U.S. Army Public Health Command (Provisional)
formerly U.S. Army Center for Health Promotion and Preventive Medicine

31-012-0310

Just the Facts...

Rust and Preventive Medicine Aspects of Stainless Steel Water Tanks

Bottom Line

Moderate amounts of rust on the interior surfaces of stainless steel water tanks used for potable field water storage and transportation generally will not adversely affect the water's potability. Preventive Medicine (PM) personnel who inspect the water tanks should not fail them based solely on the presence of rust unless 25% or more of the interior surface area is rusted.

Stainless steel has been tested by NSF International (NSF) and has been shown to be highly resistant to leaching of any contaminant that might taint drinking water. It is listed in NSF/ANSI (American National Standards Institute) 61, as an approved material for direct contact with drinking water (1).

Any discrepancies observed during inspections by PM personnel should be documented and brought to the attention of the owners/operators of the equipment. However, if the discrepancies will not adversely affect the quality of the water, the decision to remove the equipment from service for maintenance, cleaning, and/or disinfection should be the decision of the owning unit rather than the inspecting PM personnel.

Background

The current inspection sheet for potable water containers (DA Form 5457), requires selection of "YES" or "NO" for the criteria "No Rust." The selection of "NO" theoretically fails the inspected container, and PM inspectors may require it to be cleaned and disinfected before it can be filled with drinking water. Requiring this may result (from a health perspective) in unnecessary cleaning and maintenance that could reduce the service life of the tanks and impair the Army's ability to provide adequate volumes of potable water to Warfighters in a timely manner.

Iron corrodes and forms iron-oxide (rust) when it contacts oxygen. The interiors of modern Army field water trailers (Buffaloes) and Load Handling System (LHS)-compatible tank racks (Hippos) are constructed from stainless steel that is resistant to staining and rusting. Stainless steel is an iron alloy that contains at least 10.5% chromium. When this alloy is exposed to oxygen, the exposed chromium oxidizes and forms a very strong yet invisible film on the surface of the metal that prevents oxygen from contacting the iron in the alloy, making the alloy rust and stain resistant. The stainless steels used in Buffaloes and Hippos also contain nickel (~10%) and molybdenum (~2%), which increase its resistance to chloride corrosion. The natural formation of the protective chromium oxide film is referred to as "passivation," and this natural process can be enhanced by removing contamination such as dirt, grease, free iron particles, machining lubricants, and fingerprints from the surface, and increasing the level of chrome in the protective film after production. This is accomplished by cleaning, degreasing, and immersing the alloy in a nitric acid solution followed by immediate and thorough rinsing with clean water. Thereafter, if the protective chromium oxide film is scratched or otherwise physically or chemically damaged, it will form again upon exposure to oxygen in the air or water that it holds.

Stainless Steel Corrosion

After production and initial passivation, chlorides, welds, imperfections in the alloy, and physical damage can penetrate the protective film and cause rust if for some reason the passive layer does not reform. High chlorine residuals, low pH, and high temperatures all enhance the rates of rusting in Buffalo and Hippo water tanks wherever the passive film has been compromised. The resulting rust may be localized, or it may be spread across the tank's inner surface.

Stainless steel thrives on cleanliness. Any dirt, sediment, biological growth, or other conditions that may hinder natural passivation and trap corrosive agents next to the surface should be brought to the attention of the owner/operator, because they reduce the inherent corrosion protection of the stainless steel.

Chlorides attack the passive film; the more concentrated they are, and the longer they remain in contact with the film, the greater the extent of attack. Calcium hypochlorite granules are very corrosive, and when used to disinfect the water in a tank, if they sink to the bottom of the tank undissolved, they will cause severe local corrosion. Hypochlorite granules should always be completely dissolved in water in a bucket or other container and the

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resulting chlorine solution added to the water in the tanks. Superchlorination – that is, filling the tank with a 100 ppm (mg/L) chlorine solution and holding it for an hour – after cleaning a tank, may be difficult to implement under field conditions. Adequate disinfection may be provided by combining a 10 mg/L chlorine solution with a 24-hour contact time, if the time is available (2). Chlorine solutions can be pumped from tank to tank and will remain effective as long as the chlorine concentration is maintained throughout the process. Tanks must be well rinsed with potable water after disinfecting them, to reduce the chloride concentration in contact with the passive film. Prior to long term storage, any remaining rinse water should be completely removed and the tank interior dried, so the oxygen in the air can keep the passive film intact during storage.

