Decommissioning of Large Components as an Example of Steam Generator from PWR Nuclear Power Plants

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ABSTRACT

This paper describes the procedure for the qualification of large components (Steam Generators) as an IP-2 package, the ship transport abroad to Sweden and the external treatment of this components to disburden the Nuclear Power Plant from this task, to assure an accelerated the deconstruction phase and to minimize the amount of waste.

INTRODUCTION

In the scope of the deconstruction of PWR reactors, the following components are to be decommissioned (example PWR, Nuclear Power Plant Stade, Germany (NPP Stade) with mass indication):

- Reactor Pressure Vessel	approx.	500 Mg
- 4 pieces Steam Generator	approx.	660 Mg
- Pressure Holder	approx.	85 Mg
- 4 pieces Main Cooling pumps	approx.	140 Mg
- Several tanks and tubes	approx.	250 Mg

The complete mass of these large components with approx. 1635 Mg is the waste stream with the biggest cost relevance for the deconstruction phase.

A decommissioning of Steam Generators (biggest mass fraction with approx. ca. 660 Mg), at the power plant's premises is very time-consuming. Therefore, the task is to use an external treatment for such large components, because this has no influence on the deconstruction of the power reactor and the conditioning of waste, in this case a clearance measurement is not time-critical and therefore an accelerated deconstruction can be assured.

TRANSPORT REQUIREMENTS

For the approval of the transport, the regulations of the ADR/RID are effective and therefore the classification in

- SCO-I max. 4E+04 Bq/cm^2 at touchable surfaces
- SCO-II max. 8E+05 Bq/cm^2 at touchable surfaces, whereas a qualification of the Steam Generator as a packaging type IP-2 is required.

By use of a, exemplary performed by NPP Stade, system decontamination according to the CORD-Method, rinsing of the Steam Generators with $HMnO_4$ / Oxalic acid, a decontamination factor of 160 was achieved (source NEI Oct. 2006).The Steam Generators were therefore classified as SCO-II and a qualification as an IP-2-Packaging was required.

Due to the fact of existing plugged tubes, the SCO-II classification could not absolutely be verified. Therefore, the transport had to be performed under special arrangement.

For the IP-2-Qualification the mechanical verification should show that after a handling accident during the transport no loss or distribution of the radioactive content will occur and that a reduction of the shielding will not lead to an unallowable increase of the highest dose rate on the outer surface of the Steam Generator.

On basis of the horizontal orientation during handling and the transport, only a drop on the surface line and, acc. to ADR-regulations, a drop height of 0.3 m was considered. The calculated simulation of the drop was performed so that the Steam Generator had to sustain the most possible damage.

Therefore, the following two impact actions were inspected:

- Drop in horizontal orientation onto the Steam Generation surface line
- Drop with a lightly inclined Steam Generator surface line

The calculations of the deformation and of the elongation were performed according to the Finite Element Method with the 3D Finite Element Program LS-DYNA (see Figure 1 and 2).

