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OHAAKI STEAM SUPPLY PURGING

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ABSTRACT

This paper describes the methodology used to purge all the pipelines associated with the steam production system at Ohaaki. This includes the two phase lines, steam branchlines, steam mains and reinjection lines.

INTRODUCTION

The commissioning procedures for the Ohaaki steamfield required all the two phase pipelines, steam branchlines, steam mains and reinjection lines to be purged before turbine first roll. The method for purging the steam mains was defined by Designpower (Foong) and the remaining pipelines defined by Works Wairakei Geothermal (Taylor).

Target bars were inserted in the steam flow during each steam main purge to indicate the steam cleanliness and purge effectiveness. The target bars were machined from 25mm square mild steel bar and polished.

The acceptance criteria for the target bars was defined by Mitsubishi as:

> "Target plate to be exposed to the flow for 2 minutes. Two consecutive plates shall be obtained which have indentations less than 1mm in diameter."

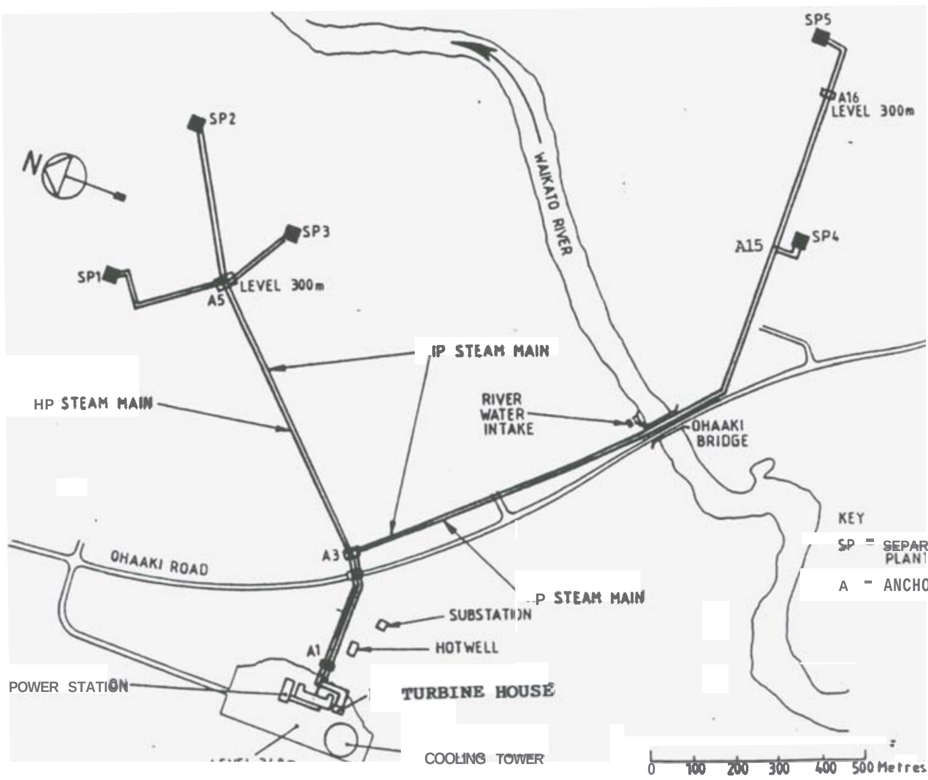

Diagram 1: Overall Layout of Main Steam Transmission Pipelines.

DISTURBANCE FACTOR

The basic analytical tool used for purging is "Disturbance Factor". The disturbance factor is defined as follows:

$$DF = \frac{W_s^2 x V_s}{W_t^2 x V_t}$$

Where W = flow rate
V = specific volume
t = rated flow and conditions
s = flow and conditions during purge

The disturbance factor is basically a comparison of the turbulence (or drag on the walls) at purge conditions compared to normal full load operation. To achieve a minimum disturbance factor of at least 1.5, the flowrate must be increased above rated flow conditions or a lower pressure and hence a higher specific volume used.

SEQUENCE

The Ohaaki steamfield was purged in the following sequence which was determined from the commissioning requirements:

- Two phase pipelines
- Reinjection system
- Steam branchlines
- Steam mains A5-A3 & A15-A3
- Steam mains A3 to Station

The West Bank steamfield was commissioned first followed by the East Bank steamfield.

TWO PHASE PIPELINES

Typically Ohaaki has individual two phase lines which connect each well to a separation plant. The two phase pipelines range in diameter from 250 mm to 500 mm. Each pipe was purged for a minimum of 2 hours with a minimum disturbance factor of 2.0. Steam velocities greater than 50 m/sec were typical.

The disturbance factor was calculated by the standard formula using total mass flow and a specific volume determined from the Homogeneous theory i.e.

$$V = V_g X + (1-X) V_f$$

where X = dryness
g = gas
f = liquid

The rated mass flow through each pipeline was taken as the maximum well flow. Therefore in order to achieve the required disturbance the operating pressure was reduced from 15 bar g to 6 bar g.

During the two phase purge the steam was discharged from the steamfield commissioning vents while the water was discharged through the dump valves to the separation plant silencer. All separation plant pipework was thoroughly purged during this phase.

