Application of Hi-F Coat for Recontamination Reduction at Shimane Unit 1

Makoto Nagase[1], Naoshi Usui[1], Satoshi Oouchi[1], Hideyuki Hosokawa[2], Hiroyasu Kajitani[3], Akinori Yamashita[3] and Tomohiro Minami[3]

[1]Hitachi-GE Nuclear Energy, Ltd

[2]Energy and Environmental Systems Laboratory, Hitachi, Ltd

[3]The Chugoku Electric Power Company, INC

Abstract

Hi-F Coat was first applied to Shimane Unit 1 during the 27th outage as a countermeasure to reduce recontamination after the chemical decontamination. Dose rate measurements of the PLR piping at the 28th outage showed that recontamination was suppressed about 1/2 to 1/3 by Hi-F Coat. Coated film was found to be easily removed with radioactive nuclei by the next chemical decontamination. Farther dose rate reduction can be expected with Zn injection based on the laboratory tests.

1. Introduction

Chemical decontamination is one of effective methods to reduce environmental dose rate in the containment vessel before large scale maintenance or inspections to reduce radiation exposure at nuclear power plants. However, it is difficult to keep a low piping dose rate for several operation cycles after chemical decontamination. Rapid dose rate increases within a few operating cycles have been seen in some plants[1)2)]. This is due to the removal of oxide film by chemical decontamination, which brings on a rapid oxide film formation in the operation after decontamination, resulting in the high Co deposition rate under certain circumstance such as reducing condition. So, we developed a new method to make an artificial oxide film after chemical decontamination. Laboratory data showed a ^{60}Co deposition reduction effect of 1/5 compared to non-treatment for up to 3100 hours[3)]. We named this new method Hi-F Coat (<u>Hi</u>tachi <u>F</u>errite <u>Coat</u>ing). Hi-F Coat was first applied to Shimane Unit 1 in 2008 and the reduction effect of recontamination was confirmed after 1 cycle operation in 2009. The application results of Hi-F Coat and the effect to reduce recontamination are described in this paper.

2. Brief explanation of Hi-F Coat

Hi-F Coat is the technology to make a thin and fine pure magnetite film on the metal surface whose oxide film was removed by a chemical decontamination. Magnetite is one of chemical forms observed in the natural oxide under BWR operating conditions and has no side effect on the plant. This fine magnetite film becomes a kind of barrier of oxygen and metal diffusion and the metal corrosion rate decreases, which results in the low Co deposition rate. Magnetite film can be formed by using the same equipments for chemical decontamination just after chemical decontamination process. After the film formation process, residual chemicals can be also decomposed by the catalyst used for the chemical decontamination process in order to reduce the secondary waste. These features enable a minimum application time, a low cost and a small secondary waste.

3. Application of Hi-F Coat

Hi-F Coat treatment was first applied just after the chemical decontamination to Shimane Unit 1 during 27th outage in 2008. Application targets of chemical decontamination and Hi-F Coat were both A and B loops of PLR piping as shown in Fig. 1. The highest water level was different for PLR pump inlet piping and outlet piping. So, the first chemical decontamination and Hi-F Coat were carried out from PLR pump inlet valve to riser piping by closing the inlet valve. Then it was opened and the second ones were carried out from PLR pump inlet piping to middle of outlet piping. Another loop was also decontaminated and coated in the same way. As a result, Hi-F Coat treatment process was applied total four times.

Hi-F Coat treatment was carried out by injecting iron formate solution and hydrogen peroxide and hydrazine. Planned values of iron and hydrazine concentrations are 250±50 ppm and from 200 to 600 ppm, respectively. The measurement results showed almost all of measure values were within the planned ones as shown in Table 1.

