CO-OPERATION DEVELOPMENT PROJECT FOR NEW TREATMENT OF STEAM GENERATORS'S – IMPACT ON FINAL DISPOSAL VOLUMES AND RECYCLING IN NORTHERN EUROPE

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ABSTRACT

This paper describes a real case of cost effective volume reduction of a retired, full size SG removed from the Ringhals Nuclear Power Plant, Sweden. The project is described from the first step of fulfilling the demands from the authorities before treatment to the results of the treatment. The evaluations of the method is also included and compared to the other possibilities and the driving forces that work in favour of our method. The waste owners' strategy is also described in this paper. Finally is the method of treatment described as a principle as well as the results. Technical details as well as detailed results are given in Paper 7131 [ref 1].

BACKGROUND

All pressurized water reactors (PWRs) are equipped with steam generators (SG) for transfer of heat between reactor tank and steam turbine. In many power reactors the old SG's have been replaced because of increase of input and maintenance problems. The others plants will either exchange their SG's during operational lifetime or take them out in connection with decommissioning of the plant.

Retired SG's are waste which normally is stored intermediately on site waiting for transport for final disposal. The reason for temporary storage often relates to the absence of optimal waste treatment options and/or lack of funds for waste treatment. Also SG's which are taken out during decommissioning will have to be disposed of. The final storage of waste is often costly and there is a tendency of cost increase. There is therefore a strong incitement to minimise the volume that has to be disposed of as well as recycling of material resulting in saving natural resources.

A cost effective waste treatment method to solve the SG problem has so far not been widely available.

AUTHORITY ASPECTS

In many countries the competent authorities are demanding plans for relevant waste treatment solutions for retired SG's, or those which will be retired, as well as other waste streams.

The Swedish regulators demand the establishing of ”waste treatment plans” for all waste categories arises from exchange of components or for other waste arising from operation of nuclear installations. This ”waste treatment plan” shall characterise the waste and explain how the waste will be treated for final disposal .

Many countries have similar problems where SG’s have been or will be replaced. Their authorities might not accept temporary site storage of larger components as a final solution.

ALTERNATIVES OF FINAL DISPOSAL IN SWEDEN

Direct storage in SFR in the future

Today’s plan for retired SG’s is storage on-site until SFR (The **S**wedish **F**inal **R**epository for operational waste) is planned to close. In that final SFR operation period the SG’s will be shipped to SFR and be disposed of in the transport tunnels that lead to the repository caverns.

The closure of SFR is planned to take place when the Swedish nuclear programme will end and the operational short-lived radioactive waste is disposed.

Advantages of SFR scenario

In order to place the SG’s in the tunnels of SFR, there is no need for expensive technical development and no additional waste treatment. And as a consequence of that there are no direct costs as of today for waste treatment and transport.

Disadvantages of SFR scenario

This alternative requires much volume in the SFR and the inventory for certain nuclides (Fe-55, Ni-63) in SFR is limited and would with the SG’s in the tunnels be largely exceeded.

There would be a need for license review for the SFR when using the method to disposal of entire SG’s in the tunnels, including new re-evaluation of applications to various authorities as Environmental Court, SSI, SKI, SKB and other interest groups and organisations. Most probably new caves would have to be built with adequate barriers against propagation of activity.

In addition an interim storage would have to be constructed at Ringhals-site for the additional three SG’s that are planned to be replaced in year 2011.

THE NEW WASTE TREATMENT METHOD

Waste treatment means that an SG could be handled with the goal to obtain a minimum of residual waste and maximum rate of free-release and recycling of material. This has to be achieved within reasonable costs and under the condition that the residual waste from the SG treatment can be accepted by both authorities and by SKB for final disposal at SFR and/or SFL (The **S**wedish **F**inal repository for **L**ong-lived waste).

Advantages

The treatment of an SG would result in less volume at SFR and the future SFL and a major part of the material from the SG will be recyclable.

Things not solvde today have to be solved anyhow in a near future as regards nuclide inventory and possibilities for disposal in Sweden's final repositories.

As a result of treatment of already retired SG's at Ringhals there will be no need for an intermediate storage at Ringhals-site for the planned exchange of SGs at unit 4 in year 2011. The existing SGs storage-building can be utilized for other purposes.

Regulations for necessary waste treatment will certainly be increasingly more stringent in the future and consequently treatment will be increasingly more expensive. As a consequence the extension of SFR can be postponed. The "environmental liability" for Ringhals will decrease by not storing waste on-site for longer periods.

Significant volume of metals after the free release can be recycled back to the steel industry.

Disadvantages

SG treatment results in the radiation exposition to personnel which might be higher as compared to a postponed treatment where it could have been reduced due to the decay of short-live nuclides like Co-60.

There is a larger risk exposure in connection with transports of radioactive components, since most of the short-lived nuclides have not decayed.

From an economic point of view, the strategic decision has to be taken that the financing of the SG project will be done today without access to the decommissioning funds.

Since it is the first project of this kind treating the full size SG the uncertainty and technical challenges are considerable.

