KAWERAU TOPP1 GEOTHERMAL FLUID SUPPLY

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ABSTRACT

The TOPP1 binary cycle power plant located on Kawerau geothermal field is supplied with steam and geothermal separated water from a number of separation plants. The separation plants are located some distance from each other and operate at different pressures. The design of the delivery system for the separated water to the power plant had to overcome the pressure differences. This was achieved by controlling the plant inlet pressure below the lowest separator pressure and allowing for some flashing of the water before entering the plant.

1. INTRODUCTION

1.1 Kawerau Geothermal Field

The Kawerau geothermal field is located in the north of the Taupo volcanic Zone. The field lies under the Kawerau Township and the Norske Skog Tasman (NST) pulp and paper mill. The field has been developed by a number of entities, including KGL's 100MW double flash power station, smaller binary power plants and the steam supply to local industry by Ngati Tuwharetoa Geothermal Assets Limited (NTGAL).

1.2 NST Mill Steam Supply

NTGAL's steam supply to the NST mill consists of a number of production wells and six separation plants (SP). Steam is piped to the mill and separated geothermal water (SGW) is delivered to two binary power plants, reinjection wells and to the Tarawera River via a cooling channel.

1.3 TOPP1 Power Plant

The Tasman Ormat Power Plant 1 (TOPP1) is owned by NST. This plant is a 20MW Ormat binary plant consisting of single generator and two secondary fluid turbines. The plant uses geothermal steam in parallel vaporizer heat exchanges (HEXs) to boil the secondary fluid (isopentane) to generate a gas which runs thru the turbines to produce power. The fluid is preheated with SGW and steam condensate.

NTGAL are contracted to supply steam and SGW to the TOPP1 plant. The steam is taken off the existing LP Steam piping to the NST mill. The SGW is piped from 4 of the 6 NTGAL separation plants.

The scope of the fluid supply included the piping to the HEX flanges. NTGAL contracted the design and build of the fluid supply piping and controls to MB Century.

2. FLUID SUPPLY REQUIREMENTS

2.1 Steam

Steam is supplied to the TOPP1 vaporizers from the steam main next to the TOPP1 plant. The pressure in the steam main is fixed at the mill end of the main line. The pressure at the TOPP1 take off depends on flow and pressure drop in the steam main between TOPP1 and the mill. In normal operation there is a net flow to the mill and therefore the steam pressure at TOPP1 is higher than the mill pressure. SP30 steam pressure will be close to the mill pressure and the three other SPs will have steam pressure higher than TOPP1.

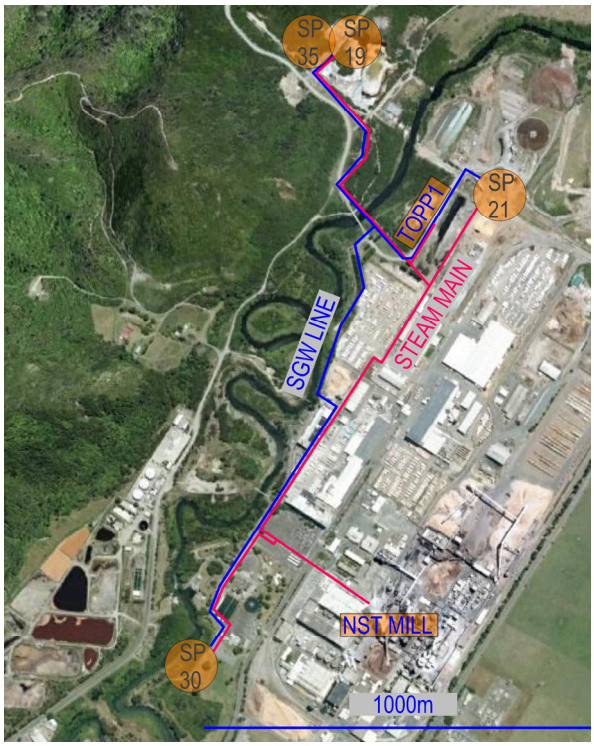

Figure 1: TOPP1 and separation plant locations

2.2 SGW

TOPP1 is supplied with SGW from 4 separation plants (Figure 1).

At each plant the water is at saturation conditions corresponding to the steam pressure. If the SGW pressure drops it will boil/flash. For example flowing this water uphill causes it to flash.

Each SP is at different elevation and distance from TOPP1. Varying pipe flow losses to TOPP1, compound the effect of difference steam pressures.

