

Sludge Removal and Retrieval of Foreign Objects in SG of Kori Nuclear Power Plant, Unit 4

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1. Introduction

Sludge deposit was removed and foreign objects were inspected and retrieved on secondary side tube sheet of the SG during January 23 and February 22, April 15 and 27 in 2013. FOLAS-I lancing system, video probe and retrieval tools were used for lancing and foreign object removal respectively. Operators of the lancing system participated in mock-up training before doing the service to minimize operation time and radiation dose. 114 bag filters and 1,053 cartridge filters were consumed for filtering of soft and hard sludge in SG A, B, and C. Total 345.9 kilo gram of sludge was removed.

Foreign objects were searched on top of 7th TSP (tube support plate), on annulus and in tube bundle. Four objects were found and removed on annulus and in tube bundle.

2. Removal of Deposit on Secondary Side SG

2.1 Scope of the Lancing Service

The SG unit 4 of Kori NPP has three Westinghouse Model F steam generators. Total 5,626 tubes are made of Inconel 600TT with outside diameter of 0.688 inch. In each SG, there are seven tube support plates with quatrefoil holes. Each tube support plate is made of 405SS which is 1.12 inch thick.

Deposit removal on secondary side of tube sheet area is often called lancing. Lancing includes 1) maintenance of sludge processing container, 2) test operation of lancing system, 3) installation of the lancing system, 4) removal of soft and hard sludge, 5) maintenance of the lancing system after operation, 6) make list of consumed spare parts, 7) submit final report.

2.2 Installation and Operation of the Lancing System

Lancing system includes lancing robot, rail, take-up system, and water hoses and air lines. Those equipments are transported into the containment vessel (CV), and installed around hand hole of the SG. Sludge processing system, which filters solid particles from sludge, is installed outside of CV. Equipments installed inside and outside of CV are interconnected through control cable, water hose, and air hose etc. Figure 1

shows lancing system installed on the hand hole of SG. Right picture shows an operator assembling lancing rail, and left picture shows the hand-hole attachment for installing the guide rail. A take-up system is used for adjusting length of the umbilical cable which is connected to the lancing robot.



Fig.1 Installation of Lancing System at Primary Side

Lancing robot is designed to move along the rail installed on the hand-hole attachment. The rail extends through inside of no tube lane to center stay rod of SG. Eight barrel spray and two high pressure nozzles are used to remove soft and hard sludge respectively.

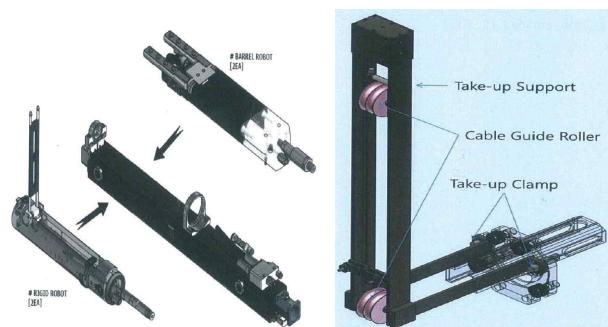


Fig.2 Lancing Robot (left) and Take-up System (right)

2.3 Sludge Removal

Bag and cartridge filters were used to screen solid particles contained in sludge. Bag and cartridge filters capture relatively large and small particles respectively. Bag filters could screen particles of larger than 10 micron. Cartridge filters could screen particles of larger than 1 micron.

Weight of solid sludge removed from each steam generator A, B, and C was 114.3, 116.6, and 115.0 kg. Bag filters removed 29.0, 27.7, and 32.2 kg and cartridge filters removed 85.3, 88.9, and 82.8 kg from SG A, B, and C respectively as shown in Figure 3.

Weight of total sludge removed during sludge lancing was 345.9 kg.

