Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 23-24, 2019

Removal of Radioactive Oxide Film Using Acidic and Oxidative Decontamination Foams

Wangkyu Choi* and Seonbyeong Kim
Korea Atomic Energy Research Institute, 111, Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, Korea
**nwkchoi@kaeri.re.kr*

1. Introduction

Decontamination is one of the methods available for reducing radiation exposure. Chemical decontamination is based on the chemical dissolution of radioactive oxide films from the internal surface of system pipes and components of nuclear facilities. Foam decontamination process as one of the chemical decontamination methods has a potentially wide application in the removal of radioactive contaminants from large components with complex shapes or large area or large volumes. The foam decontamination process has advantages such as easy operation by room temperature and small secondary waste generation [1], but it has disadvantage of relatively low decontamination factor (DF) [2]. In order to overcome this problem, it is suggested to introduce a decontamination foam containing more aggressive chemical agent and to enhance the stability of the foam to increase the contact time between the decontamination foam and the contaminated surface [3].

In this study, the removal performance of iron chromite ($FeCr_2O_4$) film coated on the surface of stainless steel 304 (STS 304) as one of the models of fixed contamination was investigated using acidic and/or oxidative decontamination foams.

2. Materials and methods

2.1. Preparation of decontamination foams

The decontamination foams used in this study were prepared by combining surfactant, silica nanoparticles, and chemical reagents. Acidic decontamination foam (AF) contains HNO_3 and/or HF as an inorganic acid. Oxidative decontamination foam (OF) contains Ce(IV) as an oxidizing agent. Detailed composition of decontamination foams is summarized in Table 1.

Table 1. Composition of Decontamination Foams

Foam Type	Chemical Composition
AF-1	1 wt% EM100¹⁾ + 1 wt% M-5²⁾ + 2M HNO_3
AF-2	1 wt% EM100 + 0.5M HF + 2M HNO_3
OF-1	1 wt% EM100 + 1 wt% M-5 + 0.05M Ce(IV)
OF-2	1 wt% EM100 + 1 wt% M-5 + 0.1M Ce(IV)
OF-3	1 wt% EM100 + 1 wt% M-5 + 0.2M Ce(IV)

1) Nonionic surfactant, ELOTANT Milcoside 100, C08-10 alkyl polyglucoside
2) CAB-O-SIL® M-5 Fumed Silica Nanoparticle

2.2. Experiments on the removal of oxide film

In order to evaluate the removal performance of oxide film using acidic and/or oxidative decontamination foams, $FeCr_2O_4$ oxide film coated on the STS 304 specimens prepared in an autoclave was used as fixed contamination.

Oxide removal tests were performed in a small scale experimental apparatus having foam volume of 5 L to evaluate the oxide removal characteristics and appropriate oxide removal conditions and in a bench scale test apparatus having foam volume of 300 L to demonstrate and verify the oxide removal performance (Fig. 1).

The oxide removal performance of the specimens was evaluated by measuring weight loss before and after experiment.

The cyclic foam filling process in which newly generated foam is periodically brought into contact with the oxide film surface was applied to remove oxide film using acidic and oxidative decontamination foams.

Fig. 1. Bench scale test apparatus.

3. Results and discussion

$FeCr_2O_4$ film formed with a thickness of *ca.* 10 ㎛ on the STS 304 specimen prepared in the autoclave was completely removed within 3 hours by oxidative decontamination foam, OF-3 containing 0.2 M Ce(IV) as an oxidant, but almost not by acidic decontamination foam, AF-1 containing 2 M HNO_3 or AF-2 mixed with 0.5 M HNO_3 and 0.5 M HF. The results are 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.

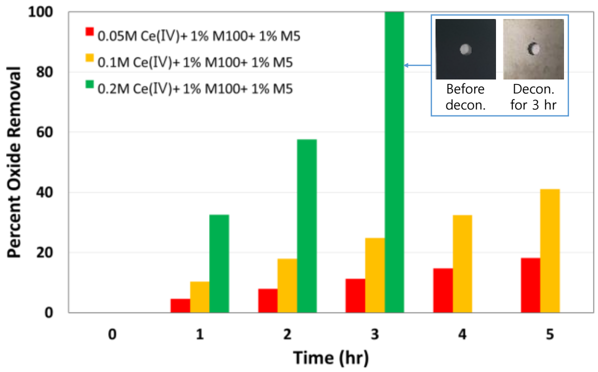

Fig. 2. $FeCr_2O_4$ Oxide Film Removal Performance Using Oxidative Decontamination Foams.

In order to verify the oxide removal performance, a bench scale test with foam volume of 300 liters was carried out and the results are given in Fig. 3. As a result of the bench scale verification test, the oxide film was completely removed within 3 hours, which shows the same as a small scale experiment with foam volume of 5 liters.

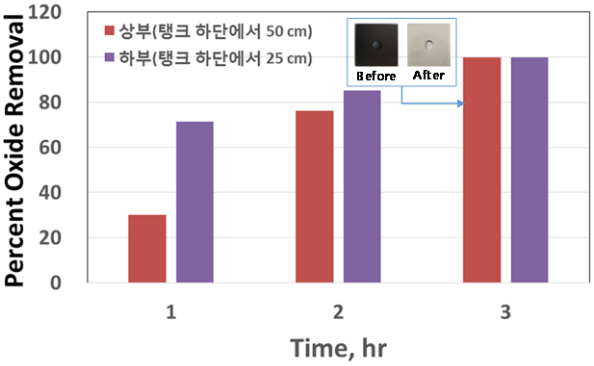

Fig. 3. Bench Scale Oxide Removal Performance Using Oxidative Decontamination Foams.

The oxide removal performance of the specimen located in the lower part of the tank is higher than that of the specimen located in the upper part of the tank. This is because the liquid content of the foam in the upper part of the tank is lowered due to the drainage of the solution present in the liquid film of the foam over time.

4. Conclusion

In the dissolution removal of the iron chromite oxide film by the decontamination foams, the oxide removal performance using oxidative decontamination foam was confirmed and the appropriate oxide removal conditions was established.

And also, the filling type foam decontamination performance using the oxidative decontamination foam containing Ce(IV) was verified through a bench scale demonstration with the application of cyclic foam filling process.

ACKNOWLEDGEMENT

This work was supported by the Nuclear R&D Program (2017M2A8A5015144) funded by Ministry of Science, ICT & Future Planning.

REFERENCES

[1] C. Dame, C. Fritz, O. Pitois, and S. Faure, Relations between physicochemical properties and instability of decontamination foams, Colloids Surf., A, 263, 210-218 2005.
[2] A.H. Love, C.G. Bailey, M.L. Hanna, S. Hok, A.K. Vu, D.J. Reutter, and E. Raber, Efficacy of liquid and foam decontamination technologies for chemical warfare agents on indoor surfaces, J. Hazard. Mater., 196, 115-122, 2011.
[3] I.H. Yoon, C.H. Jung, S.B. Yoon, S.Y. Park, J.K. Moon, and W.K. Choi, Effect of silica nanoparticles on the stability of decontamination foam and their application for oxide dissolution of corroded specimens, Ann. Nucl. Energy, 73, 168-174, 2014.