

# Performance Evaluation of Decontamination Foam According to the Characteristics of Surface Contamination

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## 1. Introduction

Foam decontamination process has a potentially wide application in the removal of contaminants from large components with complex shapes or large area or large volumes. This process can be applied to any direction regardless of walls, floors and ceilings, and basically it has the advantage of generating less secondary wastes[1]. However, there is a disadvantage that the decontamination factor (DF) is relatively low only by one batch application[2]. In order to improve the DF of the foam decontamination process, many attempts have been made to introduce various chemical decontamination agents into the foam and enhance the contact time of the foam between the chemical decontamination agent and the contaminated surface by introducing a viscosifier to improve the stability of the foam[1,3].

In this study, the effects of periodically supplied new decontamination foam on the decontamination performance was investigated. In addition, the decontamination performance of the foams containing various chemical components was evaluated according to the characteristics of surface contamination.

## 2. Materials and Methods

### 2.1 Preparation of Decontamination Foam

The decontamination foams used in this study were prepared by combining surfactants, silica nanoparticles, inorganic acids such as HNO<sub>3</sub> and HF, and oxidizing agents such as Ce(IV).

In order to evaluate the decontamination performance of the contaminated specimens, various decontamination foams prepared are summarized in Table 1.

### 2.2 Performance Test with Decontamination Foam

Decontamination performance tests were carried out by applying various decontamination foams as

shown in Table 1 to the simulated specimens contaminated with non-fixed particles and oil, and the specimens with fixed corrosion oxide films.

Table 1. Composition of Various Decontamination Foams

Foam Type	Chemical Composition
F-1	1 wt% EM100 <sup>1)</sup> + 1 wt% M-5 <sup>2)</sup>
F-2	1 wt% EM100 + 1 wt% M-5 + 2M HNO <sub>3</sub>
F-3	1 wt% EM100 + 0.5M HF + 2M HNO <sub>3</sub>
F-4	1 wt% TBS <sup>3)</sup> + 1 wt% M-5 + 0.1~0.5M Ce(IV) + 2M HNO <sub>3</sub>

1) ELOTANT Milcoside 100, C08-10 alkyl polyglucoside

2) CAB-O-SIL® M-5 Fumed Silica Nanoparticle

3) Zonyl® TBS, Anionic fluorosurfactant,

Particulate contaminated specimens and oil contaminated specimens were prepared as non-fixed contaminated specimens. Simulated particulate contamination specimens were prepared by coating a mixture of Eu<sub>2</sub>O<sub>3</sub> and fluorescent powders on a 20x20 mm stainless steel surface. Simulated oil contamination specimens were prepared by coating a mixture of TBP as an oily contaminant with the fluorescent power on the stainless steel surface. Specimens coated with NiFe<sub>2</sub>O<sub>4</sub> and FeCr<sub>2</sub>O<sub>4</sub> were used as fixed contamination specimens. The NiFe<sub>2</sub>O<sub>4</sub> coated specimens having a thickness of 500 nm were prepared using the E-beam evaporator system. Specimens with FeCr<sub>2</sub>O<sub>4</sub> film having a thickness of ca. 10 μm formed on the surface of stainless steel 304 were prepared in an autoclave.

The decontamination performance test was carried out in an experimental apparatus consisting of a foam solution make-up tank, a decontamination foam generator and a foam filling column. After the simulated contaminated specimens were placed in the foam filling column followed by filling with the decontamination foam through the foam generator. As the drainage is continuously generated from the liquid film of the filled foams, the solution accumulated at the lower end of the filling column at intervals of 20 minutes is recirculated to the foam solution make-up tank and a new decontamination foam prepared via a

foam generator was fed to the bottom of the foam filling column. As a result, the dry foam at the top of the filling column is pushed out and filled with new foam. This is called 'push-blowing' cyclic foam filling process.

The decontamination performance of the particulate and oil contaminated specimens was evaluated by analyzing the state of the surface and the removal of the contaminants using the UV lamp before and after applying the decontamination foam to the specimens. Similarly, the decontamination performance of the corrosion oxide film contaminated specimens was evaluated by measuring weight loss before and after decontamination.

### 3. Results and Discussion

The decontamination performance was improved by keeping the physicochemical properties of the decontamination foam substantially constant by applying 'push-blowing' cyclic foam filling process.

In the removal of contaminants from the simulated specimens by the decontamination foam, non-fixed contamination consisting of a mixture of  $\text{Eu}_2\text{O}_3$  particles, TBP oil and fluorescent powder was completely removed within 4 hours by neutral decontamination foam, F-1 containing no acids or oxidants.

For the removal of the fixed contaminants, the  $\text{NiFe}_2\text{O}_4$  film coated on the stainless steel specimen at 500 nm thickness was completely removed within 2 hours by acid decontamination foam, F-3 mixed with nitric acid and hydrofluoric acid. On the other hand, only *ca.* 3% of the  $\text{NiFe}_2\text{O}_4$  was removed during the same time period by acid decontamination foam, F-2 containing only nitric acid as shown in Fig. 1.

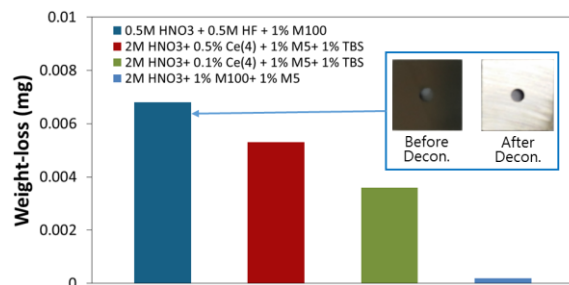


Fig. 1. Comparison of Foam Decontamination Performance of  $\text{NiFe}_2\text{O}_4$  coating specimens.

$\text{FeCr}_2\text{O}_4$  film with a thickness of 10  $\mu\text{m}$  produced in the autoclave was completely removed within 2 hours by oxidative decontamination foam, F-4

containing Ce(IV) as an oxidant, but almost not by acidic decontamination foam, F-3 as shown in Fig. 2. It was found that the corrosion oxide film containing chromium can be removed by the oxidative decontamination foam while it was difficult to remove by the acidic decontamination foam.

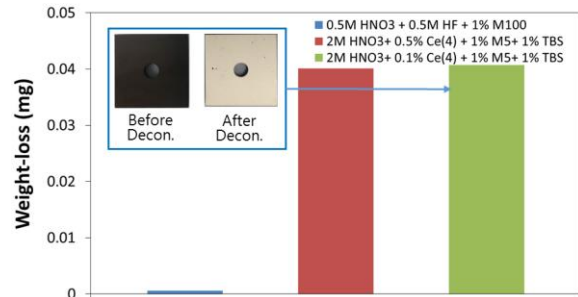


Fig. 2. Comparison of Foam Decontamination Performance of  $\text{FeCr}_2\text{O}_4$  coating specimens.

### 4. Conclusion

The foam decontamination performance was improved by applying 'push-blowing' cyclic foam filling process. It was found that the application of the appropriate decontamination foam is required depending on the characteristics of contamination. Further study is needed to optimize the condition of foam decontamination process.

### ACKNOWLEDGEMENT

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