NEW TREATMENT CONCEPT FOR STEAM GENERATORS-TECHNICAL ASPECTS

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ABSTRACT

The project that will be described is a co-operation development project (SAGA) between Studsvik and the Ringhals NPP. The objective for this development project was, to show that it is possible to perform effective waste treatment of a Steam Generator(SG), to minimize the volume that in the end will have to be finally disposed of and to recycle as much of the metals as possible. Another objective for the project was to do this in a safe way and without a large dose load to the personnel.

The treatment concept contains the whole chain of activities from loading of the steam generator at Ringhals NPP onto the special vessel M/S Sigyn, and the transportation of the SG from Ringhals NPP on the west coast of Sweden to Studsvik on the east coast, to the recycling of the metals and the packing of waste in final packages suitable for disposal.

The volume for a final repository before treatment was about 400 m^3 for the SG and after treatment the volume for final disposal is < 35 m^3 which gives a volume reduction factor of about 11. The amount of material from the steam generator that has clearance for free release is 75-80 % of the weight.

A project is started to analyse the experience from the project above and to come forward with recommendations for how to lower the dose exposure, minimize the secondary waste for final disposal and to decrease the treatment time.

Some actions are already taken:

- A new larger treatment facility is built at Studsvik, > 1000 m^2, planned to be operational in April 2007.
- Investments in a larger band saw.
- Improvements of the blasting equipment.
- Improvements of the method of segmentation of the tube bundle.
- Improvements of the method of volume reduction for the tube bundle.

INTRODUCTION

The component that should be treated was a steam generator (SG) from the Ringhals 3 NPP. The dimensions of the SG were Length: 21 meter, Diameter: 4.5 meter, the weight: 310 metric tons; the storage volume was approx. 400 m^3.

The estimations of the radiation exposure to the operators were based on measurements. Co-60 was in the range of 0.65 TBq. For the long-lived isotopes, Ni-63 was the dominant in the range of 16 TBq.

The concept for the treatment of the SG was divided into following steps:
- Transportation from Ringhals NPP to the treatment facility in Studsvik with the special vessel M/S Sigyn.
- Separation of the steam dome.
- Decontamination of the tube bundle.
- Segmentation of the tube bundle and the outer shell of the SG.
- Segmentation of the water chambers and tube plate.
- Segmentation of the steam dome.
- Melting of the material from the SG.

TREATMENT

Transportation from Ringhals NPP to Studsvik

Before the transportation of the SG a lot of preparations were done. The paper work that had to be put together were extensive, some examples; transportation permit from Competent Authority (CA), technical description of load-settlement at the ship M/S Sigyn, calculations of the capacity of the roads at Ringhals and Studsvik, all this documents was collected in the Waste Plan written by Ringhals NPP. Technical equipment for the handling with the SG at Ringhals and Studsvik has to be procured.

The transportation of the steam generator started at the temporary storage facility at the Ringhals NPP.

In order to prepare the transport of the SG, a number of shielding walls within the temporary storage facility at Ringhals had to be moved. The next step was to change the beams under the SG, to be able to load the SG onto the special trailer.

After all preparations, the SG was transported on the trailer, from the interim storage to the Ringhals harbour and on board the special vessel M/S Sigyn. M/S Sigyn is a special vessel for transports of radioactive waste from the Swedish nuclear industry.

The SG was then transported; from Ringhals NPP on the west coast of Sweden to Studsvik on the east coast, onboard the ship. At Studsvik harbour the SG was unloaded and transported to the treatment facility.

This step worked as planned and the conclusion is that it's possible, without any distortions, to transport a large radioactive component with the dimensions, Length: 21 meter, Diameter: 4.5 meter and a weight of 310 metric tons.

Fig. 1 Transportation of the SG into Studsvik treatment facility.

Separation of the steam dome

Segmentation of the SG started with the separation of the steam dome from the lower section containing the tube bundle. The cutting was preformed with a wire saw. The wire cutting was used as a test to analyse that method for future waste treatment projects. After the segmentation, the steam dome was transported to another location for final treatment.

A special designed shielded cell had been constructed for the treatment of the SG.
The cell is designed as a self-supporting unit equipped with thick steel shielding and an under pressure is maintained in order to avoid spreading of contaminants outside the cell. The cell is equipped with a separate venting system with a cartridge dust collector with automatic rinsing and a HEPA filter as a final filtering step before the air is led to the normal venting system in the building. There is a remote handled segmentation robot installed inside the cell supported by a separate hydraulic system. There are a number of tools for the robot that are used for cutting and handling of the material. The transport of material in and out of the cell is done via a sluice, in order to avoid spreading of contaminants.

The remote handled segmentation robot is operated from a platform outside the cell. For surveillance and control, there is a lead glass window and remote controlled TV cameras inside the cell and monitors on the operator's platform. Most of the work inside the cell was done by camera surveillance.

