ELECTRONIC LOGGING OF OUTPUT TESTS

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SUMMARY - Obtaining the release of production wells for output testing is a problem for most operational geothermal plants. Many wells take a long time to stabilise or else they cycle. With these wells, it is difficult to obtain reliable data especially when under time constraints. Datalogging the output tests with onsite analysis and manual backup optimises the collection of information within the limited time available. The datalogging records can allow comprehensive analysis of cycles or transients. On some wells fitted with capillary inhibitor tubing, it is possible to do productivity testing.

INTRODUCTION

The strategy behind the output testing of production wells should be to obtain the maximum amount of reliable useful data in the minimum time. There are major constraints to output testing wells at an operational power station. The station is usually operating as base load so the wells will be released for only a short time to test. During the short release period, other work such as downhole surveys, output tests and well maintenance also has to be done.

Condensing the time period required for output tests can result in poor data. Wells with poor permeability can take a long time to stabilise. The wellhead pressure (WHP) might not rise until several hours after the well has been throttled. If there are multiple feeds, a cycle might be present only over a narrow operating range. At the upper end of the output range, the WHP could collapse as when the well is above the Maximum Discharge Pressure (MDP). The usual output test method of having a chart recorder measuring a damped WHP makes it very difficult to decide if the well is stable. If the well cycles, a chart recorder often will not pick up small cycles.

If the well output tests are able to be electronically logged, then much more comprehensive data is obtained. The data taken can later be manipulated or analysed in more detail. The electronic records can be used for historical comparisons or for transient analysis. It is possible to obtain accurate data on well cycles that are very tedious or time consuming to manually log.

METHOD

It is straight forward to data log wells that are output tested by the James Lip Pressure method (James,1970). Three transmitters are required. One for the WHP, one for the lip pressure (LPP) and one for the weir box manometer (Wbx). The first two can be measured by standard range pressure transmitters. Programmable or "smart" transmitters are being used to measure the WHP. These have the advantages of giving a digital readout of the actual pressure, a programmable damping period and can be recalibrated to a new range onsite using a keypad. An appropriate ranged chart recorder and lip pressure gauge are also fitted as standard to give manual backup.

The Wbx is measured using a low range differential pressure transmitter with the HP side connected to the manometer tapping and the LP side open to atmosphere. The weir box transmitter is usually calibrated onsite using the weir box manometer. On weir boxes not fitted with a manometer it is possible to use a gas purge manometer with the transmitter in parallel to the remote manometer. This method is not as accurate as it is difficult to do a calibration. Transmitters that measure weir heights by ultrasonics or capacitance are also being considered.

There are a range of dataloggers available that can store the data from the transmitters. A minimum of four 4 to 20mA channels are needed for most tests. The fourth channel gives a spare or can be used to log another transmitter. The data should be stored in a minimum of 12 bits. This allows a resolution of 0.05%. A programmable graph package is good for field checking the quality of the data. Because of the holdup / resonance time of the weir box, very shot logging intervals can reduce the quality of the data.

OUTPUT TEST

The well is usually logged and the datalogger downloaded for a period before being taken out of service. This allows faults to be sorted out, gives a baseline and allows for the transmitters' calibrations to be checked. After the well is taken off production and put to the silencer, the output test is conducted in the normal way. Previous history gives an indication of how long the well will take to stabilise but our practice is to stay at a given setting until the chart recorder gives a discernibly stable trace. This time can vary between five minutes to more than two days. The manual readings are taken at this stage, together with any chemical samples needed, and the well throttled up. The test is usually stopped when there is little or no lip pressure or the well is past its MDP.

Variations (interference, downhole pressures)

Datalogging output tests makes it easier to check for interference with surrounding wells. The resolution of the electronic pressure transmitters is much finer than *can* be measured manually. The selected well that is to be checked for interference *can* either be discharging and the WHP monitored or shut in with the downhole pressure being measured by a nitrogen bubbler on capillary tubing. The datalogger readings will tell if there is any interference and if so, the timing and magnitude.

If the well being output tested has capillary tubing fitted for the injection of chemical inhibitors (Robson and Stevens, **1989)** it is possible to do productivity tests. This is dependant on being able to stop the flow of inhibitor to the well during the test without **risk** of deposition. One does not need to know the length of tubing in the hole as it is constant during the test. If the depth at which the tubing head has been set is known, it allows the data from the test to be matched to other downhole data.

A high pressure regulator that can go to a higher pressure than that expected at the bottom of the inhibitor tubing is fitted to a standard nitrogen bottle. The gas is bled into the inhibitor tubing through a small, fine taper needle valve. Gas flow should be fast enough to keep up with any pressure increases down the hole. The tubing pressure is measured with an electronic pressure transmitter downstream of the needle valve. Pressure at the surface is equal to the pressure at the bottom of the tubing minus the weight of gas in the tube. The programmable pressure transmitters are ideal for this use as they can be recalibrated without disconnection. **As** the nitrogen in the tube is at a high pressure, the feed rate has to be very small to give a reasonable bottle life.

