



250mW Thermal Steam Turbine

Case Study

Jan-May - 2019



EXECUTIVE SUMMARY

The Unit 1, 250mW steam turbine was shut down in January 2019 for the scheduled overhaul and statutory inspection work on the complete boiler, turbine and generator. ProGen was contracted to undertake the work relating to the steam turbine and generator.

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.

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

- IP and LP Turbine cylinder steam path inspection which entailed the full dismantling and reassembly of these two cylinders. Operating clearances and conditions noted for attention during remedial works.
- Removal of the two turbine rotors, stationary blade holders and diaphragms (IP/LP), inner casing inspection and the turbine glands.
- Remedial works on the IP and LP turbine rotors as identified during NDT.
- Cleaning of all of the turbine upper and lower IP and LP cylinders.
- Remedial works in the IP and LP turbine cylinders and stationary components as required following detailed inspection.
- Gen – Exciter rotor and stator internal inspection, cleaning and testing. Removal and testing of the H2 coolers. Electrical inspection and testing were to be carried out by client staff.
- Bearing inspections and NDT carried out on all of the turbine train white-metal journal and thrust bearings through to the exciter. (12 bearings in total).
- Disassembly and reassembly of all HP and IP steam chest control and emergency stop valves. (10 valves). Overhaul of the valves and relay servo's carried out on site.
- Full turbine train alignment measurement to be conducted during dismantling and on completion of reassembly. Adjustment of any out of specification alignment conditions.
- Inspection of the main oil tank, filters and strainers.
- Inspection and cleaning of ancillary equipment (Coolers, Filters etc.)

THE PROJECT

The overhaul works started with the issue of required access permits to ProGen. The work on the turbine was scheduled to be undertaken predominantly on dayshift running a six day on and one day off roster. The overhaul was scheduled for a duration of 10 weeks with an additional 1 week allowed for commissioning.

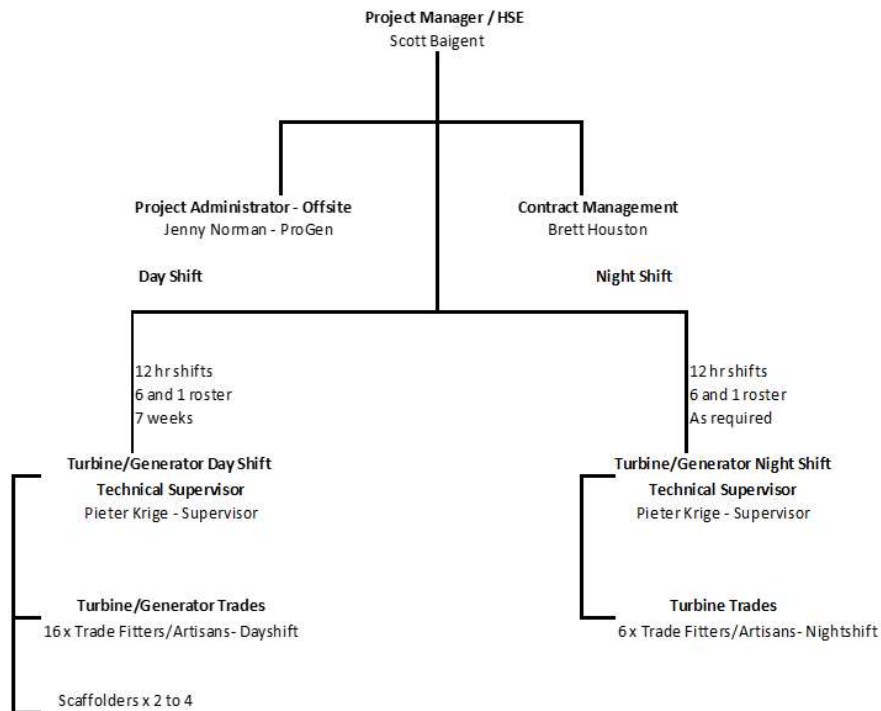
Notable findings during the Turbine overhaul included:

