Confirmation of appropriate operation condition with blasting device

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Abstract

The decontamination method of metallic waste was considered to reduce the radioactive waste in the nuclear power plant decommissioning.

Stainless steel occupies most for material of system equipments of pressurized water reactor (PWR). The radioactive materials are stuck on the surface of the equipments' internal as metal oxide (e.g. chromium oxide, iron oxide). It is necessary to remove the metal oxides efficiently from the stainless steel.

The blasting method is widely known as one of the decontamination techniques. It is necessary to introduce a blasting device that depends on the materials and the volume of metallic waste for each plant.

The cold tests were performed using the non-contaminated stainless steel plate and confirmed the abrade conditions of the plate surface. The best performance of combination of the type of abrasives, the blasting velocity and angle was selected as the appropriate operation conditions from the test results.

Next, the hot tests were performed using the contaminated samples on the appropriate operation conditions and confirmed the decontamination performance and the influence of cross contamination. The hot test results showed that to be able to decontaminate the metal to the clearance level and no influence of cross contamination in the range of the target radioactivity concentration, and abrasives could be used repeatedly.

(Contents)

1. Introduction

Low level radioactive waste (LLW) is generated with operation or decommissioning of nuclear power plants. Some metal LLW can apply clearance system by decontamination. The blasting techniques are widely known as effective decontamination technology for simple shape metals. We are considering to introduce the dry blasting device that does not generate liquid waste.

The blasting method had been utilized to the replaced steam generator of PWR in Japan and the reduction of radiation exposure was achieved. [1] This record shows that the decontamination by the blasting method is effective for metal waste. For the actual decontamination operation, it is important to confirm and set the appropriate conditions of the blasting device in advance.

In this paper, various test results and the appropriate condition of the blasting device are described.

2. BACKGROUND AND SUMMARY OF THE TESTS

The primary cooling water contains the cladding that is radioactive metal oxide. The claddings are stuck on the surface of equipments' internal that contact with the primary cooling water.

The main material of the PWR system equipments is stainless steel. We estimated that it would be necessary to abrade the stainless steel not only the claddings on the surface of stainless steel in order to the decontamination to the clearance level. Therefore, it was necessary to confirm the operation conditions of the blasting device to abrade the stainless steel.

Factors that influence the blasting performance are the type of abrasives (material, shape), the blasting conditions (angle, velocity), and also cross contamination. The cross contamination might reduce decontamination performance because the abrasives are contaminated after blasting and make contaminate the decontaminated object again when the abrasives used repeatedly.

3. APPROPRIATE ABRASIVES AND THE BLASTING CONDITIONS COMFIRMATION TEST

3.1 THE COLD TEST CONDITIONS AND PROCEDURES

(1) Blasting device

The centrifugal blasting device which is assume to introduce on actual decontamination operation was used for the cold test. The centrifugal blasting device is shown in Fig.1.

Fig.1 Appearance of the centrifugal blasting device

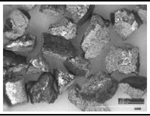
(2) Test blasting abrasives

The material of the abrasives is categorized into metallic type and nonmetallic type, and among the metallic type, steel and stainless steel are widely used. Therefore, these two materials were selected. Incidentally, metallic abrasives have advantages such as high durability, stable quality, low dust, and high abrade efficiency [2)].

There are three shapes of abrasives - grit, cut wire, and shot. The shapes of grit and cut wire are angular, and the shape of shot is sphere. Grit and cut wire were selected because their angular shape are effective for the metal abrading.

Steel cut wire (SWRH), steel grit (high hardness cast steel) and stainless steel cut wire (SUS 304), were selected from the above studies. The selected abrasives are shown in TABLE.1.

TABLE.1 Test blasting abrasives

Blasting abrasives	Abrasives size	Appearance
Steel cut wire pieces (SWRH)	φ1.0mm	
Steel grits (HHCS)	1.0mm	
Stainless-steel cut wire pieces (SUS304)	φ1.0mm	

(3) Test blasting velocities

The blasting velocity was tested at 55 m / s, 50 m / s, 45 m / s from the output of the blasting device.

(4) Test blasting angles

It is known that the blasting angle influence the blasting performance[3)].

Based on this information, the blasting angles were tested at 30°, 45°, and 60°. Diagram of blasting angle adjustment is shown in Fig. 2.