If there is tubing fitted, downhole temperature and pressure measurements by the normal methods are not possible. Careful interpretation of the data from a datalogged output test *can* give a lot of information about the conditions downhole (Clotworthy, in prep.). The data can also be compared to previous tests and the chemistry to confirm changes.

DATA ANALYSIS

Data files are transferred into a spreadsheet and the James method used to calculate mass flow and enthalpy. Manually recorded data can be used as a check on the results. Our standard practice is to do no gas correction and label the results as such. If the well has multiple feeds, gas determinations at several steps throughout the test would need to be done to make gas correction meaningful.

The data is best represented by three graphs. WHP **and** mass flow versus time, and WHP and enthalpy versus time. The third is mass and enthalpy versus WHP. From the first two, the stability of the well can be shown while the last one gives a standard output curve albeit in modified form. If the well cycles then WHP, mass **flow and** enthalpy *can* sometimes be covered in two **scales and this** plotted. Even then, the cycle might not be represented very well.

RESULTS

Examples from recent logged output tests are illustrated below. Standard plots of the ***same*** well test are shown in Figures 1-4. Figures 1 and **2** show the time trends for mass flow, enthalpy and WHP. The well had an MDP of less than 20 bg. Figures 3 show the characteristic plot of mass flow and enthalpy versus WHP using logged data with the manual data for comparison as Figure **4.**

Figure **5** illustrates the logging of a well which was investigated because of cyclic behaviour causing problems on production.

Figure ***6*** shows an example of measuring downhole pressure and WHP simultaneously during an output test.

DISCUSSION

The data we have collected so far shows that the mass flow and enthalpy invariably stabilise before the WHP does. It also shows that when the WHP is stable, the other physical parameters are stable.

Graphs of mass and enthalpy vs WHP have shown that the limits of variability are at least 3% & 30kJ/kg respectively. This can be seen as the scatter in Figure 3. These variations have to be taken into account when all derivative calculations are made. For example, gas percentages in steam at low enthalpies are very enthalpy dependent.

With the experience gained from these tests, the time taken for them has been reduced. Wells can now be out of service for less than an hour while their mass flow and enthalpy are measured at normal operating pressure and chemical samples are taken. Under optimum conditions, this time can be halved. Full output tests where the well is tested over its full range take on average one to two days including MDPs where relevant, while the slowest stabilising wells take less than a week. It is fortunate that the large mass flow wells are usually those that stabilise quickest.

In one of our more important recent tests, **a** full output test was done in three hours. **As** the well was worth about **7** MWe, the well would only be released for a short period. The test **was** done at a full range of WHPs which involved seven steps and two sets of chemical samples. Downhole pressure monitoring was also done. Datalogging of the test confirmed that the well stabilised quickly and we could have confidence in the results.

CONCLUSIONS

- Datalogging has the potential to increase the amount and quality of information from an output test.
- The information gained about stability time allows output tests to be optimised.
- Datalogging has shown that the mass flow and enthalpy have significant variability about their average stable values.

ACKNOWLEDGEMENTS

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James, R. (1970). Factors controlling Borehole Performance. *UN* Symposium *on the Development & Use of Geothermal Resources, Special Issue Geothermics,* V2.

Robson, Q., Stevens, L. (1989). Antiscalant Trial at Kawerau Geothermal Field. *Proceedings 11th Geothermal Workshop.*

