Proc. 5th NZ Geothermal Workshop 1983

Grant L. Morris

Ministry of Energy, Electricity Division
Wairakei

ABSTRACT

By 1980 Wairakei Station staff were assessing the options available to deal with the continuing rundown of high pressure (HP) steam. It was decided to convert the HP wells to intermediate pressure (IP) producers and use the ex-HP transmission lines to carry the additional IP steam to the station, from which the HP turbines would eventually be removed. The object of the modification was that the removal of the HP turbine system would be achieved without incurring a lose in total station generation. The conversion of Wairakei Power Station from a three pressure steam supply system to a two pressure system was done in November 1982 with subsequent modifications taking gross station generation to 140.1 MW by June 1983, compared with the 136.6 MW of November.

INTRODUCTION

Faced with continuing borefield pressure rundown as the field was exploited, Wairakei Parer Station adopted a policy of operating the HP turbines at or near full throttle (i.e. maximum swallowing capacity) in order to lower HP steam supply pressure and maintain production from the HP wells. Although steam mass flow was maximised by this strategy, by 1980 the station HP manifold pressure had been lowered to 6.5 bar gauge, close to the 5.2 bar minimum pressure required to turn the turbines. Details of the three pressure steam supply system are shown in Figure 1.

OPTIONS AVAILABLE TO DEAL WITH HP RUNDOWN

Leaving the three preeeure steam system unaltered would have resulted in a continued decline in HP pressure and generation until the late 1980s when all HP generation would be lost. There were two main options available to deal with the HP pressure rundown: pressure reducing valves (PRVs) at the station; or, derating the HP wells to IP.

Replacing the HP turbines with PRVs would allow the continued supply of the IP manifold from the HP transmission system but with the steam mass flow remaining the same as the unaltered three pressure system, plus the problem of the additional noise the PRVs would create within the station. As HP wellhead pressures continued to drop, those flashplants wing HP separated water would eventually cease operation as IP steam suppliers and require rebuilding as intermediate low pressure (ILP) flashplants.

Derating, or lowering pressures, at the wellheads and flashplants rather than at the station was the only alternative that offered an "immediate" generetion gain due to increased steam output expected from the decrease in wellhead pressures. Also, the redundant HP turbines would be available for use elsewhere if required without having to we noisy PRVs within the station.

JUSTIFICATION OF DERATING AT THE BOREFIELD

In order to assess the response of the HP system to changes in manifold pressure, a series of tests was conducted in August and September 1980. HP manifold pressure was raised by closing the HP turbine throttle valves, and lowered by opening the HP/IP PRVs in addition to fully open HP turbine throttle valves. Figure 2 is an extrapolation of the results of these tests and indicates an increase in HP well output of approximately 20% for a drop to IP conditione. Figure 3 shows that for 1980 a 13.8% increase in HP well output from a derated system would maintain total generation at the 1980 level, with any extra steam serving to increase generation.

MODIFICATIONS REQUIRED

BORES AND FLASHPLANTS

Under the three pressure system nearly all the HP bores fed HP eteam into the main transmission lines, and their separated water to the IP aide of the flaehplants. The derating of the HP welle and their flaehplants could be achieved in two ways.

Firstly, the HP wells could be derated at the wellhead so that the well would supply IP steam to the ex-HP transmission lines and the separated IP water would then be redirected to the LP side of the flaahplants. However, lowering inlet pressures to the wellhead separators and steam branchlines would raise steam velocities and possibly overload separator/branchline capacity on four to six HP wellheads.