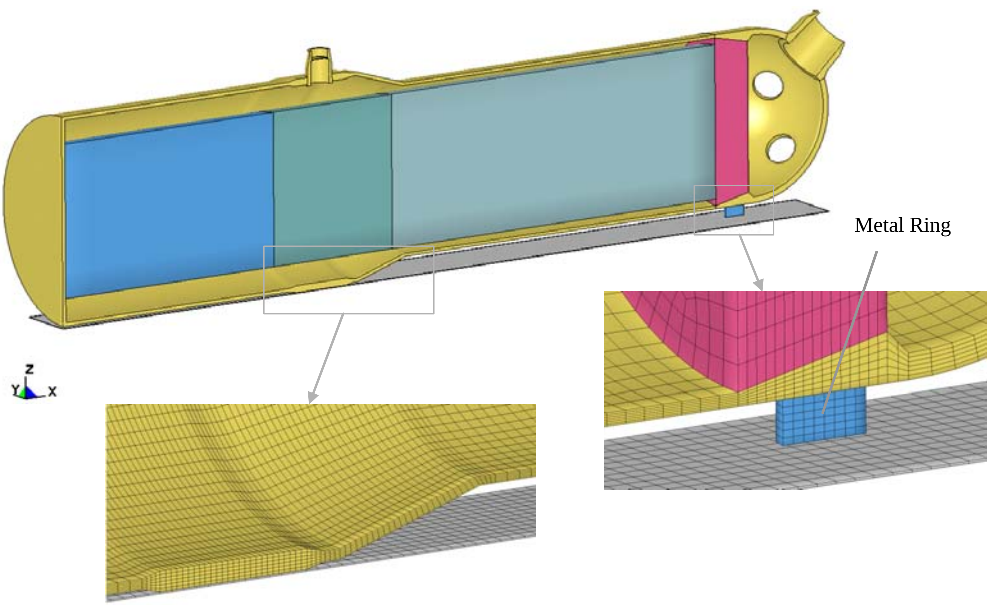

Figure 1: FE-Calculation model

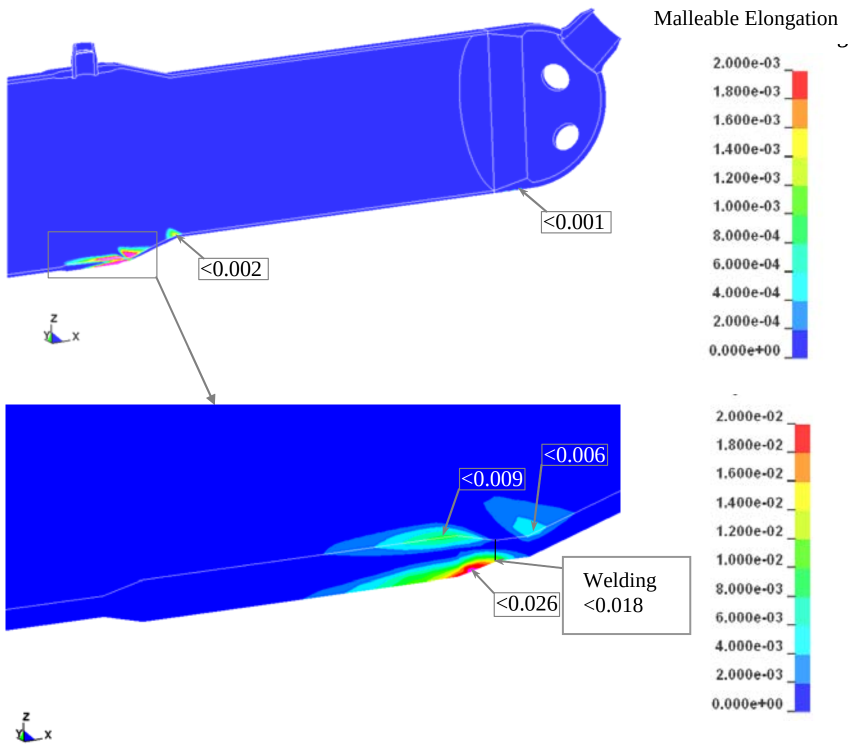

Figure 2: DUCTILE elongation of the Steam Generator

The calculations results showed that the local plastic elongations and the max. deformations of the Steam Generator will not lead to a loss or distribution of the radioactive content. Therefore, the Steam Generator could be qualified as a IP-2 packaging.

TRANSPORT PREPARATIONS

After receipt of the necessary approval from the Federal Department for Material Research and Testing (BAM, Berlin) for the IP-2-Qualification of the Steam Generator and the receipt of the transport permission under special arrangement issued by the Federal Department for Radiation Protection (BfS, Salzgitter), the Steam Generators were prepared for the transport.

All opening were closed by welded lids or welded plugs (see Figure 3). The work was performed by an approved vendor on basis of work and test step plans. After the dismantling (see Figure 4) the Steam Generators were cleaned and painted with a special painting for fixing the removable contamination.

Figure 3 and 4: CLOSING of the openings and dismantling of the Steam Generators

TRANSPORT PERFORMANCE

After finalization of the preparations and the dismantling done by NPP Stade once a day, one Steam Generators was taken over by GNS using a heavy load truck (see Figure 5). Prior the loading of all four Steam Generators on a transport ship, the components were subject to an interim storage on the NPP premises (see Figure 6).

Figure 5 and 6: TAKING over of the Steam Generators by GNS and interim storage

After all of the four Steam Generators were taken over by GNS, the components were transported to a pier near to the premises of the NPP. Once a day, a Steam Generator was taken over by a floating crane at the pier and was then loaded onto the Swedish transport ship MS SIGYN (see Figure 7). After a ship transport of two days, the ship arrived at the premises of Studsvik Nuclear in Sweden. The unloading was performed by using a heavy load truck (Roll Off System, see Figure 8).

Figure 7 and 8: LOADING of the Steam Generators onto the transport ship and unloading in Sweden

DECOMMISSIONING

The treatment/decommissioning of the Steam Generators (see Figure 9) requires the sensible separation in single parts because

- the Steam Generator can be divided basically in a not contaminated and in a contaminated part,
- a release for the recycling of parts is possible (reduction of the mass of waste) and
- a volume reduction by melting is economical, in respect of a interim or final storage later on.