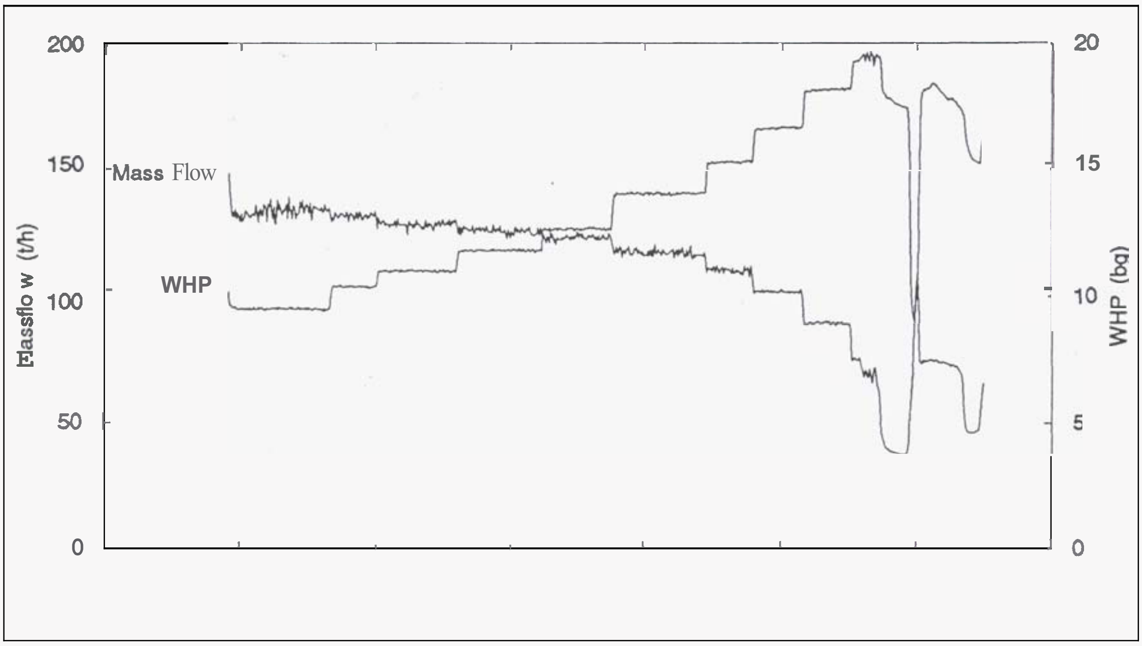

Figure 1 - Plot of logged WHP and mass flow.

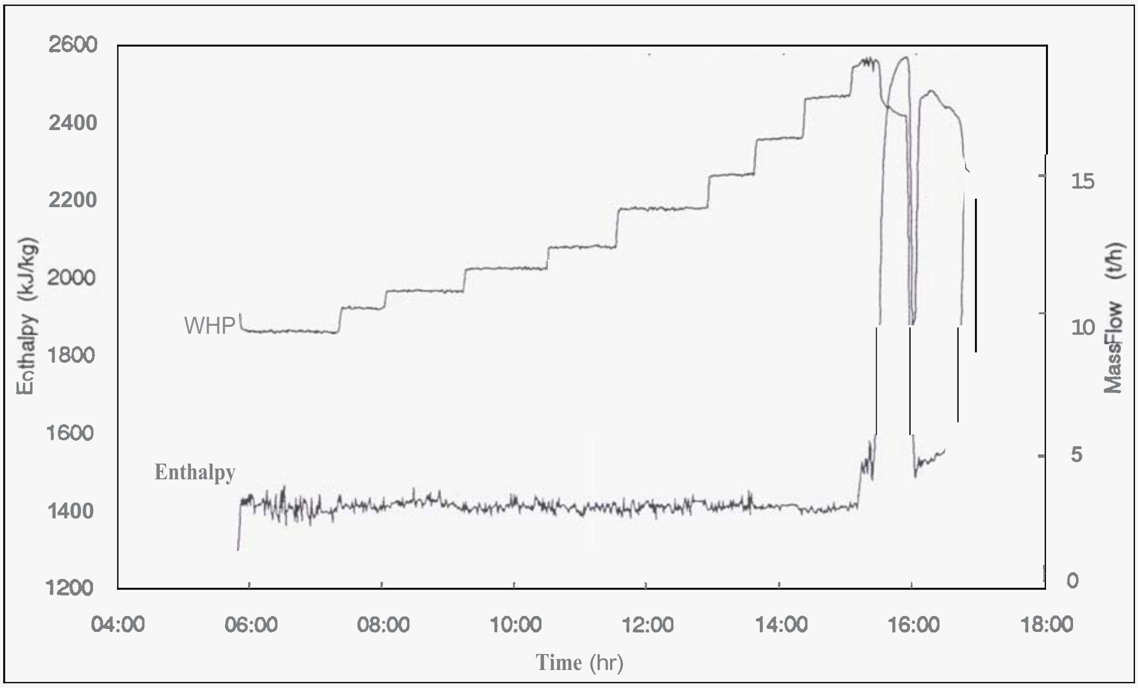

Figure 2 - Plot of logged WHP and enthalpy.