The cell was moved forwards step by step, as the work progressed, by special hydraulic equipment.

The shielded cell was connected to the SG before the next step.

Fig. 2 The special designed shielded cell.

Decontamination of tube bundle

Decontamination of the tube bundle was performed by grit blasting. Special designed remote controlled blasting equipment was purposely developed.
Used blasting material and oxides from the tube bundle was collected in special containers, designed to be able to send directly for final disposal. The filter bank that was cleaning the air coming from the blasting equipment was also mounted in a container, designed for final disposal.

The dose rate on the surface of the outer shell was 0.5 mSv/h, before the blasting and 0.01 – 0.02 mSv/h, after.

Of the 4674 tubes, 4615 were decontaminated, the rest was plugged. The result showed that > 85 % of the activity from the tube bundle was removed. The remaining activity was inside the tubes that were not decontaminated and inside the water chambers.

During the time the blasting process took place, improvements were performed. The improvements were both on the blasting equipment to improve the reliability as well as to reduce the radiation exposure to the operators.

The target value for the decontamination of the tube bundle was exceeded. The result from the blasting showed that the tube bundle could be melted combined with compacting for volume reduction, which decreases the volume of the secondary waste to final disposal.

Segmentation of the tube bundle and the outer shell of the SG

Segmentation of the tube bundle and the outer shell of the steam generator were started after the decontamination of the tubes. The segmentation was done in the shielded cell using the remote controlled robot.

The tube bundle was enclosed in an 80 mm thick outer shell and a 9.5 mm wrapping. The tube bundle was made of 4674 U- tubes, fixed longitudinal by 14 baffles, put together with a large plate. In the feed water inlet, there were a number of plates to control the water flow.

The SG was put onto pulley supports, that it could be rotated during the process, in order to increase the efficiency of segmentation.

The segmentation of the tube bundle was divided into several steps, equal to the length of the cell. After each step the cell was moved forward.

Each step was consisting of:

1. Cutting of the outer shell;
2. Cutting of the wrapping;
3. Cutting of the tubes;
4. Cutting of the baffle plate;

The cutting of the outer shell was done by cutting torch into pieces of a size that they could be transported out from the cell through the sluice, for grit blasting and melting. The wrapping was handled the same way.

The tubes and the baffle plates were cut by abrasive grinding machine. The tubes were cut and loaded into storage boxes, before compacting and melting. The volume of the tube bundle was about 45 m^3, and the volume was reduced to < 5 m^3 by compacting and melting.

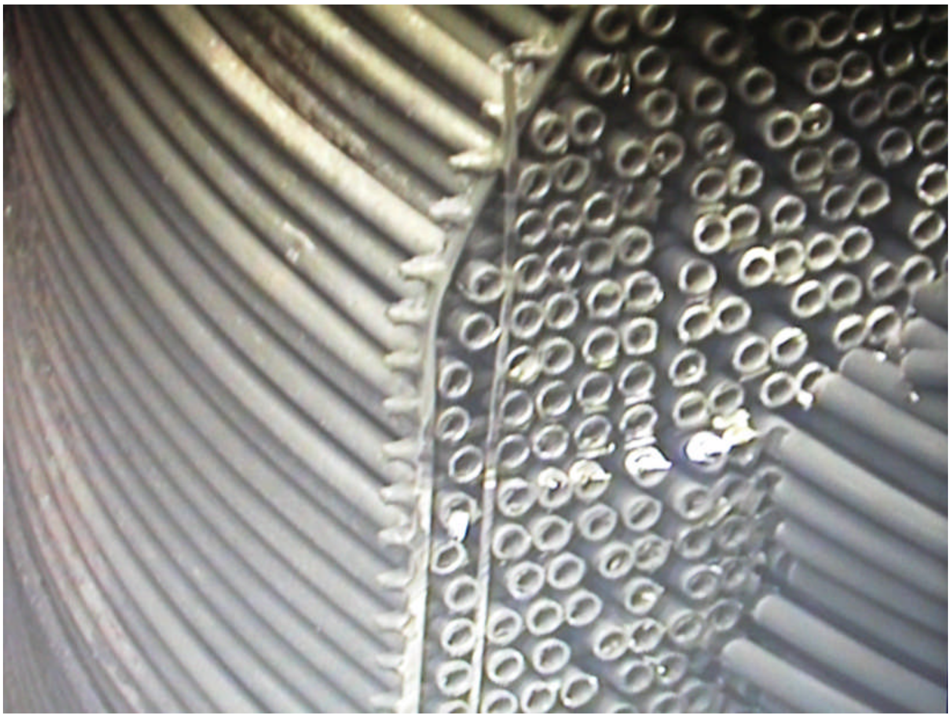

Fig. 3 Tube bundle cut into pieces.

