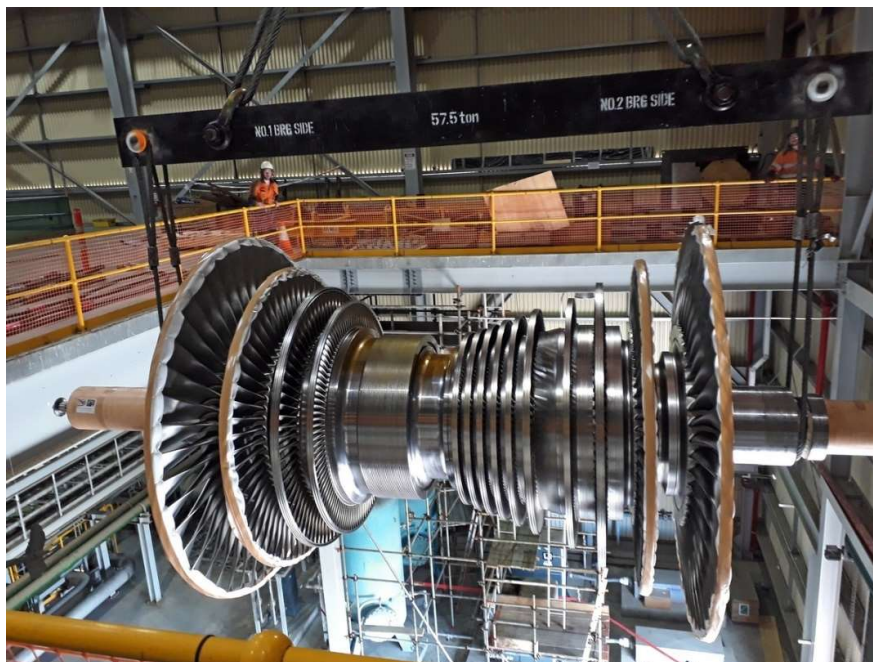




# **100MW Geothermal Steam Turbine Case Study**

**Jan-Feb - 2018**



## EXECUTIVE SUMMARY

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The 100MW Geothermal Power Station was shut down in January 2018 for the scheduled overhaul work on the Steam field, Separators and Scrubbers, Cooling Tower, Steam Turbine Generator (STG), Hot Well Pump (HWP) and Transformer replacement. ProGen was contracted to undertake the work relating to the STG and its auxiliary plant.

Pre-overhaul ProGen undertook the following preparation work

- Review the scope of work and equipment manuals.
- Visit site to attend and contribute to planning meetings and coordinate preparation activities.
- Review the assembled work packs then develop the detailed turbine overhaul plan and coordinate with Client Planner to integrate the plan into the overall plant outage plan.
- Review the Inspection Test Plan (ITP) and assemble the relevant Inspection Test Reports (ITR's).
- Develop and issue Site Specific Safety Plan (SSSP).
- Review and update all critical lift plans including those required for the pre-shut work.
- Provide all the key trade resources and logistics to undertake the scheduled work on the turbine, generator, ancillaries and valves.
- Mobilise to site and coordinate the prestart activities with scaffolding and lagging and worksite layout. Clean and reposition the turbine components.
- Remove and secure all necessary gratings for crane access.

Key work Outage work undertaken by ProGen for the STG and Generator area entailed the:

- Turbine steam path inspection of the steam turbine generator (STG).
- Exchange of turbine rotor, stationary blade holders (HP/LP), labyrinth ring and the turbine glands =- basically a full steam path change out.
- Water-blast cleaning of the turbine upper and lower cylinders.
- Generator – rotor and stator internal inspection and testing. Removal and cleaning of the air coolers. Electrical inspection and testing was to be carried out by a local Contractor.
- Inspection of steam strainers (HP/LP) and associated pipework.
- Disassembly and reassembly of specified steam control and stop valves. Off-site overhaul of valves and servo's carried out by a local Contractor.
- Inspection and cleaning of the condenser. Water-blasting carried out by a local Contractor.
- Overhaul of the A & B main oil Pumps. Offsite overhaul of the pumps carried out by a local Contractor.
- Inspection and cleaning of ancillary equipment (Coolers, Filters etc.)

The overhaul works started with the issue of required access permits to ProGen. The work on the turbine was scheduled to be undertaken on day and night 12 hr shifts running a six day on and one off - offset roster. The overhaul was scheduled for a duration of 19 days with an additional 2 days allowed for commissioning.