The separation plant water control valves were only opened during the purge and left open. On completion of all the two phase line purges each separator and control valve was internally inspected. Any debris tended to collect in these places particularly behind the plugs of the water dump control valves. Welding wire and pieces of construction timber were the most common form of debris found.

REINJECTION PIPELINES

The reinjection pipelines were purged to remove debris and to clean the pipe walls. This was considered necessary to prevent debris from being injected into the reinjection wells.

These pipelines were purged with two phase fluid because insufficient water was available to generate a reasonable disturbance factor as liquid flow. The reinjection system was sectionalised into typically 100-1000 m long sections depending on the physical layout. Two phase fluid was produced from separated water by throttling the flow on the upstream side of each section. The fluid was discharged by temporary blowing spools installed at the downstream end of each section. These blowpipes were installed in place of reinjection system isolation valves or at the reinjection wellheads.

The separated water was produced at 6-7 bar g and throttled to 1-3 bar g to produce the two phase flow. The wet two phase discharge caused some problems with surface erosion.

STEAM BRANCHLINES

Each steam branchline was purged up to the steamfield commissioning vents which were installed at the junction between the steam branchline and steam main (A5 & A15). The separators were operated at lower pressure to produce disturbance factors greater than 2.0. Each steam branchline was purged for a minimum duration of 6 hours. The steam was vented from the steamfield commissioning vents.

The steam flow metering flobars and steam dryness probes were removed during the purge. Typically the lowest possible separator operating pressure was used without allowing separator breakdown to occur. Steam velocities of 40 - 50 m/sec were typical during the purge.

Following each purge all the branchline drain pots were cleaned of debris and the pipes were internally inspected. Approximately 5 litres of pipe scale and welding rods were removed from each drain pot.

STEAM MAINS A5-A3 & A15-A3

The steam mains between A5 and A3 were purged for 6 hours with a disturbance factor of 2.0. The East bank steam mains between A15 and A3 were each purged twice on consecutive days for 6 hours with a disturbance factor of 2.0. The additional purge was considered to be good practise following inspection of the A5-A3 purge. An improvement in pipe cleanliness was apparent after 2 purges.

These steam mains were purged by operating all the separation plants, connected to the main, at full flow and reduced pressure.

The steam was vented from a temporary vent installed above an anchor at A3. The vent discharged the steam vertically through a diffuser which had a movable shroud. Pressure and mass flow could be controlled by appropriate adjustment of this shroud.

Following the purge all the steam main drain pots were cleaned of debris. These drain pots typically had 5-10 litres of corrosion products, pipe scale, welding rods and slag.

STEAM MAINS A3 TO STATION

The actual procedure for purging these pipelines was provided by Designpower (Foong and Gill). Steam was provided from the West Bank steamfield, throttled at A3 via orifice plates and discharged from temporary pipework in front of the HP turbine house.

Some of the pipework was not able to be purged (eg the turbine inlet pipework) and this was manually cleaned and painted before commissioning commenced. This pipework was also thoroughly cleaned and inspected after the purge and before turbine first roll.

The steam was discharged through temporary pipework designed to provide the appropriate backpressure to the steam flow and to give the required steam velocity for target bar acceptance criteria. The discharge from the temporary pipes was later modified to pass it through the temporary vent diffuser.

The target bars were constructed from carbon steel, machined to 25 mm square and the surface polished to a mirror finish. A carrier was designed which allowed the target bar to be rotated 90 or 180 degrees. The purge was always operated with a sacrificial side presented to the flow. During each purge the target bar was rotated and each face presented for 2 minutes.

Each of these steam mains was purged 3 times for approximately 4 hours. The noise generated from venting the steam was a major community and industrial problem. A workable compromise was developed whereby each purge commenced at 3 pm and finished at 7 pm. This method minimised the noise exposure to the workforce while the community was subjected to higher noise levels at a time their household background noise levels were high. Noise levels as high as 65 dBA were recorded at some of the houses.

The target bars were buffed following exposure to remove the light surface corrosion and prepare the surface for inspection. All the target bars complied with the acceptance criteria on the three non-sacrificial sides.

Following the purge all the drain pots were removed and cleaned. These drainpots typically had 5-10 litres of pipe scale, welding rods and corrosion products.

DISCUSSION

Internal inspection of the pipelines following the purge showed that all debris had been removed and the scale had been stripped from the pipe walls. The cleanliness varied slightly between lines and was qualitatively assessed as totally clean (100%) to very clean 90%.

The drain pots were cleaned at least twice after the purge (whenever possible) and a significant quantity of corrosion products removed. The general opinion was that an extended continuous operating period was required to form the stable corrosion layer of magnetite.

Location of the permanent steam vents at the station assisted cleaning of the pipes as the steam system could be operated at full flow before turbine first roll. Therefore providing additional purges.

Purging may subject the pipeline to the most severe duty of its operating life. Vibration was the greatest problem and this caused failures of two nozzles adjacent to the throttling orifice during the A3 to station purge. The temporary vent silencer was also subjected to intense vibration and this was closely inspected following each purge.

Water-in-steam was a major concern during each steam main purge. This was caused by condensation associated with heating the steam mains. Typically the steam main was operated for 10-15 minutes before dry steam was vented.

ACKNOWLEDGEMENTS

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