Segmentation of the water chambers and tube plate

The water chambers were cut with a torch into pieces suitable for the band saw. Thereafter the pieces were segmented in the band saw before blasting and melting.

The tube plate was tilted over, after the water chambers were removed. The tube plate was then cut into pieces in the band saw before blasting and melting.

The water chambers and the tube plate were plated by a corrosive resistant layer of SS-steel and Inconel (cladding). In the cladding, there were small (micro) cracks were radioactivity had migrated, during operation. Therefore, the contamination could not be removed by blasting. The remaining activity was too high to enable clearance for free release, after melting, without a special treatment. The solution of the problem was to separate the cladding by cutting and melt it together with the tubes. The rest was possible to melt and clear for free release.

Fig. 4 Water chambers in the band saw.

Segmentation of the steam dome

The internals of the steam dome was cut into pieces for melting. Thereafter the outer shell was cut into approximately 10 pieces, decontaminated and directly cleared for free release.

The aim for this sequence was exceeded as the plan was to melt the outer shell before clearance for unconditional reuse, as it turn out is was possible to clear the material for free release after decontamination and proper testing.

Melting

Melting of the material from the outer shell of the tube bundle, material from the water chambers, tube plate and the internals from the steam dome was done according to normal procedures. The result from the melting was as expected and the material was cleared for free release.

The tube bundle material and the cladding from the water chambers and the tube plate were melted for volume reduction. This metal was not possible to free release because of the amount of rest activity. It was a setback that the cladding couldn't be decontaminated by blasting, but after some investigations it was recognise that the contamination was inside micro cracks in the surface.

The possibility to melt the tube bundle was a big success in the work to reduce the volume of the primary waste. Development is presently focused at the method of melting tubes in order to minimize the radiation exposure and improve the working environment.

Secondary waste

The amount of material from the steam generator that has clearance for free release is 75-80 % of the weight. The rest of the material, not possible to release, is the tubes, cladding from the water chambers and tube plate and the secondary waste from blasting, cutting and melting.

The volume for a final repository before treatment was about 400 m^3 for the SG and after treatment the volume for final disposal is < 35 m^3 which is a volume reduction factor of about 11.

Table 1 Summery of secondary waste from the development project SAGA.

Secondary Waste	Volume (m^3)
Non combustible operation waste	13
Ash from incineration	0.5
Dust from ventilation	2
Used blasting material and oxides	3
Material not possible to free release	8
Slag from melting	3

RADIATION EXPOSURE

The goal for the collective dose to the operators during the project was set to 30-40 man-mSv but it became < 70 man-mSv at the end. The cause of the divergence is mainly because of the increase in man-hours that wasn't accounted for.

The largest individual external dose was < 6 mSv. No internal doses were reported.

No accidents were reported.

No significant spreading of contamination occurred during the project.

CONCLUSIONS AND THE FUTURE

The objective for this development project was, to show that it is possible to perform effective waste treatment of a steam generator, to minimize the volume that in the end will have to be finally disposed of and to recycle as much of the metals as possible. Another objective for the project was to do this in a safe way and without a large dose load to the operators.

The goal for volume reduction of the material to final disposal was set to < 40 m^3 and the result becomes < 35 m^3 which is a good result. The amount of material from the steam generator that has clearance for unconditional use is 75-80 % of the weight. The material not possible to recycle has been volume reduced for final disposal.

The dose budget for the project was exceeded, the main reason for that was the increase in man-hour during the project.

A project has been started to analyse the experience from the treatment of the steam generator and to come forward with recommendations for how to lower the radiation exposure to the operators, minimize the secondary waste for final disposal and to decrease the treatment time.

Some actions are already taken:

- A new larger treatment facility is built, > 1000 m^2.
  The new building will give us the opportunity to work in a more effective way and that will give us the possibility to lower the dose load to the personnel. Inside the building there will be flexible walls that can be located depending of the size of the treated object. Another big advantage is that the handling with the secondary waste will be more efficient.

- Investments in a larger band saw.
  The new band saw will make segmentation of the water chambers and the tube plate more efficient. It will also probably give us the possibility to free release more of that material. The new equipment will also have a positive impact on the dose load and treatment time.

- Improvements of the blasting equipment.
  The improvements of the blasting equipment will lower the total time for blasting to a third. It will decrease the need for maintenance which will lower the dose load to the personnel.

- Improvements of the method of segmentation of the tube bundle.
  The improvements will make it possible to free release more of the material, lower the amount of secondary waste and decrease the treatment time.

- Improvements of the method of volume reduction for the tube bundle.
  There will in the future be possible to choice between two ways of volume reductions for the tube bundle:
  - Compacting for volume reduction before final disposal.
  - Compacting and thereafter melting for volume reduction before final disposal.