

Steam Generator Lancing and FOSAR for HANUL Nuclear Power Plant Unit 2

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1. Introduction

We cleaned deposits on the tube-sheet of the Hanul NPP unit 2 steam generators from October 14 until November 19, 2014. Sludge weight removed during the deposit removal operation was 10.68 kg. Annulus, tube-lane, and in-bundle area of the steam generators were searched for possible foreign objects. Three foreign objects were found and removed. Mock-up training before the operation was helpful to finish the service as scheduled.

2. Scope of the Service

The scope of the lancing and FOSAR service includes the followings:

2.1 Removal of secondary side deposits

- Taking over the lancing equipment.
- Bringing the equipment in the containment vessel and install it.
- Removal of sludge deposit on the tube-sheets.
- Inspection and removal of the hardened sludge on the tube-sheets.
- Withdrawal of the equipment and clean the area around the steam generator.

2.2 Search and retrieval of the foreign objects in secondary side of steam generator

- Bringing the FOSAR equipment into the containment vessel around steam generator.
- Inspection and removal of foreign objects on annulus and on no tube lane of steam generator secondary side.
- Inspection and removal of foreign objects in tube bundle of steam generator.
- Inspection and removal of foreign objects based on ECT results.
- Inspection of tube row number 1.

3. Equipment

3.1 Lancing Equipment

Hanul Nuclear power plant has CECIL water jet lancing system. It is consisted of the robot/rail assembly, the take-up assembly, and the stationary pulley as shown in Figure 1. Lancing robot moves along the rail which is installed in no tube lane of the steam generator.

Umbilical cable is connected between the robot and the manifold. It is composed of water hose and electrical cable. When the robot moves to the center of the steam generator, the floating pulley of the take up assembly moves down to compensate the length of the umbilical cable.

Barrel spray mode uses pressurized water of 200 bars for removing soft sludge. To remove hardened sludge, higher pressure of 1,000 bars is applied through the lance. Flexible lance is used to approach hardened sludge at inside of tube bundle.

CECIL equipment was developed by Foster-Miller Inc. by the support of EPRI (Electrical Power Research Institute). Its unique feature includes flexible lance which could reach to the top of the tube sheets. The main objective of the flexible lance was to remove hardened sludge in between steam generator tubes mainly on hot leg side of the tube sheet. Therefore, it was designed to be inserted between the SG tubes.

CECIL patent on flexible lance was applied on Feb. 22, 1989. Patent is protected for 20 years in the United States. Therefore this flexible lance technology is available to everyone since Feb. 23 2009.

3.2 FOSAR Equipment

FOSAR(Foreign Object Search And Retrieval) equipment is composed of a video probe, the retrieval tools, and the guide tubes as shown in figure 2.

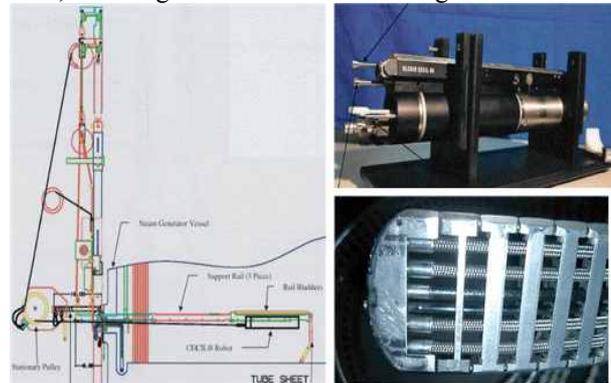


Fig. 1. Lancing Equipment Used for Hanul Unit 2

4. Lancing and FOSAR

Lancing of SG B was installed on October 28, 2014. Barrel spray was started on October 29, 2014. It took about 4 days to finish lancing of SG 'B'. Two bag and

14 cartridge filters were used to remove solid sludge from the mixture of water and sludge. 3.78 kg of sludge was removed.