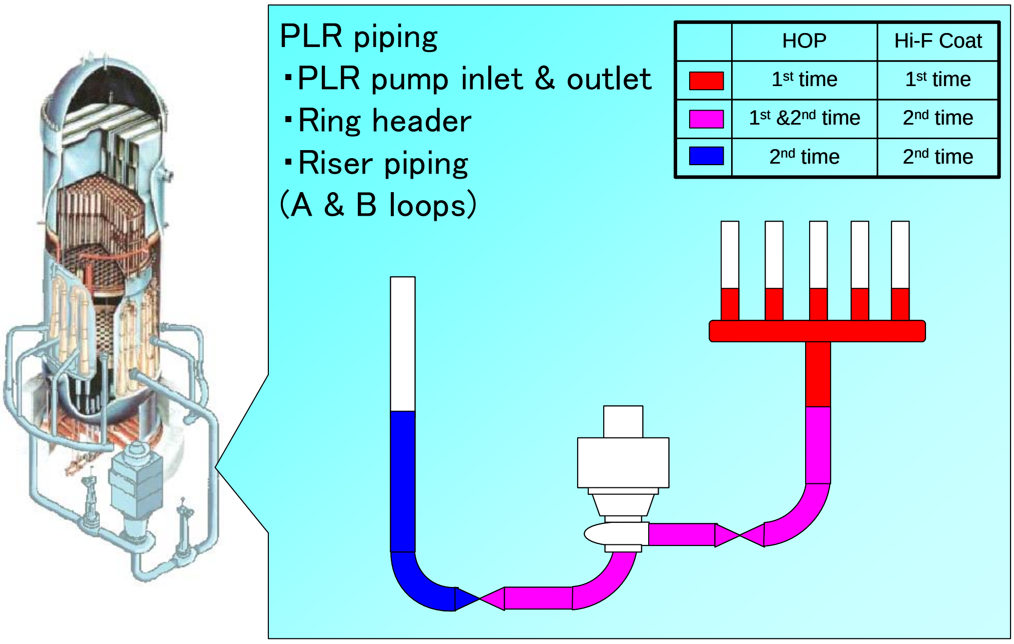

Fig. 1 Application target of HOP decontamination and Hi-F Caot

Table 1 Hi-F Coat treatment conditions

Parameter	Planned value	Measured value
Fe conc.	250±50 ppm	263～296 ppm
N2H4 conc.	200～600 ppm	160～560 ppm

The coated film was confirmed by the test pieces set in the test piece unit and the short temporary piping used for the temporary equipments system for the application as shown in Fig. 2. The good appearances of test pieces, inside of temporary piping and valve body were seen when it was removed. Film amount of test pieces was measured by the weight change and that of temporary piping was measured by dissolving the film in the oxalic acid solution and measuring iron concentration of the solution. Table 2 shows the deposited film amount of test pieces and the temporary piping. Film amount was more than 125 μ g/cm2 which was about twice of targeted minimum amount. Average amount of film was about 270 μ g/cm2 which was enough to reduce Co deposition based on the laboratory tests. So, four applications of Hi-F Coat were successfully conducted during 27th outage.