Notable findings during the Turbine overhaul included:

- The turbine upper casing was rotated in a safe and efficient manner in the unloading bay following the procedures set out in a specific Lift Plan. The positioning of the casing was a critical factor in being able to allow the unloading bay to function for movement of other equipment.
- Extensive erosion was discovered in the lower cylinder LP steam space surrounding the HP steam inlet pipes. Weld repairs were required to rebuild the eroded sections and also to replace the eroded section of the HP chamber drain line.
- Turbine glands #1 & #2 as well as the inner HP gland bushes were exchanged. Each of the gland housings were re-dowelled to the respective turbine casings.

- Disassembly coupling alignment measurement were close to specification.
- Reassembly coupling alignment achieved an acceptable result. An adjustment of the generator bearing elevations was required as the turbine rotor position was changed due to the lowering of Bearing #1 and #2 along with some horizontal correction. The generator frame was not moved.
- Turbine journal and thrust bearing components were found to be in excellent condition. The turbine jacking oil hoses were replaced on the turbine bearings.
- Condenser was water-blasted, inspected and cleared of debris. General condition of the condenser is very good.
- Turning gear was in good condition with no sign of damage or defects.
- The generator and exciter inspection was conducted without any remarkable observations. The lower bearings were not removed.
- All three generator coolers were removed and set outside for thorough cleaning and inspection. Several attempts were required to remove the debris from the tubing.
- The A and B Main Oil Pumps were removed from the tank and sent to a local Contractor for overhaul.
- Both Lube Oil Coolers were found to be in reasonable clean condition with only small amounts of debris. The lower Oil cooler (B) was found twisted. Due to difficulty and safety issues the cooler tubes were not removed.
- The turbine oil was removed from the oil tank and circulated through a kidney loop filter to condition the oil for further operation. The oil tank was thoroughly cleaned and inspected. Lube and control oil filter elements were replaced and the jacking oil filter cleaned.
- The turbine control valves were removed from the pipework and transported to a local Contractor for off-site overhaul. When completed, the components were installed back into the pipework.
- Generator electrical inspections were conducted by a local Contractor. No notable findings resulted.

The unit was completed with the work permit signed off at the completion of Day 19 night shift.

The unit commissioning was then carried out on Day 21 after the reinstatement of the steam field plant and a managed warming of the steam supplies. The Turbine was at rated speed after 4 hours followed by overspeed tests and was synchronised to the Grid after 7 hours from start of commissioning.

A strong focus on HSE was maintained throughout the overhaul. There were no first aid injuries recorded and 1 near miss reported. Safety observations were undertaken by staff using the ProGen 'Stop & Think' forms, three "Supervisor inspections" and two "Safety Observations" were conducted by the ProGen supervisory staff. A total of forty five ProGen "Stop and Think" assessments were recorded by staff. Twice daily shift toolboxes were held in each area and recorded. There were no reported environmental issues.

The quality of the work completed met all required standards. HSE standards were maintained throughout the project with a strong focus on auditing and monitoring safe work practices.

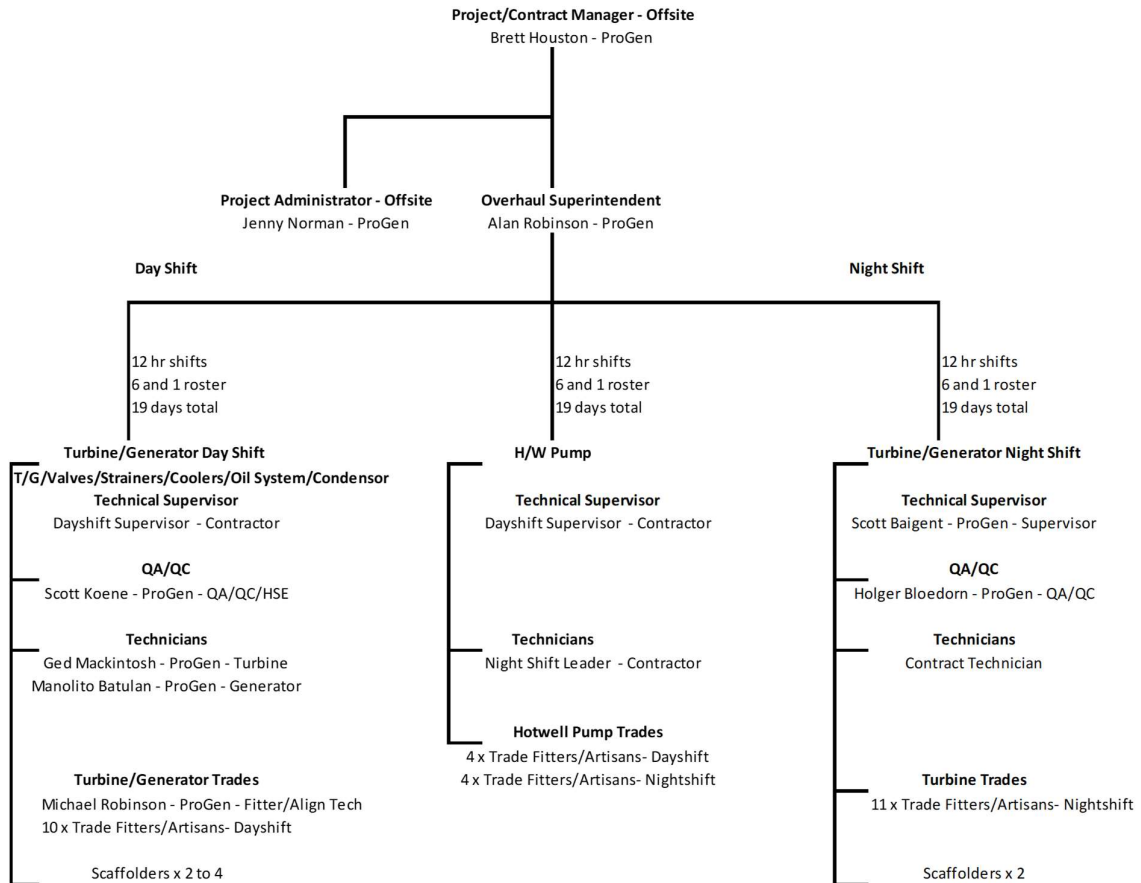
The combined ProGen and Contractor teams worked extremely well together and completed all work to the quality required in a safe and efficient manner. In addition, the support and assistance of the OEM and Client staff allowed quick and efficient decisions to be made. This allowed work progress to be maintained at an effective, productive rate.