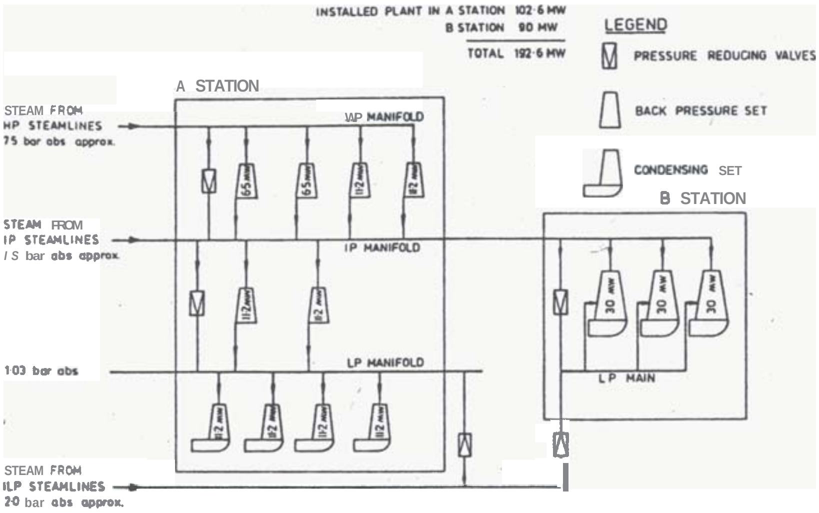

FIG. 1a Flow diagram showing machine arrangement at Wairakei A & B stations

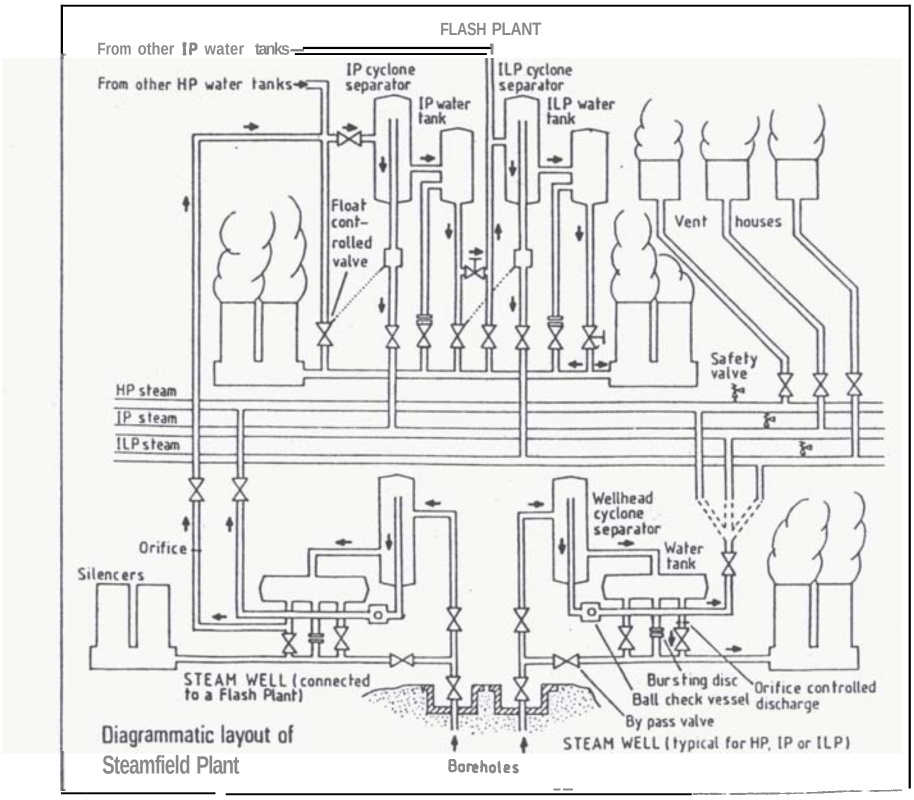

FIG. 1b

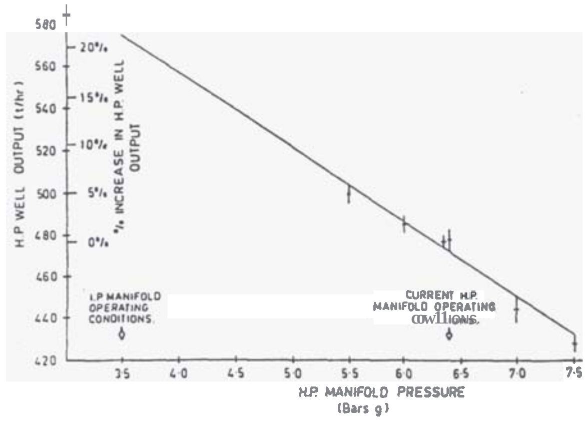

FIG 2 H P WELL OUTPUT AGAINST MANIFOLD PRESSURE

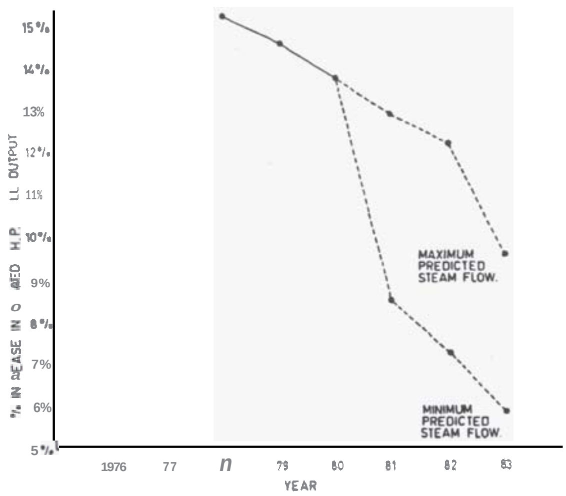

FIG 3 INCREASED OUTPUT REQUIRED FROM DERATED H P WELLS TO MATCH H.P. GENERATION.

The second alternative, derating at the flashplants would require all HP wells to supply two phase fluid to their flashplants which would produce the IP and ILP flash steam, making individual HP wellhead separators and steam branchlines redundant. Although derating at the flashplant offered the tidiest alternative by doing away with HP wellhead equipment and steamlines, it would require considerable modification to flashplant capacity, the water lines feeding it and the steam lines to the mains. Also, directing such a large quantity of steam (approximately 175 t/hr for steam mains would require either some form of manifold connecting the mains or splitting of the incoming flow to distribute it evenly amongst the main steam transmission lines.

Derating at the wellhead was the preferred alternative on account of its relative simplicity and the fact that the derated HP wells could be returned to service as soon as the main lines were recommissioned, with subsequent alterations to branchlines and separators being done as required to improve their performance.

Those HP bores that were not connected to flashplants would simply become IP wells as they fed into the ex-HP steam mains, requiring only that their water discharge orifices (where fitted) be enlarged to allow water removal at the lower pressure.

TRANSMISSION LINES

With a larger mass flow of IP steam being brought to the station it was important to determine if the main steam lines were capable of handling the flow involved without undue pressure loss. For 3 x 762mm, 5 x 508mm and 1 x 432mm bore steam lines carrying enough IP steam to fully load the station (over 1000 t/hr) the velocities and pressure losses were calculated as given in table 1.

Due to previous rearrangements of steam line pressures at Wairakei, the two 762mm HP lines were already connected at two places to the IP system, but isolated with blanks. In addition to removing these blanks it was decided to interconnect the HP and IP systems at two further locations to even out flow distributions and thereby reduce pressure losses. One such crossover connection was at "Anchor 10" in the middle of the borefield production area, which was also to serve as a terminal point for the introduction of additional steam from the three "200 series" wells being included in the production system. The other crossover was at "Anchor 7" (1.4 km from the station) which connected all nine IP transmission lines as they left the borefield for the station.

SAFETY AND VENT VALVES

The HP and IP borefield vent valves were to be connected in parallel as IP vents, in which role they could handle nearly 50% of the maximum flow to cope with variations in borefield production and station steam demand. Also, two extra IP safety valves were added to one of the station manifolds so that full IP flow could be discharged by the IP safety valve system.

