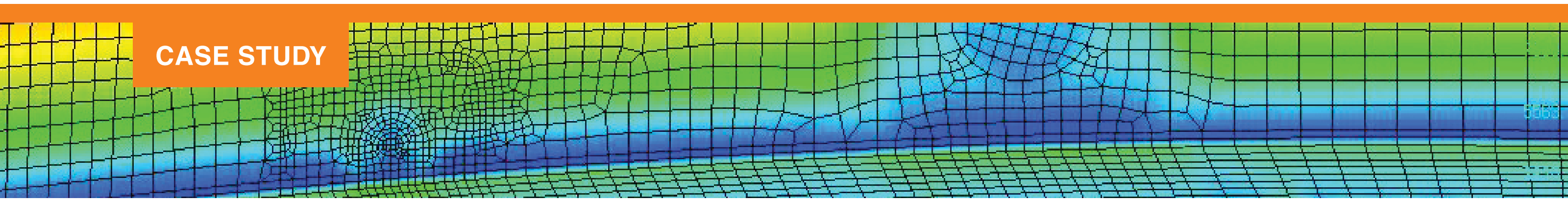
Quest Integrity

CHALLENGE CONVENTION



CASE STUDY

PIPING ANALYSIS AND LIFE ASSESSMENT OF STEAM PIPEWORK

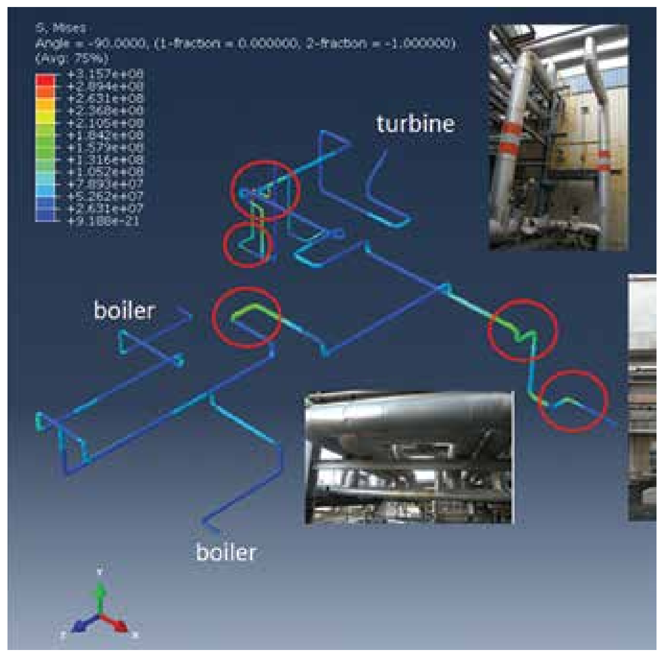
OVERVIEW

Quest Integrity was requested to perform a piping stress analysis and remaining life assessment of the HP, NOx, IP and LP steam high energy piping (HEP) systems at a Co-Generation Power Station. The overall aim of the assessment was to identify the welds that posed the highest risk of developing damage and provide an assessment of the overall condition of the HEP systems. Furthermore, the remnant life of the pipe welds was determined based on the results from the piping stress analysis.

BACKGROUND

The pipework was fabricated from alloy and carbon steels, depending on the design temperatures. The high temperature pipework (HP and NOx) was mainly fabricated from 2¼Cr1Mo lower alloy steel, and the lower temperature pipework (IP and LP) mainly from carbon steel.

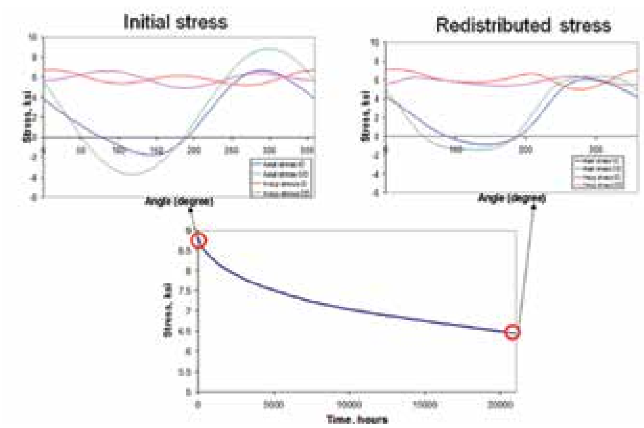
Conventional high energy piping (HEP) analysis uses the ASME B31.1 Power Piping Code which is a standard for piping system design to determine the inspection areas. This is done by performing the piping stress analysis based on the design requirements in the code and selecting locations where the highest system stress occurs. This stress is due to a combination of internal pressure and dead weights and thermal expansion, and constraints from terminal points. However, the Code based piping stress analysis does not take into account the appropriate damage mechanisms, i.e. creep and/or fatigue, redistribution of thermal stresses and weldment life consumption due to material degradation.



Piping stress analysis results

The method Quest Integrity employed for the piping analysis and life assessment of HEP system in this case was an alternative to the conventional approach. Quest Integrity's piping stress-analysis method calculates the stresses and displacement as a result of sustained loads and thermal expansion loads.

In addition, based on the outcome of the piping analysis, the location of the weld inspection is prioritised based on the most probable damage mechanisms, realistic multiaxial stresses at weldments and time-dependent life consumption due to creep damage in service.



Graphs showing redistribution of thermal stresses due to creep

RESULTS

The piping analysis, remnant life assessment and risk analysis of the HEP systems were carried out and the following conclusions were drawn:

- The cold to hot movements of the most of the hangers were well within the design movement and the direction of the movements was consistent with the hanger travel design. It was found that one variable spring hanger appeared to be topped out and two floating supports. The appropriate boundary conditions were imposed on the as-found piping model to reflect the behaviour of the malfunction hangers.
- The piping stresses obtained from as-found conditions in general complied with the design criteria set out in the piping codes such as ASME B31.1.
- The number of fatigue cycles to failure of the welds in the piping system was determined based on the alternating stress amplitude of cold start and hot start individually obtained from the FE analysis.
- A creep analysis was performed in the HEP systems in "as-found" condition to take into account the creep relaxation due to creep. The creep rupture life and life fraction consumed due to creep were also determined to take into account the evolutionary behaviour of creep stress at the weldments.
- The risk analysis was carried out for each weld to take into account the weld type, frequency of inspection and detected defects or indication found during the inspection as well as stress and life calculations. The 41 welds (25% of total number of welds) in the HEP systems were identified as "Medium to high" risk in terms of risk of failure and the inspection testing plan was developed based on the risk based priority.

Malfunctioned hangers or supports

Weld No.	Remnant life, hours	Stress, MPa	Site weld	Inspection	Indication or defect	Risk factor	Ranking
1335-OD-J10	162,816	276.1	YES	NO	NO	8.9123	1
1335-OB-J5	107,557	269.0	NO	NO	NO	8.8947	2
1335-OD-J11	166,791	308.8	NO	NO	NO	7.9649	3
1331-1A-J6	711,560	287.7	YES	NO	NO	7.9474	4
1333-1A-J1	711,560	287.7	YES	NO	NO	7.9298	5
1335-OB-J6	1,359,199	172.0	YES	NO	NO	7.8246	6
1335-OC-J1	1,359,199	172.0	YES	NO	NO	7.807	7
1331-3B-J3	1,240,370	120.4	YES	NO	NO	7.5439	8
1333-1A-J5	1,650,264	117.6	YES	NO	NO	7.5088	9
1333-1B-J1	1,650,264	117.6	YES	NO	NO	7.4912	10

Typical example of risk analysis results