

STEAM GENERATOR EXCHANGE—A SERVICE TO BACKFIT AND UPGRADE NUCLEAR POWER PLANTS

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ABSTRACT

After about 30 years of operating experience with pressurized water reactors it is now known that certain regions of U-tube steam generators (SGs) are particularly prone to tube damage. Intergranular stress corrosion cracking (SCC) has been observed on the reactor coolant side of SGs with tubing of Inconel 600, especially in the vicinity of the expanded tube connections and the tube bends.

On the secondary side, flow-induced tube vibrations have been seen to exacerbate material erosion, also known as fretting, which affects the tubing in the region of the tube spacers and baffle plates. Other corrosion mechanisms such as denting, pitting, so-called wastage, intergranular attack (IGA) and intergranular SCC have also been observed.

SG Design Aspect

Measures are developed and tested to enhance the integrity of the steam generator tubing that focus on the design and the operation of the steam generators. They include optimization of flow conditions, use of low stress tube expansion techniques, design optimization of water/steam cycle and monitoring of its water chemistry parameters.

SG Maintenance and Repair

Strategic planning of steam generator maintenance and repair is another key issue for plant availability and reliability. In Germany, maintenance and eventual repair considerations are an integrated part for reliable SG performance.

The main indicator for SG integrity still is the eddy-current testing of SG tubes. SGs affected by tube damages are inspected and eventually repaired based on individual assessment criteria, such as corrosion progress between cycles, period between inspections, etc.

Notwithstanding that German SGs have good operating experience, an integral repair concept is realized by developing techniques based on manipulators for tube plugging, sleeving, welding, machining etc.

SG Cleaning

Cleanliness is one of the most important prerequisites for a steam generator long lifetime.

Periodic tube sheet lancing in combination with measures such as replacing Cu-containing materials from the feedwater/steam cycle results in a minimum build-up of crud. In case there are big amounts of crud at locations which cannot be reached by water jets (such as tube supports), chemical cleaning is an effective measure to remove copper as well as corrosion products.

SG Replacements

Economic aspects provide in some cases adequate justification for steam generator replacement. Although SG replacement is one of the most extensive and expensive repairs it can improve overall plant operating performance (power upgrading up to 12 and 15% have been demonstrated) and is the most profitable alternative in terms of life cycle cost considerations.