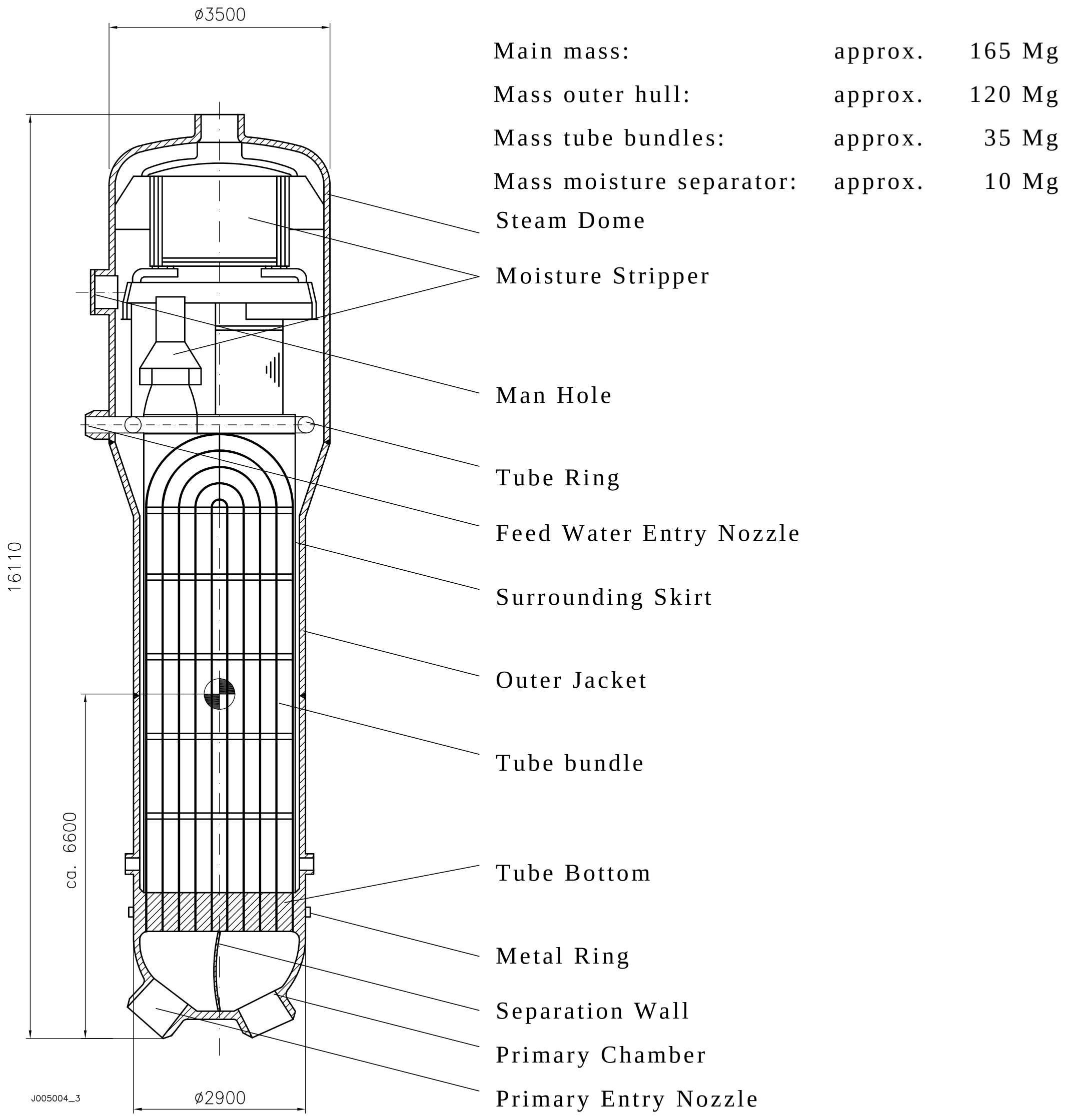

Figure 9: STEAM generator, exemplary from NPP Stade, Germany

During the external treatment at Studsvik Nuclear in Sweden which will commence in January 2008, the Steam Generators are dismantled in single parts by using mechanical and thermal cutting methods.

On the primary side these parts are (see Figure 9):

- Primary chamber,
- Tube bottom and
- Tube bundles.

On the secondary side these parts are (see Figure 9):

- Moisture stripper,
- Outer jacket and surrounding skirt,
- Steam dome and
- Tube ring.

After further disassembling, the secondary parts can be melted to ingots and after radiological evaluation of samples released for further recycling according to Swedish regulations.

After further disassembling and decontamination e.g. by sand blasting, the primary parts can also be melted to ingots (see Figure 10, 11 and 12). After melting, a radiological evaluation is also performed which indicates whether the material can be released for recycling after decay storage or whether the material has to be transported back as secondary waste.

According to the actual knowledge and experience received from the treatment of the Steam Generators from the Swedish NPP Ringhals, more than 80 – 85 % of the mass of a Steam generator can be directly released for recycling.

The remaining approx. 15 - 20 % of the mass has to be transported back as secondary waste. The secondary waste consists of the not releasable ingots as well as of residues out of the disassembly (residues from the mechanical of thermal cutting processes, residues from the decontamination process, slag from the melting process).

Therewith, a well-proved decommissioning way is available.

Picture 10, 11 and 12: SEGMENTATION, melting process and final ingots

CONCLUSION

The transport of large components to an external treatment facility is linked with many advantages for a Nuclear Power Plant:

- Disburden of the Nuclear Power Plant from the treatment of such components,
- no timely influence on the deconstruction phase of the power reactor and therewith an accelerated deconstruction phase and
- minimization of the waste to be returned and therewith less demand of required waste storage capacity.