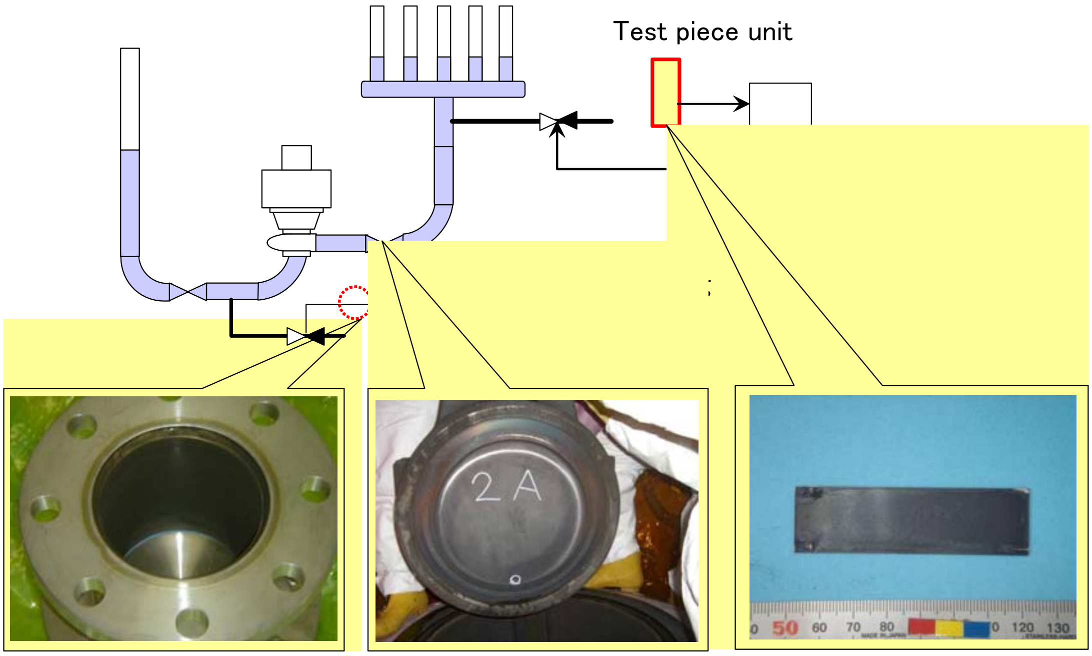

Fig. 2 Hi-F Coat treatment results

Table 2 Deposited film amount of Hi-F Coat treatment

Sample item	Application	Sample No.	Deposited amount (μ g/cm2)
Test piece	1st time	1	230
		2	270
	2nd time	3	302
		4	192
	3rd time	5	125
		6	132
	4th time	7	402
		8	498
Temporary piping	2nd time	A	150
	4th time	B	359

4. Effect of Hi-F Coat

Shimane Unit 1 experienced the rapid recontamination of PLR piping at the 23rd outage just after one cycle operation from the previous chemical decontamination as shown in Figs. 3 and 4. The deviation of dose rate became larger after hydrogen injection and some points showed the higher value. So, after next decontamination at 25th outage, NWC operation for the first 54 days at the beginning of the 26th operation cycle was carried out to make the stable oxide film on the decontaminated surface, which showed some recontamination reduction at Point 4, but not for Point 3. PLR dose rate at the 27th outage became the highest value at some points and all kinds of applicable countermeasure to reduce dose rate were adopted for the 28th cycle. NWC operation for the first 90 days at the beginning of the 28th operation cycle was also adopted although Hi-F Coat treatment was applied after chemical decontamination.

As a result of NWC operation of 90 days and Hi-F Coat, dose rate of PLR piping became lower at the 28th outage. It was about 0.4 mSv/h and less than half of the previous recontamination level after one cycle operation. We evaluated the contribution of NWC operation of 90 days and Hi-F Coat and concluded that the recontamination was suppressed about 1/2 to 1/3 by Hi-F Coat.