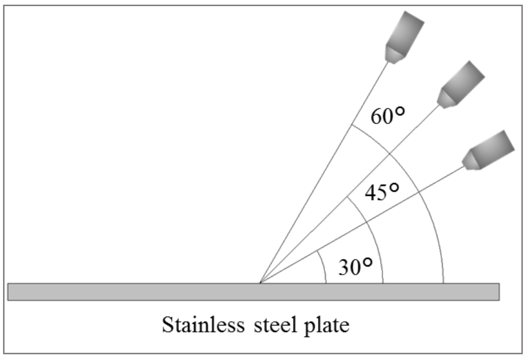


Fig. 2 Diagram of blasting angle adjustment

(5) Test details

The cold test was performed in the following two steps.

The first step, the abraded weight was checked by changing the combination of the type of abrasives and the blasting velocity. SUS 304 flat plates were placed on the rotary table inside the blasting device, and were abraded at three kinds of abrasives and three kinds of blasting velocities. The abraded weight was calculated difference of plate weight blasting before and after. The largest abraded weight combination of the type of abrasives and the blasting velocity was selected as the appropriate blasting condition.

The second step, the abraded weight was checked by changing the blasting angle. The type of abrasives and the blasting velocity selected in the first step were used as the second step conditions. SUS 304 flat plates were placed on the angle adjustable table inside the blasting device, and were abraded at three kinds of blasting angles. The abraded weight was calculated difference of plate weight blasting before and after. The largest abraded weight angle was selected as the appropriate blasting condition. The internal condition of the blasting device during the cold test is shown in Fig.3.

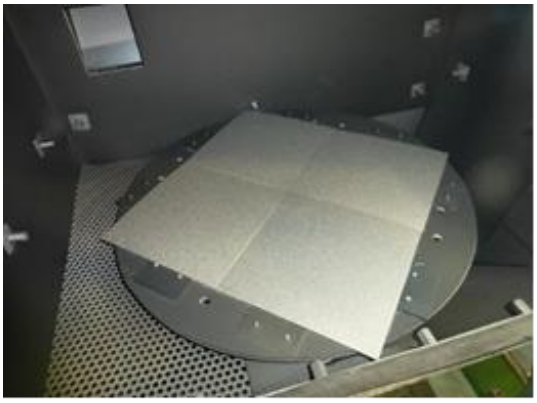


Fig. 3 The internal condition of the device

3.2 TEST RESULTS

Fig. 4 and Fig. 5 show the first step test results and Fig. 6 shows the second step test results.

(1) Blasting abrasives

Fig.4 shows the abraded weight of the each abrasives. The abraded weight by the steel cut wire pieces showed the largest on the every blasting velocities. From this result, the steel cut wire pieces was selected as the appropriate abrasives.

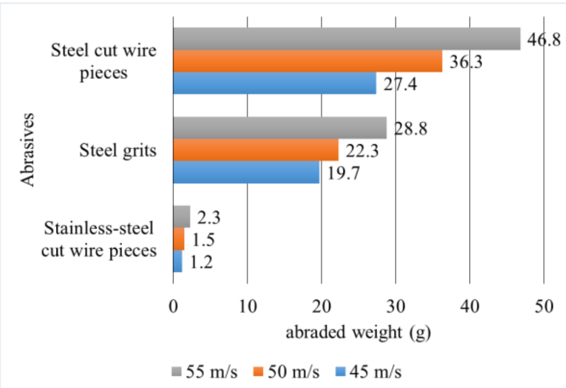


Fig.4 Abraded weight of the each abrasives

(2) Blasting velocity

Fig.5 shows the abraded weight of the each blasting velocity. The abraded weight increased according to the blasting velocity getting faster on the every abrasives, and the velocity of the 55 m / s showed the largest abraded weight. From this result, the velocity of 55 m / s was selected as the appropriate blasting velocity.