Rust and Drinking Water Health Guidelines

Iron dissolves from rust into the water in the tanks. The iron concentration in the water increases with contact time and the ratio of the rusted area to the volume of water contained. At concentrations above the National Secondary Drinking Water Standard (0.3 mg/L), the dissolved iron may impart a rusty color and a metallic taste to the water; however, drinking it will produce no adverse health effects. The 1-year Military Exposure Guidelines (MEGs) for iron – the levels at which adverse health effects may begin to be observed in some individuals – are 4.2 mg/L for 5 L/d, and 1.4 mg/L for 15 L/d consumption rates (3).

Inspections, Cleaning, and Maintenance

Owning and operating units are responsible for routine inspection, cleaning, and maintenance of the water Buffaloes and Hippos assigned to them. Unit personnel must evaluate and maintain the field operational worthiness of the equipment as well as the tanks' suitabilities to carry potable water. In terms of container serviceability (but not health), a small but deeply corroded pit or crevice may be equal in urgency to a much larger but less severe area of surface rust. Preventive maintenance checks and services, including water tank inspection criteria, cleaning requirements, and procedures are delineated in the applicable Technical Manuals (TM) (4 and 5). Hippo-specific cleaning procedures are also available in a supplemental training guide that is available from the U.S. Army Combined Arms Support Command (CASCOM) (6).

Procedures for PM personnel inspections of water tanks together with recommendations on materials and procedures for their cleaning and disinfection are presented in Technical Bulletin Medical (TB MED) 577 (7). PM personnel should inspect Buffaloes and Hippos in their areas of responsibility quarterly, as the operational mission permits, to provide medical oversight, ensure that they are serviceable, and confirm that they will maintain the quality of the potable water that is put into them. Tanks that consistently contain chlorinated potable water need to be cleaned and disinfected only when inspections and/or deteriorating water quality indicate that need.

Conclusions

Rust in Buffaloes and Hippos is primarily a serviceability concern, and is not a significant health hazard. Pitting, crevice, and surface rust that covers less than approximately 25% of the interiors of these types of tanks should not be the basis for PM rejection and denial of their continued service. PM inspectors should not fail a water trailer or Hippo for interior rust unless water tests indicate that iron or other metal concentrations exceed their corresponding military field water standards or MEGs, or there have been consumer complaints concerning the color and/or taste of water stored or delivered in that container.

Additional Information

For additional information, contact the Water Supply Management Program, U.S. Army Public Health Command (Provisional) , at Comm: (410) 436-3919, DSN 584-3919, or via email, at: water.supply@amedd.army.mil.

References

1. NSF/ANSI Standard 61, *Drinking Water Systems Components Health Effects*, NSF International, Ann Arbor, MI, 2005.

2. ANSI/AWWA C652-92, *Disinfection of Water- Storage Facilities*, American Water Works Association (AWWA), Denver, CO, 1 February 1993.

3. Technical Guide (TG) 230, *Chemical Exposure Guidelines for Deployed Military Personnel*, 2003.

4. TM 10-5430-244-10, *Operator's Manual for the Load Handling System (LHS) Compatible Water Tank Rack*, Headquarters, Department of the Army (HQDA), January 2007.

5. TM 9-2330-267-10, *Operator's Manual for Trailer, Tank: Water, 400 Gallon, 1-1/2-Ton, 2 Wheel, M-149, M149A1, and M149A2*, HQDA, July 1991.

6. *Hippo Inspection & Cleaning*, Supplemental Training Guide, CASCOM, Fort Lee, VA, 27 September 2008.

7. TB MED 577, *Sanitary Control and Surveillance of Field Water Supplies*, HQDA, December 2005.