In other locations (e.g Ngawha) binary power plants have used transfer pumps at each SP to increase the pressure of the SGW at each SP to maintain a common pressure above the highest SP steam pressure. This maintains the SGW above saturation and prevents flashing. This also means the pressure in the preheater HEX is higher than the steam pressure in the vaporizer. Condensate then has to be

pumped from the Vaporizer to the preheater. Pumps at each SP are expensive to build and operate.

The system developed for TOPP1 uses a control loop where the process variable is the difference in pressure between the steam supply to TOPP1 and pressure in the SGW inlet manifold. The control loop set-point is nominated so the SGW pressure is below the steam pressure in all the SPs. This means there will be pressure to drive the SGW in the plants with lowest stream pressure to TOPP1. The differential also ensures that the vaporizer pressure is higher than preheater pressure and condensate will flow from the vaporizers to the preheaters.

The control loop output is sent in sequence to SGW flow control valves located at each separation plant. If the differential is lower than the set-point these valves close, and opened when the differential is high. The SGW flow control valves have an override function that will maintain a water level in the separation plants.

SP30 also has the option to use a control loop to back pressure the steam branch line and increase the separation plant pressure. The higher pressure will push SGW to TOPP1 should the pressure drop in the steam main cause the SP30 pressure to drop below the TOPP1 SGW manifold pressure. The back pressure control loop maintains a SGW level in the separator when the plant's SGW flow control is fully open.

The effect of lowering the SGW pressure is that the SGW flashes at the SGW flow control valves. The fluid passing to the TOPP1 SGW manifold is two phase, steam and water. The steam fraction is small 1-2% by mass.

2.2.1 SGW manifold - two phase separation

A large diameter, DN750, SGW manifold is provided at the plant to allow gravity separation of the SGW and steam phases. A top vent valve and level control loop vents the steam phase and allows the saturated water, only, to enter the plant preheaters.

An auto opening manifold drain is also used keep the SGW line hot and to maintain a reasonable SGW flow from SP30 when the TOPP1 plant is off line.

The manifold is also expected to gather an accumulation of sand/gravel. Manways are installed to aid cleaning.

3. POWER CONTROL

There is no direct control between the TOPP1 plant and the Steamfield controls. TOPP1 uses heat source control valves located on the discharge legs of the preheaters to control the plants fluid flow and power generation. The steam flow to the plant is generally constant and the SGW flow is used to trim the power output. Opening the heat sources valve draws more SGW into the plant. The Steamfield sees this as a drop in SGW pressure and opens the separation plant SGW valves to flow more SGW and maintain the steam/SGW pressure difference.

When there is no more SGW available TOPP1 needs to limit the opening of the heat source valves.

4. REINJECTION

Supplying fluid to TOPP1 required NTGAL to increase reinjection capacity. The fluid from TOPP1, combined cooled SGW and steam condensate, is piped 3.4 km to two new reinjection wells (KA49, KA53) in the north of the field.

The fluid from the plant can also be directed to the existing cooling channel for surface disposal. The operators can use this control valve to either, control the reinjection line pressure or send the set flow to the cooling channel and balance to reinjection.

Design of the reinjection line allows for a future pump station.

Plant operation found that, if the reinjection pressure was too low CO_2 gas came out of solution and caused problems; in particular it caused the flow meters to give false high readings. A few bar of pressure was required to keep the gas in dissolved.

4. PH CONTROL

Cooling of SGW increases silica concentrations and scale can form in the reinjection piping and wells. pH modification is used to delay scale formation. (Gallup 2011)

An acid injection system and pH control loop has been installed 100m downstream of the TOPP1 plant. This system monitors line flow and pH and adjusts the acid injection rate to maintain the pH within a set band. The system has the ability to dump fluid to a pond at the reinjection well pad when the pH is outside the required band. H_2SO_4 is the acid used. This is stored on site in a 30,000l tank.

6. DISTRUBTUED CONTROL (DCS)

The NTGAL field is controlled with PLCs located at the separation plants and the pH control hut. Fibre optic (FO) cable, run along the pipelines, links the PLCs to the HMI screens located in the KGL power station control room. Installation of the PLCs in the control huts at the pH control pump station and SP30 were required for the TOPP1 project. Some control loops like the SP30 level control required the process values to be passed between PLCs over the FO network.

Flows, pressures and temperatures in and out of the TOPP1 plant are monitored by both the station and steam field DCS. Duplicate transmitters have been installed where both parties monitor the same variable. NTGAL also monitors the position of some of the station controlled valves. Signal isolators/splitters are used to provide NTGAL with an analogue signal. NTGAL also provides the station an analogue signal indicating the status of the differential pressure control loop.