Pipe Bore (mm)	Flow (t/hr)	Velocity (m/s)	Recommended Max. Velocity (m/sec)	Pressure Loss (bar/100m)
432	47	37	-	0.046
508	73	41	49	0.046
762	216	54	61	0.046

STATION PIPEWORK

The main modification required at station was the provision of crossover pipework to connect the HP and IP manifolds in order to bypass the HP turbines. Rather than reconnect several existing lines of 400 NB or less (turbine inlet and PRV lines) to effect the HP/IP crossover it was decided to use two 762 mm bore crossover lines, matching the line sizes which connect to form the HP manifold. The crossovers were located where the HP and IP manifolds are closest together and on the same level so that they could be made sufficiently flexible without having to resort to compensators or exceesively high loops.

With the removal of the HP steam system in 'A' station the pipework could be considerably simplified by doing away with the HP turbine inlets plus all HP drains and flash vessels.

Also, the steam driven gas ejectors used on the four LP condensing sets were redesigned and modified to allow them to operate on IP instead of HP steam.

INSTALLATION OF MODIFICATIONS

A complete station and steamfield shutdown was arranged for 21 November 1982 to allow the installation of those modifications that could not be completed with the station on load. During and immediately after the shutdown period contract welders, NDT inspectors and contract laggers were employed in both the station and steamfield.

Once the existing blanks between the HP and IP transmission lines were removed and isolating valves were installed at the A7 and A10 crossover locations to enable their construction to be completed "on load", the main steam lines were ready to be returned to service. Installation of the HP/IP manifold crossovers in 'A' station formed the critical path of the shutdown work end, once completed on 30 November 1982 along with removal of redundant steam lines, fitting of blank flanges and IP safety valves, the station and steamfield pipework could be warmed through and returned to service. At this point the IP and ILP wells and most of the flashplants were running and the derated HP wells were returned to service with excess water bypassing to waste pending enlargement of their water diecharge orifices.

POST-SHUTDOWN MODIFICATIONS

The following seven months saw a steady increase in station generation as flashplants and wellheads were modified to improve their performance.

Flashplant 1 for instance had been returned to service with the IP flash vessel bypassed but the water flow to the single LP flash vessel was too great (i.e. the separation broke down and water carry-over was excessive), so that Flashplant 1 was subsequently shut down and the ex-IP flash vessel reconnected to operate as an LP flash vessel and allow the flashplant to use all the water being delivered to it.

Similarly some of the derated HP wells had to be run at higher than normal IP pressures (achieved by throttling their steam branchline isolating valve) to prevent their separators being overloaded. A total of five wellhead separators were replaced with increased capacity plant and two 200mm branchlines were rebuilt from 300mm pipework.

Both crossovers at A7 and A10 were completed and although no noticeable improvement in pressure distribution was noticed, the manifolding at these two points allows better control of IP steam at the vent valves and from the 200 seriee wells respectively.

EFFECTS OF THE CONVERSION TO A TWO PRESSURE SYSTEM

The original aim of converting Wairakei from a three to a two pressure system was to remove the HP turbines without incurring a loss in generation. To this end the conversion was successful with gross generation reaching 140.1 MW by 14 June 1983, and one large well still to be connected, compared with 136.6 MW immediately prior to the station shutdown.

Unfortunately a number of factors have prevented the true effects of the conversion being known. Since mid 1982 station has been in the process of replacing the differential pressure meters used in the borefield for steam flow measurement, so that the exact some of the IP steam flow increase is not known. Also, in mid 1983, as the last wellheads and flashplants were being modified to produce full output, a number of wells in the borefield were shut down to allow their incorporation in the 200 series steam main which was brought into service on 15 June 1983, increasing station gross load to 151.8 MW by the end of August 1983.

With the major modifications already installed and only a few "fine tuning" details to be completed, the conversion to a two pressure system will have been achieved within the budgeted cost of $500.000.

ACKNOWLEDGEMENT

The permission of the General Manager of the electricity division of the Ministry of Energy to publish this paper is acknowledged.

REFERENCES

I.A. Thain (1980): "Wairakei - the First Twenty Years"

B.E. Stacey (1980): "Wairakei Power Station. A Generation Prediction from 1981 to 1985" (NZE internal report).