Barrel spray of SG A started on November 2 and finished on November 3, 2014. It took about 2 days to clean SG A. Two bag and 14 cartridge filters were used to remove solid sludge from the mixture of water and sludge. 3.18 kg of sludge was removed.

Barrel spray of SG C was started on November 6. Final barrel spray was finished on November 9, 2014. It took about 4 days to clean SG C. Two bag and 14 cartridge filters were used to remove solid sludge from the mixture of water and sludge. 3.72 kg of sludge was removed as shown in Figure 3.

Three foreign objects were found, one on November 3, the other one on November 10, and another one on November 11. The longest foreign objects were 36.5mm in length. Two objects were metal chips, and the other one was small coal fragment as shown in Figure 4.

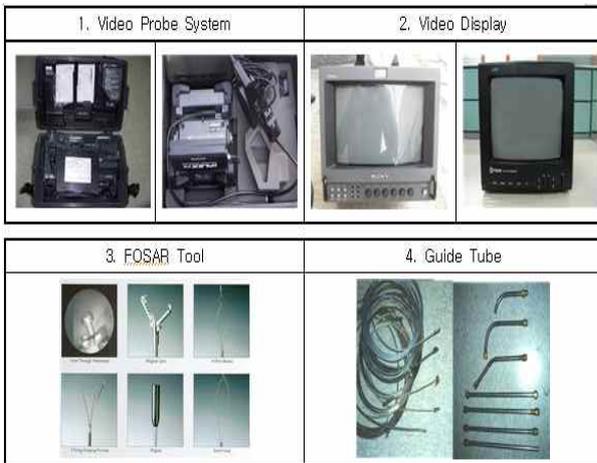


Fig. 2. FOSAR Equipment

Steam Generator	Filter Type	Number(EA)	Weight(kg)	New Filter(kg)	Packaging (kg)	Net Sludge (kg)
'B'	Bag	2	3.00	0.82	0.16	1.36
	Cartridge	14	9.74	3.66	0.16	2.42
	Sub-Total	16	12.74	4.48	0.32	3.78
'A'	Bag	2	2.38	0.82	0.16	0.74
	Cartridge	14	9.76	3.66	0.16	2.44
	Sub-Total	16	12.14	4.48	0.32	3.18
'C'	Bag	2	2.5	0.82	0.16	0.86
	Cartridge	14	10.18	3.66	0.16	2.86
	Sub-Total	16	12.68	4.48	0.32	3.72
TOTAL	Bag	6	7.88	2.46	0.48	2.96
	Cartridge	42	29.68	10.98	0.48	7.72
	Total	48	37.56	13.44	0.96	10.68

Fig. 3. Sludge Removed from Each SG

No.	Foreign Object No.	Coordinates		Type	Image	Size	Etc.
		Col.	Row				
1	HU2R19SGB01	63/64	19	Metal Chip		Length 17.0mm Thickness 0.2mm Weight 0.0073g	Found (Nov.03) Removed (Nov.03)
2	HU2R19SGC01	23/24 ~ 24/25	22 ~ 24	Metal Chip		Length 36.5mm Thickness 0.2mm Weight 0.0214g	Found (Nov.10) Removed (Nov.10)
3	HU2R19SGC02	76/77	32 ~ 35	Coal		Length 20.0mm Thickness 4.0mm Weight 0.2440g	Found (Nov.11) Removed (Nov.12)

Fig. 4. Foreign Objects Found/Removed

5. Conclusions

Sludge lancing and FOSAR were successfully completed for Hanul nuclear power plant unit 2 during the 19th outage. Mock-up training before the service was helpful for the operators to finish the job on time.

Inspection, barrel spray, final barrel/flushing, and sludge collector cleaning was completed for the three steam generators 'A', 'B', and 'C.' Six bag filters and 42 cartridge filters were consumed to remove 10.68 kg of sludge.

Three foreign objects were found and removed. One foreign object (HU2R19SGB01) was found in SG 'B', and two objects (HU2R19SGC01, HU2R19SGC02) were found in SG 'C.'

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