- The as-found turbine train alignment check revealed that the unit alignment was close to the desired condition. Pre-shut checks had revealed little of concern.
- The IP cylinder was dismantled following the planned sequence, recording all as-found operating clearances and conditions as the components were exposed. The components were set aside for cleaning and inspection according to the schedule.
- The LP cylinder was dismantled and components set aside for cleaning and inspection. As-found clearances were recorded as the dismantling progressed.
- The LP turbine top inner casing was rotated in a safe and efficient manner in the unloading bay following the procedures set out in a specific Lift Plan.
 - o The LP diaphragms removed and set aside for cleaning and NDT. Several defects were addressed prior to reassembly.
 - o The upper casing diaphragm ledge keys clearances were reviewed and corrected where necessary.
- The LP turbine rotor was hand-cleaned and inspected. The blading was NDT checked. Erosion and unusual markings were assessed and identified for remedial action.
- All of the turbine glands, #1 through to #6 as well as the inner IP balance pistons were cleaned and inspected.
 - o The IP cylinder HP balance piston had suffered damaged and missing long fins as a result of axial contact with the shaft castellations. These were cleaned up with the remaining long fins removed
 - o The remaining glands were found to be in good condition and available for continued service.
- The IP rotor inspection revealed some axial and radial migration due to the steam forces causing the loss of the brazed connection between the roots and shrouds. The movement of the blade packets were considered to be a high risk to ongoing generation reliability.
 - o Following a technical review, it was decided that these blade packets needed to be re-connected to provide the necessary support. The remedial works required a significant number of welds to be completed on the blading shrouds.
- The IP inner and outer casings were inspected for condition and NDT'd to assess for known defect changes as well as any developing issues.
 - o The stationary blading was found to be in a similar state to the IP rotor where blading packets have lost their brazed support and have begun migrating. The repairs were conducted in a similar manner to the turbine rotor.
 - o The half-joint surfaces were checked for flatness by conducting fully bolted blue checks on the surfaces. Several areas of both inner and outer cases needed to be resurfaced by scraping and grinding to remove hollow sections and leak zones
 - o Several gaskets and flanges on the lower IP casing were found to be leaking. All of the accessible joints and pipework were removed and gaskets replaced.
- Turbine, generator and exciter journal and thrust bearing components were removed for inspection and NDT. Several of the bearings needed to be re-metalled due to fatigue of the babbitt. The journals were all cleaned and returned to the appropriate grade of finish.
- The planned generator and exciter inspections were conducted without any remarkable observations. Air seals, bearing oil seals and exciter components were reinstated without incident.
 - o The generator hydrogen seals were removed, refurbished and reinstated without any issues. The turbine end seal was replaced with a re-babbitted seal. The exciter end seal was reconditioned in-house.

- Frame pressure tests were conducted to confirm gas-tightness of the generator frame.
- Final insulation resistance tests confirmed the acceptability of the rear end insulation against circulating currents.
- The turbine oil was removed from the oil tank and circulated through a kidney loop and press filter to condition the oil for further operation. The oil tank was thoroughly cleaned and inspected. No work was done on any of the oil pumping equipment.
- All of the turbine steam control valves were removed from the pipework and stripped for inspection and remedial works.
 - The valve components were checked and refurbished as required. The reheat and main steam ESV's required lapping
 - The HP steam chests were NDT'd with several of the chests requiring confirmation of known defect site acceptability and also some blending of newly discovered indications
 - The relay's and servo's of all of the valves were stripped and inspected for wear and serviceability. Several of the relays required remedial machining and bushing with a number of the main shafts needing re-chroming.
- A full realignment of the steam turbine and generator shaft train was carried out. This entailed shaft alignments, turbine casing adjustments for radial position and also some adjustment to the axial location of the HP and IP cylinders to restore the desired positions
 - Coupling box-up was completed with confirmation shaft journal concentricity's.

A strong focus on HSE was maintained throughout the overhaul with a strong focus on auditing and monitoring safe work practices. There were two first aid injuries reported that resulted in no lost time. Safety observations were undertaken by staff using the ProGen 'Stop & Think' forms and weekly "Supervisor inspections" were conducted by the ProGen supervisory staff. Daily shift toolboxes were held in each area and recorded. There were no reported environmental issues.

The ProGen team 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 Client staff allowed quick and efficient decisions to be made. This allowed work progress to be maintained at an effective, productive rate.



DIAGRAMS AND PHOTOS