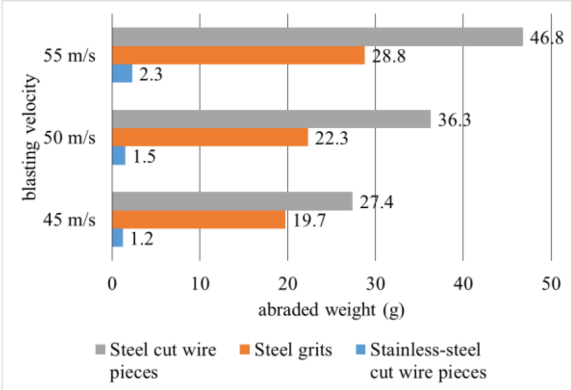


Fig.5 Abraded weight of the each blasting velocity

(3) Blasting angle

Fig.6 shows the abraded weight of the each blasting angle. The abraded weight increased according to the blasting angle getting larger, and the angle of the 60° showed the largest abraded weight. From this result, the blasting angle of 60° was selected as the appropriate blasting angle.

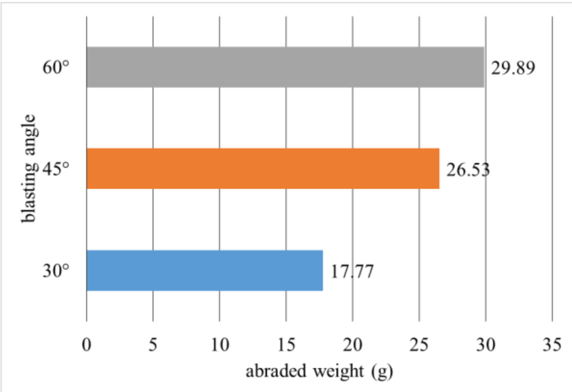


Fig.6 Abraded weight of the each blasting angle

(4) Summary of the cold test

TABLE.2 shows the appropriate blasting conditions to the stainless steel on the cold test.

TABLE.2 Summary of the cold test

Item	Appropriate Condition
Blasting Abrasives	Steel cut wire pieces
Blasting velocity	55 m / s
Blasting angle	60°

4. DECONTAMINATION EFFECTS CONFIRMATION TEST

4.1 THE HOT TEST CONDITIONS AND PROCEDURES

(1) Blasting device

The air blasting device was used for the hot test because the centrifugal blasting device could not be used due to space restrictions in the hot test site. The air blasting device is shown in Fig. 7.

The air blasting device was different from the cold test device, however, the hot test result could be applied to the centrifugal blasting device by evaluating the abraded depth from the abraded weight. This is because both the blasting device physically remove the metal oxide.

Fig.7 Appearance of the air blasting device

(2) Test sample

The contaminated stainless steel piping was used as a test sample. The piping is expected to be relatively generated as actual metal wastes.

The piping was cut about 5 cm × 2 cm per piece for the test and the next measured Co-60 radioactivity concentration and the surface contamination counting rate of each pieces. The maximum value of both measurements were about 10 Bq / g, and about 21,500 cpm. Appearance of the test sample before cutting is shown in Fig.8.

Fig.8 Appearance of the test sample before cutting

(3) Test details

The test conditions specified in TABLE.3. The test pieces were decontaminated several times by blasting abrasives, and for each blasting, the test pieces' surface contamination count rate and weight were measured. After the surface contamination count rate went down to the same count rate of the background, radioactivity concentration was measured with a Germanium pulse-height analyzer (Ge-PHA).

TABLE.3 Decontamination effect confirmation test conditions

Item	Condition
Equipment	Air-blasting device
Blasting Abrasives	Steel cut wire pieces
Blasting angle	60°
Air pressure	0.54 MPa
Blasting unit	120 s/time

4.2 TEST RESULTS

(1) Appearance of the test pieces

The blackish brown metal oxide on the surface of the test piece was removed a couple of blasting, confirmed to remove at the relatively early stage.

After that, the decontamination was continued. However, the appearance of the test piece surface did not change significantly. The appearance of the test pieces' surface is shown in TABLE.4.

TABLE.4 Surface conditions before and after decontamination

	Test piece
Before decontamination	
Decontamination one time blasting	
Complete decontamination	

(2) Decontamination effect

The blackish brown metal oxide was removed at a relatively early stage, however, the surface contamination count rate was about 1,000 cpm or more. This means contamination still remain and necessary to continue the decontamination.

After several blasting, the surface contamination count rate of the test piece went down to the same count rate of the background. At that time, the measurement result of Co - 60 radioactivity concentration was 0.1 Bq / g or less. From this, it was confirmed that the decontamination to below the clearance level by blasting was possible if the Co - 60 radioactivity concentration of decontamination object was about 10 Bq / g. Decontamination effect confirmation test results are shown in Fig.9 and TABLE.5.

