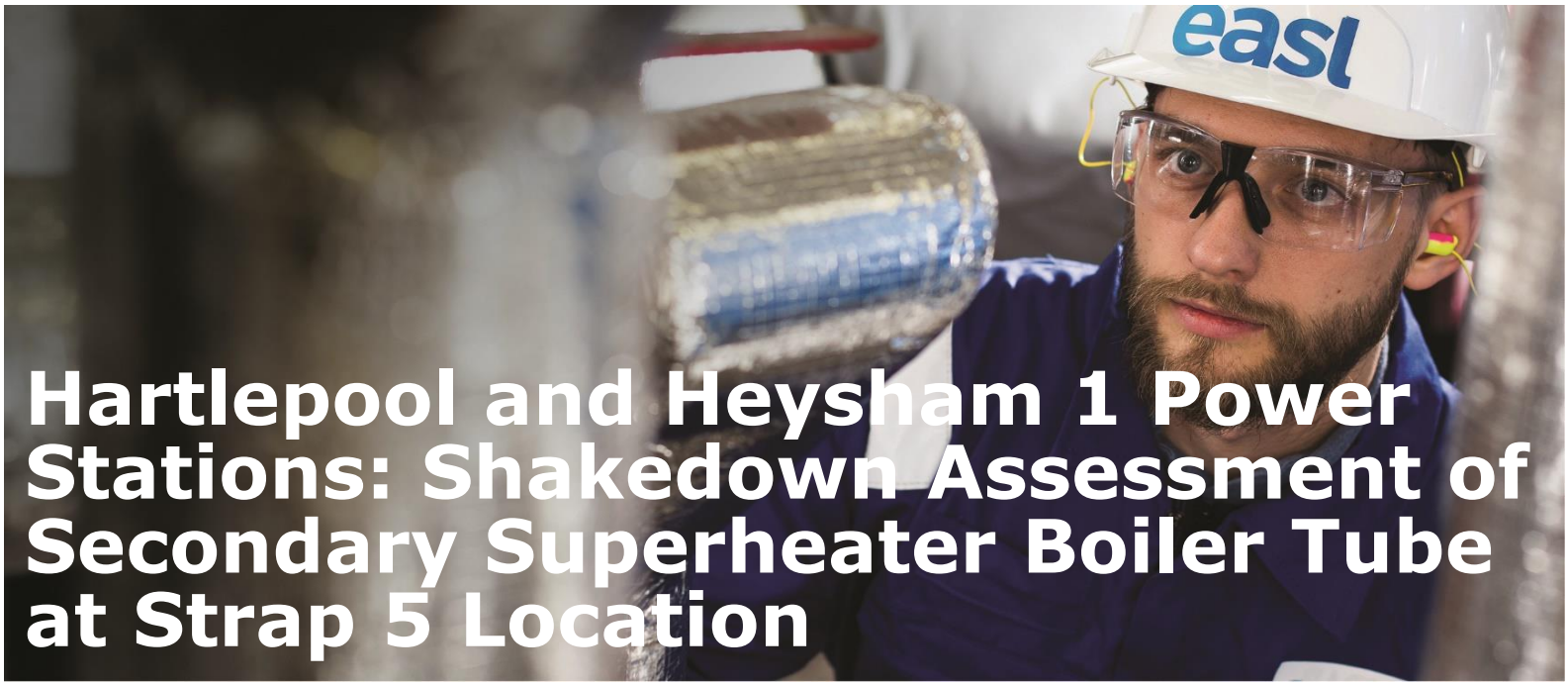


# Hartlepool and Heysham 1 Power Stations: Shakedown Assessment of Secondary Superheater Boiler Tube at Strap 5 Location

## Case study

**An assessment had previously been completed by EASL looking into the structural integrity of the Heysham 1 and Hartlepool pod boiler super-heater tailpipes. Following a successful completion of this work, EASL was again approached for further scrutiny of the super-heater boiler finned tube at a location termed "strap 5". EASL performed a shakedown assessment upon the "strap 5" component.**

## Problem

In our previous assessment it was originally considered that the creep-fatigue crack initiation assessment for the super-heater bifurcation would give results that would imply acceptable results for the boiler tube at the strap 5 location. However, it was apparent that the above expectation would not be met and that an explicit assessment would have to be made.