Integration of the HWP critical path activities carried out by a local Contractor was successfully completed with the good cooperation of all parties in the turbine hall.

Post overhaul ProGen developed and issued the Client a full and detailed overhaul report with recommendations to improve reliability and future outages.

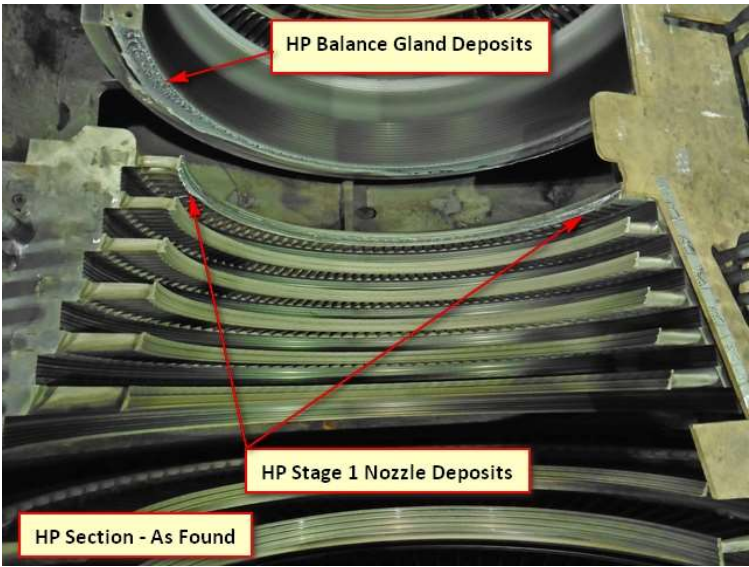


## ProGen Outage Team

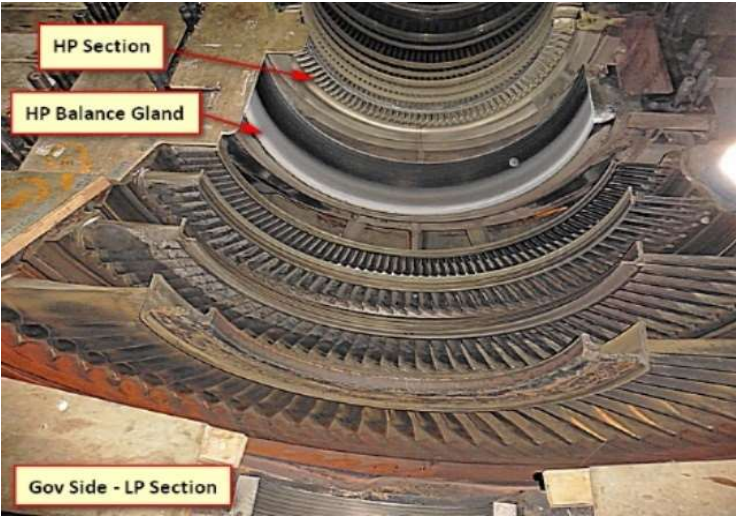




DIAGRAMS AND PHOTOS



Picture above showing general condition of the lower cylinder HP steam path



Picture above showing the general condition of the LP steam path (Gov Side)





