [for the B-1B bomber]. This was done with wire brushes, rags and solvents, and not exactly the best job. Since we've been using Evapo-Rust, our time is cut to about one to two hours. Most of this time is used for soaking, about an hour, during which we accomplish other tasks. We use 30 to 45 minutes actually wiping down tools, depending on size of kits."

Other Air Force corrosion issues include mild steel aqueous parts washers (APW). The internal parts of the washers are showing significant corrosion damage after being in service over four years. Evapo-Rust is being reviewed as a method of removing rust from APW parts during refurbishment.

Dr. Rick Miles, Air Force Corrosion Prevention and Control Office states; "Let me stress that this is not an endorsement by the Air Force. The Air Force does not endorse specific products. This is simply to say that so far in our testing, Evapo-Rust has proven to be a solid product and will most likely be one of the products indicated in our final report as one that should be used to refurbish APW parts. ...We are currently evaluating several chemicals to remove corrosion from APW parts. Several have shown the ability to remove corrosion as advertised, but so far, only Evapo-Rust has shown the ability to remove corrosion without any concerns over personal protection during use." – *McGlothlin & Jago*



**Figure 3: Tracks from the M1 Abrams tanks, before and after being de-rusted using Evapo-Rust.**

agents bind many different metals and contain EDTA, citric acid, glycolic acid, or their sodium salts. The active ingredient in Evapo-Rust bonds to iron exclusively, separating the iron from iron oxide, but is too weak to remove iron from steel because the iron is held much more strongly.

One gallon can de-rust up to 300 pounds of steel. The load actually has to do with the true amount of iron oxide it can absorb or remove. One gallon will remove a  $1/2$  pound of pure dry rust (considering rust to be about  $1/17$  the weight of iron). On average, one may expect the cost to de-rust be between \$0.04 to \$0.08 cents per pound, depending on the severity of the rust.

There are limits to any product, and Evapo-Rust is no exception. As it is a water-based solution, it works only when liquid. It will not lose any active ingredients due to evaporation; only the water evaporates. It works faster warm than cold, ideally at room temperature, about 70° F or above. This makes it an ideal dip-tank product, but it does limit other applications. Spraying, pumping, damming, covering a patch in plastic or other methods must be employed to maintain the reaction on surfaces that cannot be immersed. Some very clever adaptations have been employed using a water fountain pump and a catch basin to treat car hoods, tanks and welded seams.

Disposal is generally not an issue, with the procedure being to clean and degrease parts before de-rusting to keep hazardous contaminants from entering and to allow it easy access to the rust. If no hazardous contaminants are introduced, only the chelated iron should dictate disposal; and in most cases, it remains sewerable. However, some states, such as California, do have water restrictions on chelated iron. Always check your local, state, and federal guidelines for disposal.

Evapo-Rust, a patent pending technology addresses the mission of the current U.S. Army and upcoming DoD Corrosion Prevention and Control Programs: cut costs, increase readiness and decrease maintenance burden. And where it may not replace all media blasting on scale and on large low value items where removing healthy metal with the rust is not a

## Steadfast and Loyal

The 4th Infantry Division is the Army's First Digitized Division. It is commanded by Major General Ray Odierno, and the Command Sergeant Major is Charles Fuss. The Division shares a long and distinguished history that includes combat in three wars. It

has earned twenty-one campaign streamers with twenty "Ironhorse" soldiers receiving the Congressional Medal of Honor.

The 4th Infantry Division and its supporting elements will be referred to as "Task Force Ironhorse" during its deployment in the Gulf. The name refers to the division's nickname, "Ironhorse," which stems from its reorganization after the Vietnam War to a mechanized division.

Today, the 4th Infantry Division is the most lethal, modern and deployable heavy division in the world; it is prepared to conduct full-spectrum combat operations. It is organized with five brigade-sized elements: three maneuver brigades, a combat aviation brigade, division artillery and division support command. The division is split-based, with one maneuver brigade in Fort Carson, Colorado, and the remainder in Fort Hood, Texas, about 60 miles north of the capital city of Austin.



problem, in medium to high value work in manufacturing, restoration of weapons, equipment, tools, engine, machine and auto body parts it offers the DoD a big bang for the buck. ■

### About the Authors

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