

Removal of Secondary Side Deposit and Foreign Objects in SG of Yonggwang Nuclear Power Plant, Unit 2

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1. Introduction

Removal of deposit and foreign objects on secondary side tube sheet of the SG was made during February 15 and March 20 in 2013. KALANS III lancing system and video probe system for FOSAR were used for lancing and foreign object retrieval respectively. Mock-up test and training before the service were made to minimize operation time and radiation dose. 8 bag filters and 49 cartridge filters were consumed for filtering of soft and hard sludge in SG A, B, and C. Total 21.05 kilograms of sludge was removed.

Five foreign objects were found and removed in tube bundle of SG A, in annulus and tube bundle of SG B, and in tube bundle of SG C.

2. Removal of Deposit on Secondary Side SG

2.1 Scope of the Lancing Service

The SG unit 2 of Yonggwang 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.

Removal of secondary side deposit on tube sheet of SG is often called lancing. Lancing service comprises 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 for primary side includes lancing robot, rail, take-up system, and water hoses and air lines. Those equipments are transported into the containment vessel, and installed around hand hole of the SG. Sludge processing system, which is installed outside of CV, is major secondary side equipment. Primary and secondary equipment are interconnected through control cable, water hose, and air hose etc. Figure 1 shows lancing system installed on hand hole of SG. Left picture shows an operator assembling lancing rail, and

right picture shows various water connectors for supplying pressurized water. A blue roller is used for adjusting 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 hand-hole attachment. The rail extends through inside of no tube lane to center stay rod of SG. Ten barrel spray and two high pressure nozzles are used to remove soft and hard sludge respectively.

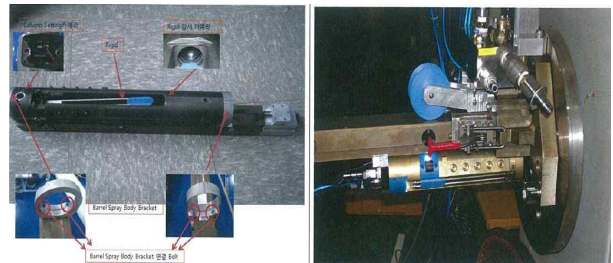


Fig.2 Lancing Robot Installed in Rail

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 7.55, 5.43, and 8.07 kg. Bag filters removed 1.51, 1.10, and 3.26 kg and cartridge filters removed 6.04, 4.33, and 4.81 kg from SG A, B, and C respectively as shown in Figure 3. Weight of total sludge removed during sludge lancing was 21.05 kg.

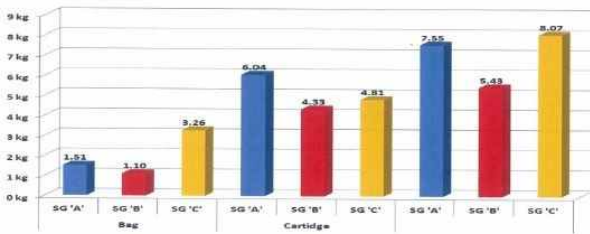


Fig.3 Sludge Removed from SG A, B, and C

Figure 4 shows amount of sludge removed in kilograms during each overhaul (OH). From 1st to 8th OH, Booy Clean lancing equipment was used. The amount of sludge removed shows gradual increase as operation time. From 9th to 13th OH, CECIL lancing system was used. Its inter-tube lance was effective for removing hardened sludge on the tube sheet and tube surface, therefore, more sludge was removed than in previous OH. From 14th to 20th OH, KALANS III lancing system was used. KALANS system was designed mainly for barrel spray which is similar to Booy Clean. Low level chemical cleaning was performed during 19th OH. 517.28 kilogram of sludge was removed by the low level chemical cleaning. We could easily infer that high level chemical cleaning might remove much more sludge. However, as chemical cleaning is very expensive, high level chemical cleaning in the middle of life time of steam generator is recommended.

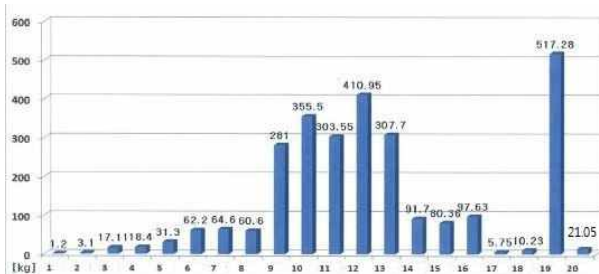


Fig.4 Sludge Removal History

3. Removal of Foreign Objects in SG

3.1 Scope of the FOSAR Service

Scope of foreign object search and retrieval (FOSAR) 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. Five foreign objects were found and retrieved by the retrieval tool and the guide tube. One foreign object was found on annulus, and the other four were found in tube bundle. The longest object was 91mm long. All the foreign objects are assumed to be inserted at manufacturing workshop because they are metal chip or welding rod.

Right pictures shows five foreign objects which were retrieved during the FOSAR service. The first object was found in SG 'A', column 89/90, and row 47, 20mm long, and assumed to be metal chip. The second object was found in SG 'B', column 87/88, 20mm long, 35mm long, assumed to be welding slag. The third object was found in SG 'B', column 91/93, row 47/49, 91mm long, assumed to be metal chip. The fourth object was found in SG 'C', column 45/47, row 34/35, 38mm long, assumed to be welding rod. The fifth object was found in SG 'C', row 108/109, column 22/23, 43mm long, assumed to be metal chip.



4. Conclusions

During the 20th OH of Yonggwang NPP unit 2, we removed 21.05 kilograms of sludge and five foreign objects from three steam generators. Gradual increase in weight of sludge removed is assumed to show us that more sludge is created as operation time of steam generator increases.

Low level chemical cleaning at 19th OH removed 517 kilograms of sludge which was dominant of all the sludge removal weight. We could assume, from this fact, that high level chemical cleaning could remove significant amount of sludge compared to mechanical lancing method.

Five foreign objects which were removed from inside of SG showed us that more thorough inside cleaning and inspection is necessary during fabrication of steam generator. All the objects were assumed to be inserted at manufacturing workshop.

REFERENCES

- [1] Tae-hwa Kim, Young-kug Kim, etc., Final Report, "The 20th of Yonggwang Nuclear Power Plant, Unit 2 (Steam Generator Secondary Lancing & FOSAR)," April 2013.