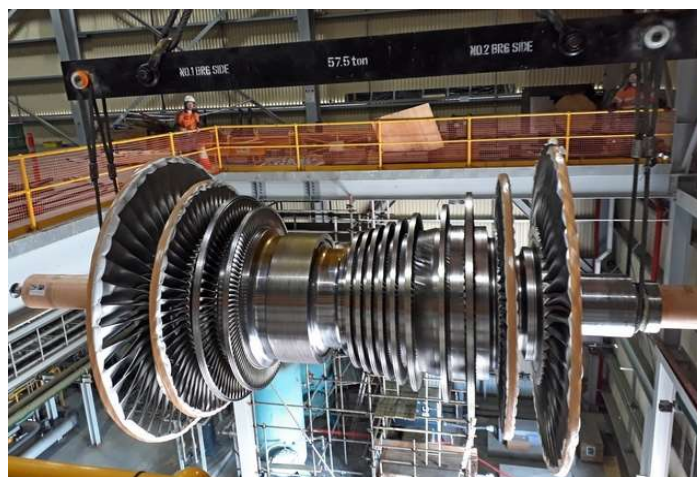
Pictures above and below of the HP Steam Inlet pipework showing erosion and corrosion.



Pictures above showing the damaged HP steam inlet pipe before and after repairs



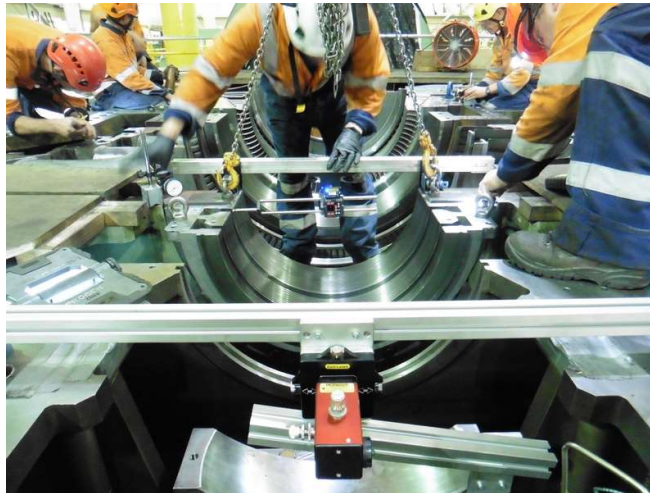
Picture of set-up for the removal of the lower HP Blade Ring



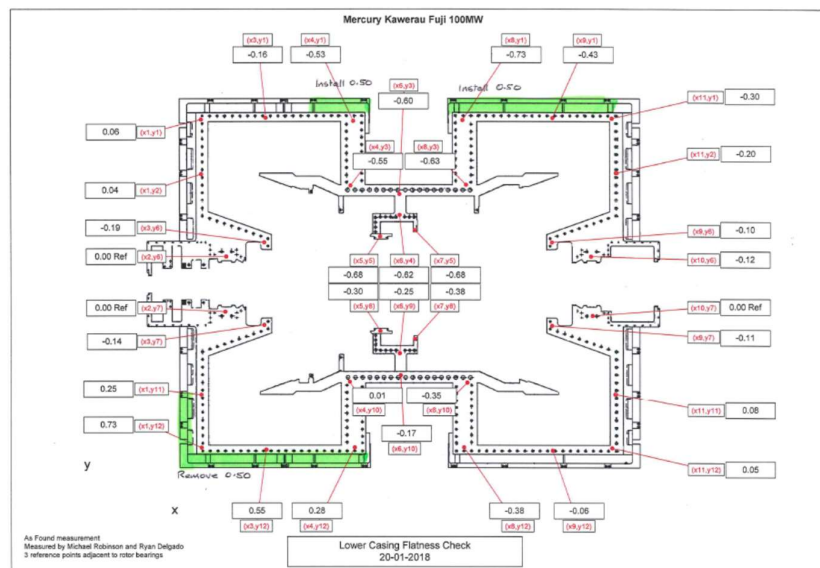
Picture of the new turbine rotor being lifted to the turbine deck with conventional rigging.



Picture of the turbine lower casing with new components installed



Final positioning of LP gland seals before tightening.



The As-Found flatness check turned out to be not optimal. The casing was shimmed according to instructions of the OEM as outlined in the chart above. In summary, 0.50mm was removed from the RH Front exhaust limb and inserted in the LH Centre pads. (Green highlight).