The new shakedown assessment produced was a prerequisite for the creep-fatigue crack initiation assessment for the strap 5. The integrity assessment considered the effects of single tube chemical cleans as well as an additional three full scale chemical cleans. These cleans would have introduced metal loss hence inducing higher stress in the components.

## Solution and results

A hybrid FE model was generated for the assessment with the model constructed from a combination of a global tailpipe model using elbow elements and a detailed local boiler tube model using 3D brick elements. A section of the boiler tube at the strap 5 location in the parent global model was replaced by the detailed local FE model.

The global FE model was constructed using mainly ABAQUS elbow elements. The detailed FE boiler tube model was

*Figure 1 – Example photographs of boiler tubes Constrained within a strap arrangement.*

generated given a mesh density that was deemed adequate to capture the stress concentration. The extent of the

model was such that the local model tube ends would give no significant effect at the centre of the local tube model where the interface with strap 5 constraints are located.

The hybrid model predicts detailed and accurate stress results for the component of interest while utilising all the resources available. It also considers the interaction of extents outside the component of interest while giving detailed and accurate results at the component of interest itself.

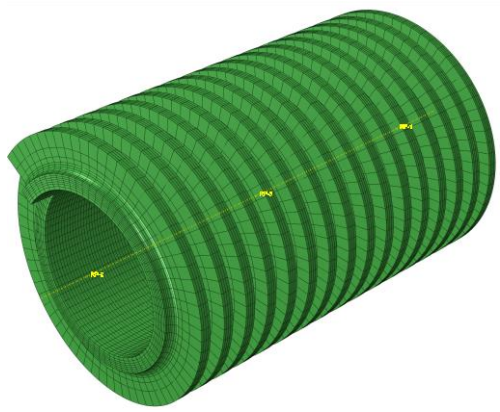

***Figure 2 – Detailed local FE model of boiler tube with fins.***

The component, in reality, can be subject to loading cycles including cold shutdown, through start-up, normal operation, reactor trips and return to shut down. The maximum stress range of these combinations was identified. The boiler tubes were identified as being subject to their expected pressure and temperature loads, and prescribed boundary displacements corresponding to the thermal displacements.

A von Mises equivalent stress distribution plot under the start-up conditions for a location near to the trap 5 location was produced from the models and the above mentioned inputs. Within this plot two stress lines for shakedown are also present.

The significance of the cyclic loading was compared against Section 6.6.2 of R5 Volume 2/3. This check, when compared against the two stress lines, suggested that shakedown could not be claimed. However, the equivalent stress ranges were greater than the elastic stress range of the material accommodates which was less than 20% of the section length. As such, it was likely that shakedown could be demonstrated using an inelastic cyclic FE analysis.

# Conclusion

The hybrid FE model was conducted for the tailpipe. The model included the strap 5 location with detailed 3D brick elements. The stress analysis was carried out, with the equivalent stresses and stress ranges were calculated along the stress lines through highly loaded tube wall sections.

Subsequently, a simple global shakedown using elastic stress was found to be not satisfied. It was recommended and required that further demonstration of shakedown was needed.

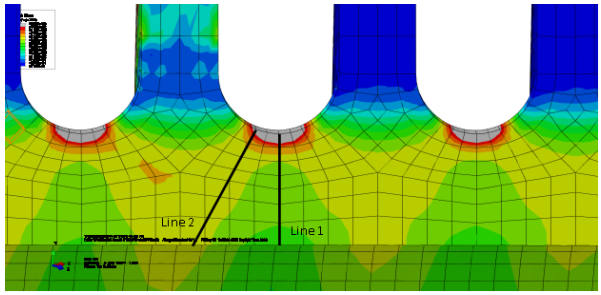


*Figure 3 – Cross-section of local FE tube model.*

# Other applications

**EASL always work with clients to identify cost effective solutions to operational challenges.**

**If you would like to discuss how EASL can help your business please get in touch.**

engineering analysis services ltd.
2 Edward Court, George Richards Way, Altrincham, WA14 5GL
0161 923 0070 www.easl-stress.co.uk