DRIVING FORCES FOR WASTE TREATMENT OF AN SG

The driving forces for waste treatment a foremost:

- Lower total final repository costs
  - A volume reduction of the order of 85-90 % is possible.
- The space not used for the SG's can be used for other components
- The utilities get rid of their liability for components otherwise being stored on-site for longer times
- Clear signals to the authorities, to the public and to investors that "the Nuclear world" is solving their problems

RINGHALS' STRATEGY

Ringhals has a long-term demand to solve their liability problem as related to the retired components.

There was even a demand in 2005 to present to the Swedish authorities a long-term waste treatment plan comprising the entire site of Ringhals.

Up to recently the primary strategy was to ship the complete SG, untreated, to the tunnels down at SFR-storage, in connection with SFR's closure. The content of the long-lived isotope Ni-63 in the SG tubes is far above design criteria for the SFR repository.

In many countries there is no possibility for disposal of large components in one piece due to the limited space available at final disposals. A Ringhals SG weighs 310 tons and the storage volume would be about 400 m^3. Considering the high costs per m^3 for disposal in existing or planned final repositories, reduced volumes are almost mandatory.

With STUDSVIK's waste treatment method applied to SGs the secondary waste can be reduced down to 20-25 % of the original weight. Most of the material which is ready for final disposal is the tube material and parts of the water chambers and tube plate.

COLLABORATION BETWEEN RINGHALS AND STUDSVIK

Ringhals is a nuclear power plant owned by Vattenfall AB, with 3 PWR and 1 BWR unit. The PWRs were delivered by Westinghouse.

Two of the PWR's have replaced their SG's (3 from each unit) in 1989 and 1995 and the replacement at unit 4 is planned for 2011. The removed SG's are presently stored on-site awaiting final disposal.

Studsvik Nuclear AB has for many years developed methods for treatment of large contaminated, components as well as treatment and recycling of metallic scrap both from operation and decommissioning. This experience has now been applied for the treatment of a retired SG.

As will be described below, there are nuclide related problems concerning the disposal of exchanged SG's. This was the driving force to come up with a new technical solution to treat the full size component. The aim with this project was to demonstrate a method which can be applied generally to any SG that is subject to waste conditioning.

Studsvik and NPP Ringhals have successfully conducted a co-financed development project based on the technique mentioned above. The aim was to effectively treat one Ringhals SG under optimal ALARA conditions and to minimise the secondary waste. This project was dubbed "SÅGA" (the acronym of the Swedish title: Studsviks ÅngGenerator Avfallsbehandling = Studsviks SG waste treatment). The treatment of the SG was conducted at Studsvik's melting facility.

The combination of Ringhals' SG operational data, which have been extremely valuable for the dose assessments and development of the treatment method to be applied, and Studsvik's long term experience on treatment and recycling of contaminated components were ideal ingredients for a successful collaboration project.

STUDSVIK'S CONCEPT TO TREAT A SG FOR VOLUME REDUCTION AND MAXIMISING THE RECYCLING OF VALUABLE MATERIAL

The aim of the R&D project SÅGA was to investigate how large/small volumes could actually be obtained for final disposal after treatment of a Ringhals SG.

The assumption for this treatment was that the Inconel tube material was not to be subject to clearance or recycling but to be volume reduced only. Most of the material like the outer shell, the steam dome, the tube plate and water chambers etc was subject to melt and/or free-release and recycle.

The goal was to obtain less than 40 m^3 of residuals waste to be stored at SFR or SFL, respectively. Material which could not be recycled (by clearance) had to be reduced in volume and packaged for final disposal. Furthermore, the SG treatment method should be adjusted to fulfil demands for continuous conditioning of SG's at Studsvik.

The long-term goal is to treat at least three SG's per year at Studsvik melting facility.

STUDSVIK'S TECHNICAL CONCEPT

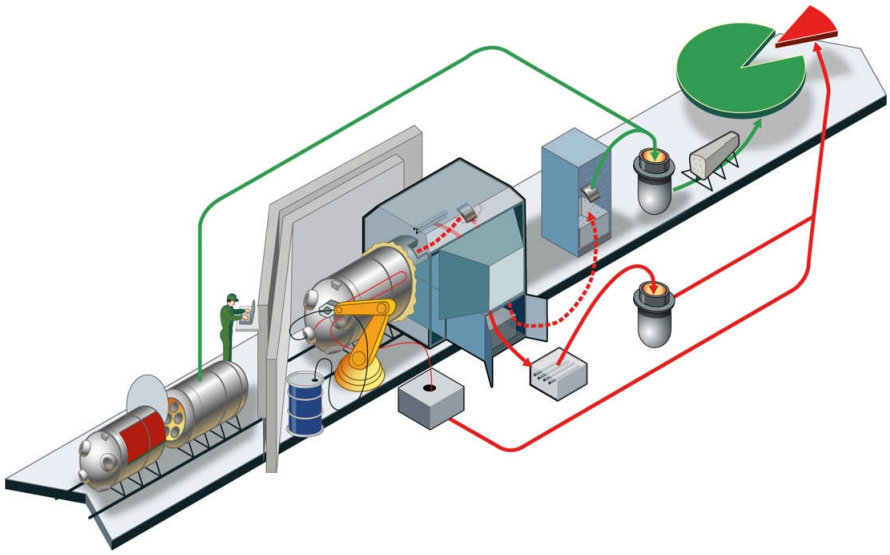

Fig 2.1. Schematic waste treatment of Steam Generators

Some technical items on the waste conditioning of the SÅGA project are summarised below, details are given in paper 7131.