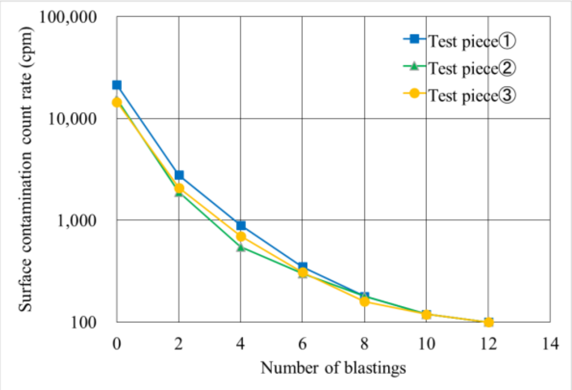


Fig.9 Decontamination effect confirmation test results

TABLE.5 Decontamination effect confirmation test results

Number of blasting	Test piece (cpm)			BG (cpm)
	①	②	③	
0	21,500	15,500	14,600	100
2	2,800	1,900	2,100	100
4	900	550	700	100
6	350	300	310	100
8	180	180	160	100
10	120	120	120	100
12	100	100	100	100

5. CROSS CONTAMINATION CONFIRMATION TEST

5.1 TEST CONDITIONS AND PROCEDURES

The influence of the cross contamination to the decontamination effect was tested.

The same conditions as "TABLE.3 Decontamination effect confirmation test conditions" were used for this test.

After the blasting to the test pieces by each of Non-contaminated abrasives and contaminated abrasives, the contamination count rate was measured. The Contamination condition of each abrasives is shown in TABLE.6.

Moreover, we compared trends of the contamination count rate. The test piece is shown in TABLE.7.

TABLE.6 Cross contamination test abrasives

Abrasives No.	Contamination condition	Surface contamination count rate [cpm]
①	Contaminated	150
②	Contaminated	150
③	Contaminated	140
④	Non-Contaminated	—

TABLE.7 Cross contamination test piece

Test piece	Surface contamination count rate [cpm]	Used Abrasives No.
A	1,000	①
B	1,200	②
C	1,200	③
D	1,100	④

5.2 TEST RESULTS

The cross contamination test results are shown in Fig.10 and TABLE.8.

Both number of blasting by two kind of abrasives were 5 to 6 times to the background contamination count rate and the trends of contamination count rate were almost the same.

Fig.10 shows the trend of the contamination count rate. In this figure, result of the test piece D is indicated by solid line, and result of other pieces are indicated by the point only. The test piece D was decontaminated by the non-contaminated abrasives and other pieces were decontaminated by contaminated abrasives. The result of the test pieces A to C showed the same trend as the test piece D, and no influence to the decontamination by the cross contamination was confirmed.

From the above test results, we confirmed that abrasives can be used repeatedly less than target range of the radioactive concentration.

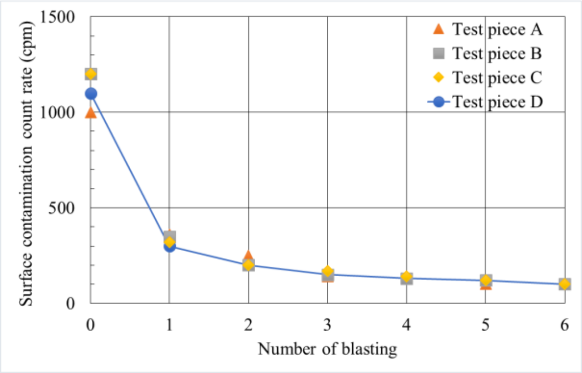


Fig.10 Cross contamination test results

TABLE.8 Cross contamination test results

Number of blasting	Test piece (cpm)				BG (cpm)
	A	B	C	D	
0	1,000	1,200	1,200	1,100	100
1	360	350	320	300	100
2	250	200	200	200	100
3	140	150	170	150	100
4	140	130	140	130	100
5	100	120	120	120	100
6	—	100	100	100	100

6. CONCLUSIONS

In conclusion, the appropriate operating conditions (abrasives, velocity and angle) of the blasting device to abrade the stainless steel were confirmed.

Moreover, the metal waste can be decontaminated to the clearance level or less by the appropriate operating conditions, and no influence by cross contamination and possible to use abrasives repeatedly was confirmed.

These data would be utilized to study the specification of the blasting device and decontamination operation.

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