Efficacy of Shipboard Countermeasure Washdown System Against Chemical Warfare Agents

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Introduction

Many naval ships currently use a seawater washdown system to pre-wash and wash away chemical, biological, and radiological contaminants from exterior deck surfaces. For ships that do not have this capability, a reactive solid bleach, detergent, and seawater is the countermeasure employed for hazard mitigation. The focus of the current study was to investigate and optimize reactive decontaminants on exterior naval ship surfaces to reduce hazards to personnel. The reactive decontamination composition was optimized using a mixture/process design of experiments (DOE) approach, determining an overall global optimal decontamination formulation. Four variants of an alternate oxidant, Dahlgren Deco, were evaluated as an alternative to the solid bleach/detergent/synthetic ocean water (SOW) formulation. The four variants showed similar decontamination efficacy values across the variants, and were similar to the efficacy observed for the global optimum formulation. Efficacy of the washdown process on select exterior deck materials results and conclusions will be presented, including details on how the DOE approach was successfully implemented during this project.

Global Optimal Deco

Optimization Study

A limited scope solid bleach/detergent/SOW DOE optimization effort was completed on Navy alloy topcoat and Navy non-skid test coupons that were subjected to accelerated curing process (30 days at 75°C) as recommended by NSWCDD. The DOE reactive solid bleach/detergent/SOW DOE optimization effort was completed on panels that were not fully cured. The objective of the 2018 limited scope DOE was to determine if the efficacy results from panels which have undergone an accelerated curing process (fully cured) would be similar to the original (not fully cured) panel results. Optimal process kinetics discovered in the 2018 DOE effort were applied to the 2017 solid bleach decontamination-ring time and brush time were bracketed, while the solid bleach/detergent/SOW formulation and test coupon material type were varied.

Decontamination of Exterior Naval Deck Materials

Using an Alternate Oxidant

The objective of this effort was to determine the efficacy of alternate oxidant formulations on Navy Alloy topcoat and traditional Navy Non-skid materials, as compared to the currently oxidized oxidant, solid bleach. The oxidant chemistry utilized in this effort was Dahlgren Deco in four distinct formulations; full strength Dahlgren Deco preparations using either DI water or synthetic ocean water, and a half-strength 1:10 Deco to water dilution using either DI water or synthetic ocean water for the dilution. This study mimics the 2017 solid bleach decontamination optimization effort utilizing the optimal conditions (contaminant age time (5 min), decon residence time (10 min), brushing) from that effort.

The four Dahlgren Deco variations performed similarly within each contamination material. This study did not demonstrate a statistically significant efficacy difference between the full strength Dahlgren Deco and the 1:10 "first Responders" diluted version. This was true both when the decontaminant was prepared with DI water or simulated ocean water. This finding implies that the oxidant’s version could potentially have similar chemical decontamination efficacy as the full strength decontamination, in this application.

In addition, preparing the decontaminant with simulated ocean water did not appear to impact efficacy in a statistically significant manner. Synthetic ocean water had a noticeable exothermic reaction, evidenced by increases in temperature and added foaming. These observations are indicative of an increase in the chemical reaction, active ingredient degradation, which could lead to decreased pot life, and thus will be investigated further by the team at NSWC Dahlgren Deco. The currently oxidized oxidant (solid bleach) and all four Dahlgren Deco variations showed the same efficacy when tested on each contamination material pair.

Additional Study: Countermeasure Washdown Efficacy on Newly Employed Shipboard Materials

A 2014 study, conducted at CEC with collaboration from NSWCDD, tested the CMWD system efficacy on the Navy alloy topcoat and traditional non-skid using contaminant VX. These materials represented the most current fielded shipboard deck materials and the contaminant represented the most current threat knowledge gap to be filled. The overall results from the 2014 study were that while a large portion of contaminant was removed from the topcoat, the non-skid surface remained contaminated. This study was designed, the retained contaminant in the material could still present a hazard to unprotected personnel, and thus a re-evaluation or extension of the decontamination treatment should be performed due to the absorption rate of contaminant into the Navy surfaces.

Some of the DOE predicted material/specific optimal pairings for both the Navy alloy topcoat and Navy non-skid test panels showed differences in optimal predicted solid bleach and detergent percentages between the FY17 DOE (panels not fully cured) and the FY18 DOE (fully cured panels). Seeing differences was expected based on the decrease in decon efficacy over time that was seen in the 2017 solid bleach optimization study. Incomplete panel cure may have impacted the absorption of contaminants into the material thereby affecting decontaminating performance. However, the global solid bleach/detergent/SOW formulation in the current study did not deviate substantially from the 2017 solid bleach optimization study. The overall global optimal formulation is 3.58% H2O2, 0.7% detergent, and 93.8% SOW.

Although the remaining contaminant was greatly decreased, the amount of retained contaminant indicates that the absorption of the contaminant into the Navy topcoat and non-skid can occur in seconds following contamination. Further investigations are recommended to determine how to mitigate the quality absorbed residual contaminant.