The most important point of the concept is its applicability to SG's as well as other larger components from NPPs within and outside Sweden.

- The Ringhals SG was shipped to Studsvik by boat.
- The Steam dome incl. the moisture separator was cut as a first step.

- The tubes were decontaminated using a dry method, i.e. blasting with steel grits, reaching a satisfactory Decontamination Factor (DF) for the further segmentation activities.

- The outer shell, tube plate and water chambers were decontaminated on the inside using grit blasting technique.

- The tube package material was compacted for volume reduction.

- The outer shell, water chamber and tube plate were segmented and melted.

- The main part of the material was possible to free-release either directly after melting, alternatively after decay storage.

- The secondary waste was conditioned in accordance with the waste plan and to meet the criteria for disposal.

Activity inventory

Due to the restrictions concerning nuclide inventory for the existing final repository the characterisation and correct sorting of the waste to be stored is essential.

This is of great importance concerning to the residual waste of the SG's to come. The long-lived nuclides is mostly concentrated in the tube material and water chambers that can become secondary waste

Today Sweden has a final repository for operational waste (SFR), has acceptance criteria that limits the content in the repository at closure. Restrictions concern many nuclides but are more restricted for long-lived nuclides and alpha emitting nuclides.

This implies that the dominant part of the activity inventory of the Ringhals SG, being Ni-63 and Fe-55, cannot be disposed of in SFR due to these limitations. Such material has to be disposed of in repository for waste containing long-lived nuclides, planned as SFL.

Evaluation of the method

The developed method contributes to fulfil the long-term demands for waste treatment plans. Thus, technical development is requested not only in Sweden but also by other countries around the world in possession of retired SGs today or in the future.

The Studsvik facilities have advanced methods for managing all working steps necessary for treatment of full size SGs.

CONCLUSION AND RECOMMENDATIONS

The goal for the project was to develop a method and techniques to achieve minimum waste volumes for final storage from the treatment of a Ringhals SG. Before the treatment the SG had a weight of 310 tons and a storage volume of 400 m^3. The result is less than 40 m^3 to be stored at SFR/SFL.

The conclusion after the conduction of the project is that an effective treatment of a full size SG can technically be achieved resulting in a long-term economical gain and a strong environmental profile due to the low volume of residues.

Recommendations for future projects will be:

- To conduct waste treatment of SG's and other large reactor components in the new, well adapted facility.
- Continue further development of methods and equipment.
- Focus continuously on ALARA-principle.
- Continue to improve logistics, routines and instructions for the various sub-moments of process.

FUTURE ASPECTS

Focusing on systematic development in the area of waste conditioning of radioactive scrap material Studsvik has established new technique and logistics based around its activity. The investment in method development for SG-treatment has generated great interest from many international utilities, owner of SG's, that has been changed or to be changed in a near future. Within the next 3 – 4 years the remaining five SG's from Ringhals will be treated at Studsvik. Also four SG's from Stade NPP in Germany are foreseen for treatment is Studsvik within the next 3 years.

The modes for waste treatment and the alternatives of needs and requirements vary essentially among the different countries and thus the goal for the different national final repositories regarding amount and characteristics of the waste residuals from an SG being acceptable. But independently of the national needs and possibilities for SG disposal, there is still a demand for volume reduction before storage at those expensive repositories. There have been cases where it turned out to be more economical to do volume reduction of larger components at site in order to save costs for transportation to the repository.

SUMMARY

In many countries waste conditioning of full size SG's is applicable, due to the large volume, the weight as well as the nuclide inventory, before it can be disposed in the final repository.

Studsvik has in this paper described the SÅGA-project that demonstrated the possibility to conduct a complete waste conditioning of an SG with a maximal recycling of steel.

The waste treatment was conducted in a way that respects radiological (ALARA) and environmental conditions.

Economically it is most important to minimise the volumes that are to be disposed of due to the costs per m^3 in today available repositories. In addition it is environmentally important to re-use most of the steel.

Further development may achieve ways to even free-release and recycle tube material. This would allow recycling of a high nickel alloy.

The need for volume reduction is important within the nuclear industry, partly because many NPPs are under decommissioning, partly because of the need of effective waste treatment in order to allow for upgrading and new installations.

REFERENCES

1 Paper 7131 NEW TREATMENT CONCEPT FOR STEAM GENERATORS-TECHNICAL ASPECTS, of this conference WM´07