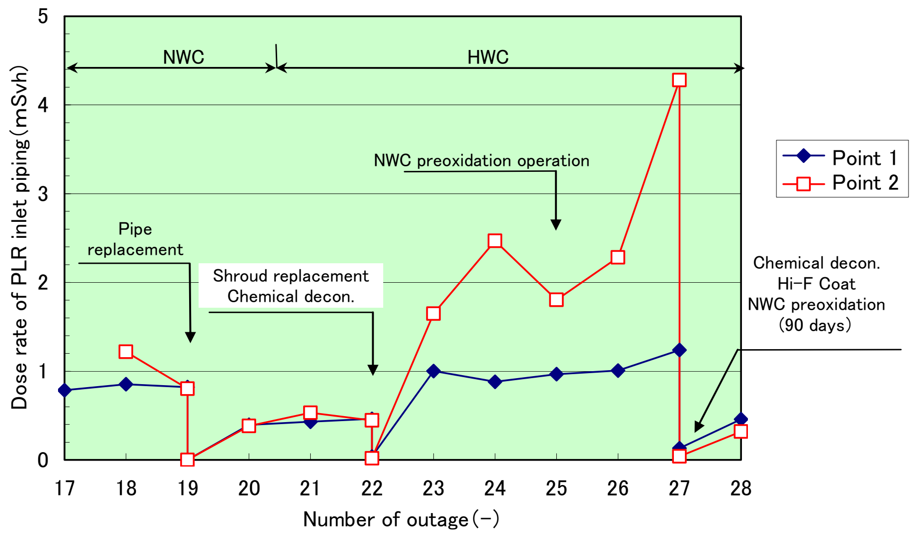

Fig. 3 Dose rate of PLR inlet piping

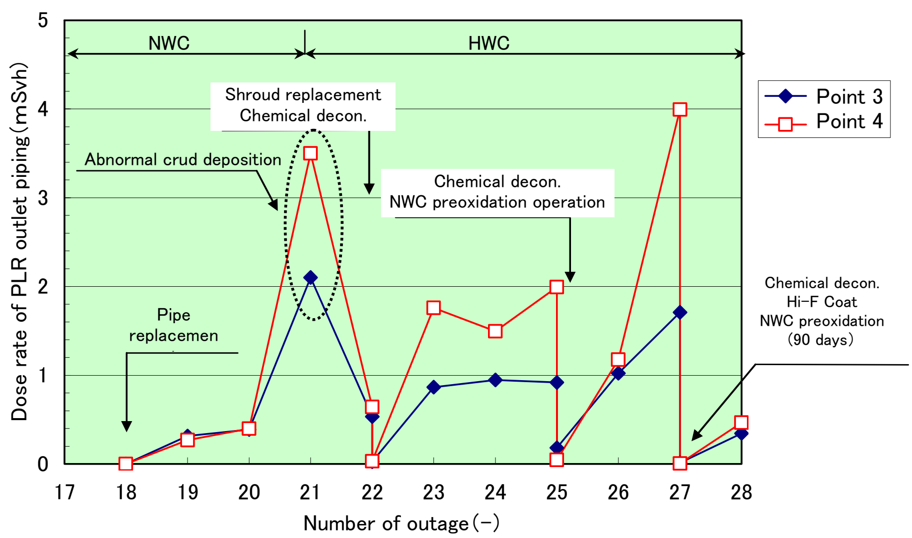

Fig. 4 Dose rate of PLR outlet piping

At the 28th outage, another chemical decontamination was carried out to reduce radiation exposure around the higher position of riser piping which was not decontaminated in the previous outage. Hi-F Coat film is made of pure magnetite which is easy to be removed by the oxalic acid solution. It was expected that Hi-F Coat film after one cycle operation was also easy to be removed by chemical decontamination. Figure 5 shows the dose rate change of PLR outlet piping at the 27th and 28th outage decontamination at the same position. The natural oxide film was removed at the 27th outage and the Hi-F Coat film was removed at the 28th outage. Hi-F Coat film was confirmed to be removed easier than the natural oxide one. Figure 5 suggests that there is some possibility to reduce operation cycle of chemical decontamination if Hi-F Coat is applied after the previous chemical decontamination.

Although Hi-F Coat is confirmed to be effective method to reduce recontamination after chemical decontamination, the dose rate is about same level of NWC conditions. In order to realize lower dose rate, we examined the combination of Hi-F Coat and Zn injection in our laboratory. Experimental results showed that the combination of Hi-F Coat and Zn injection was more effective to reduce Co deposition on stainless steel surfaces. Farther dose rate reduction can be expected by Hi-F Coat with Zn injection.