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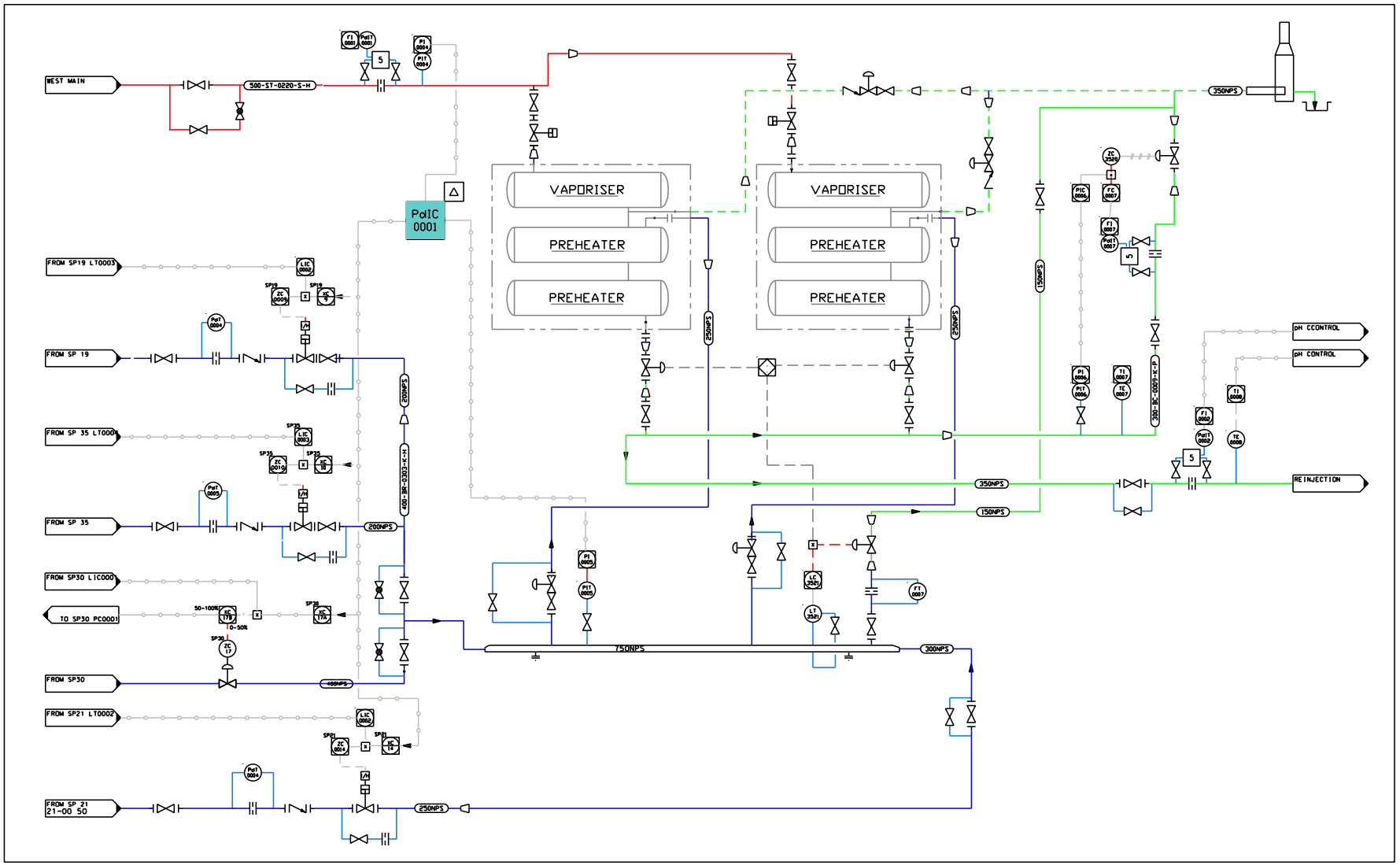

Figure 1 TOPP1 PID. Steam (red lines) enters plant to the vaporizers. SGW/brine (Blue lines) run from the separation plants to the SGW manifold and into the Preheaters. Control loop PdIC001 controls SGW line pressure to a margin below the Steam pressure. Combined steam condensate and cooled SGW (Green lines) exits the plant and is piped to reinjects wells or atmospheric discharge to a cooling channel. A level control loop in the SGW manifold vents the steam faction from SGW line.