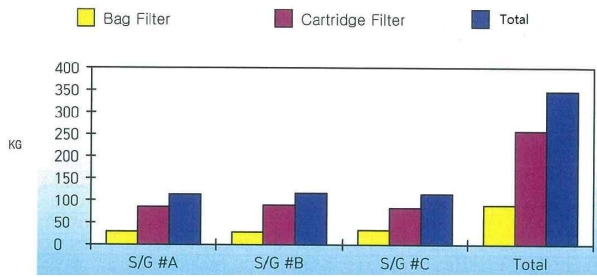


Fig.3 Sludge Removed from SG A, B, and C

Figure 4 shows amount of sludge removed in kilograms during each overhaul (OH). No lancing was performed at the 1st OH. Jet Cleaner was used at the 2nd OH. From the 3rd to the 8th OH, Booy Clean lancing equipment was used. Both Booy Clean and CECIL system were used at the 9th OH. The amount of sludge removed shows gradual increase as operation time increases. From the 10th to the 20th OH, CECIL lancing system was used. FOLAS-I lancing system was used at the 21st OH.

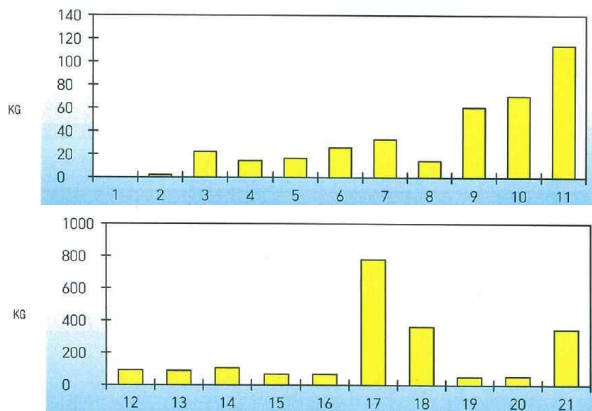


Fig.4 Sludge Removal History

3. Removal of Foreign Objects in SG

3.1 Foreign Object Search and Retrieval (FOSAR)

Scope of foreign object search and retrieval comprises 1) installation of FOSAR system into secondary side of SG, 2) search and retrieval of foreign object on the annulus, in the no tube lane, in the tube bundle, and on the 7th tube support plate. It also includes identification and removal of foreign objects identified in previous OH.

FOSAR equipment is composed of 1) video probe system, 2) image monitor, 3) object removal tools, and 4) various guide tubes. Object removal tools which are commonly used in FOSAR are the 3-prong, the snare loop, the alligator, and the magnet.

3.2 Removal of Foreign Objects

Video probe IV8675 made by Olympus was used for searching foreign objects. Four foreign objects were found and retrieved by the retrieval tool and the guide tubes. One foreign object was found on annulus, and the other three were found in tube bundle. The longest object was 67mm long.

Right pictures shows four foreign objects which were retrieved during the FOSAR service. The first object was found in SG 'A', column 59/60, and row 59, 67mm long, and identified as a hook bolt. The second object was found in SG 'C', column 38/39, and row 61, 7.5mm long, metal fragment. The third object was found in SG 'A', column 64/65, 40mm in diameter, circular metal of 152.4 gram. The fourth object was found in SG 'A', column 35/36, row 33/34, 11.6mm long metal of 1.2 gram.



Figure 5 shows a hook bolt and its location found during FOSAR service. Although it was relatively large in size, it was possible to retrieve because it was located near annulus of SG.

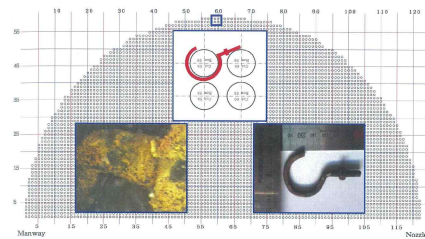


Fig.5 Hook Bolt Found in Tube Bundle Near Annulus

4. Conclusions

During the 21st OH of Kori NPP unit 4, we removed 345.9 kilo gram of sludge and four foreign objects from three steam generators.

Foreign objects which were removed from inside of SG showed us that relatively large object such as the hooked bolt might exists in steam generators. We can conclude that identifying and removing foreign object is very important to avoid possible tube failure. Removing circular metal of 152.4 gram also was successfully removed.

REFERENCES

[1] Sang-Tae Kim, Young-kug Kim, etc., Final Report, "The 21th of Kori Nuclear Power Plant, Unit 4 (Steam Generator Secondary Lancing /FOSAR)," July 2013