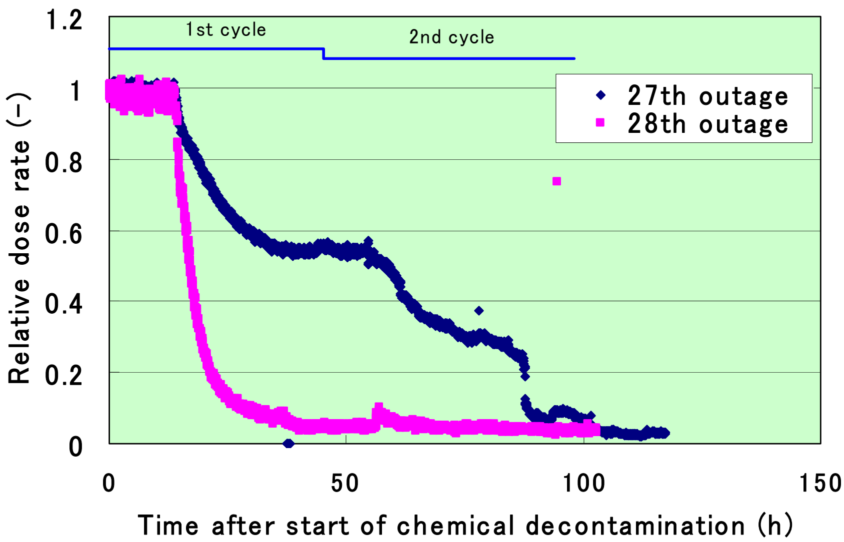

Fig. 5 Effect of Hi-F Coat on chemical decontamination

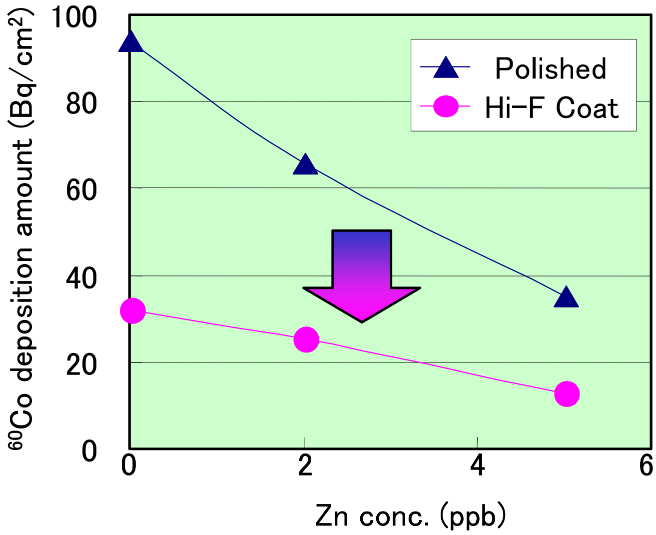

Fig. 6 Co deposition reduction of Hi-F Coat with Zn injection

5. Summary

Hi-F Coat was first applied to Shimane Unit 1 during the 27th outage as a countermeasure to reduce recontamination after the chemical decontamination. Hi-F Coat treatment was successfully applied to the decontaminated surface. Deposited amount of film was about 270 μg/cm^2 which was more than target value of 60 μg/cm^2. Dose rate measurements of the PLR piping at the 28th outage showed that recontamination during one cycle operation was suppressed about 1/2 to 1/3 by Hi-F Coat. The coated film at the 27th outage was found to be easily removed with radioactive nuclei by the 28th chemical decontamination. Farther dose rate reduction can be expected by the combination of Hi-F Coat and Zn injection based on the laboratory tests.

6. References

1) A. Miyazawa, et al., “The operation experience and the simple method to predict dose rate of primary loop recirculation system piping after 1 year chemical decontamination”, Symposium on Water Chemistry and Corrosion of Nuclear Power Plants in Asia, 2005, Gyeongyu, Korea, pp.38-41 (2005)

2) R. L. Cowan and C. J. Wood, “Control of Radiation Fields in BWRs after Noble Metal Chemical Addition”, 9th Int’l Conf. on Water Chemistry in Nuclear Reactors Systems, Avignon, France, 21 (2002)

3) H. Hosokawa, et al., “Development of Recontamination Reduction Treatment Method after Chemical Decontamination”, Symposium on Water Chemistry and Corrosion of Nuclear Power Plants in Asia, 2007, Taipei, Taiwan, pp.225-230 (2007)