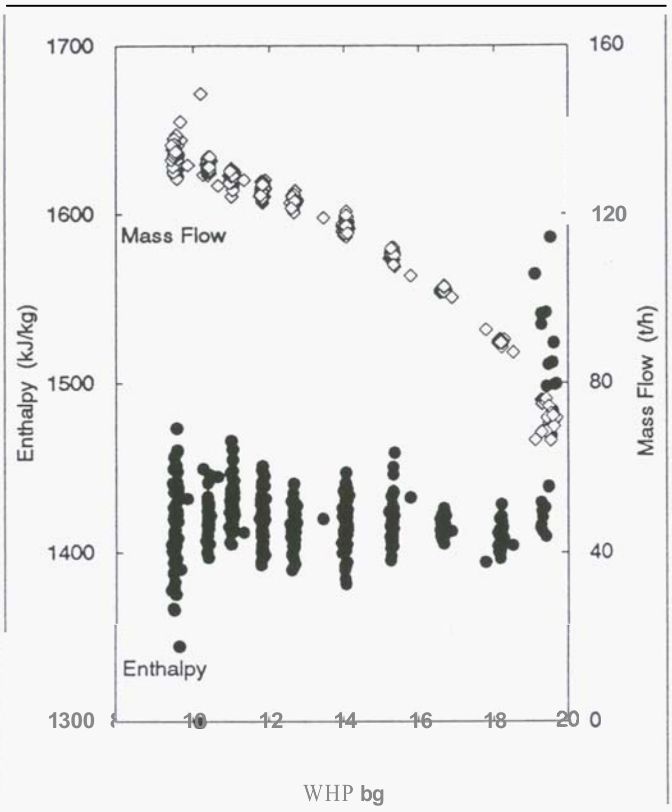

Figure 3- Plot of logged mass flow and enthalpy.

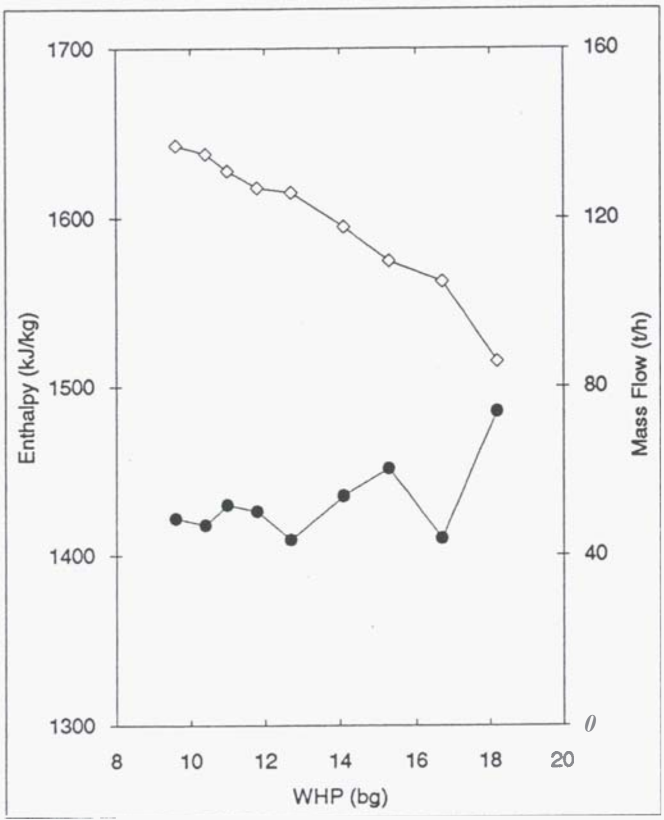

Figure 4- Same output test plotas Fig.3, from spot readings.

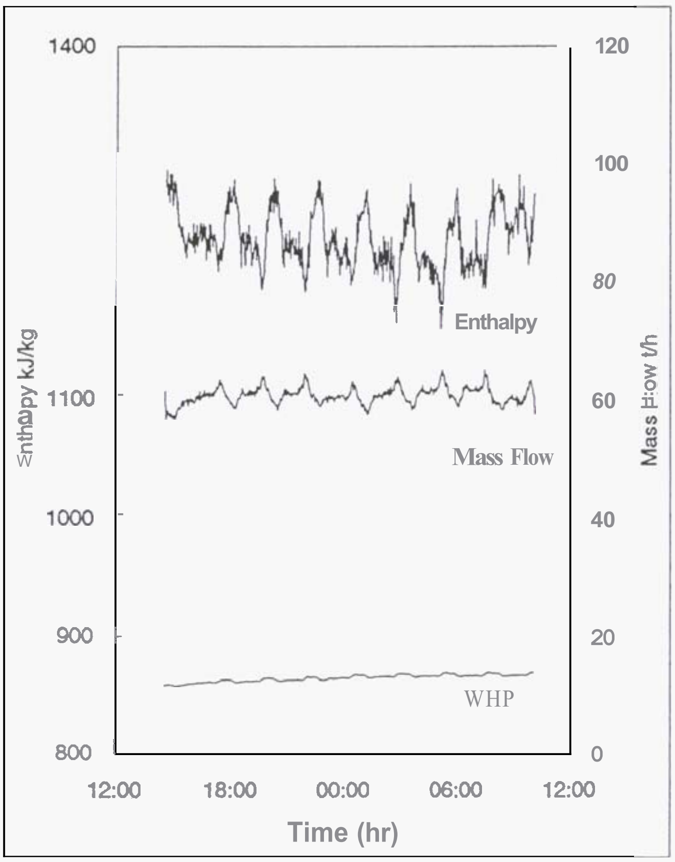

Figure 5- Cycling well.

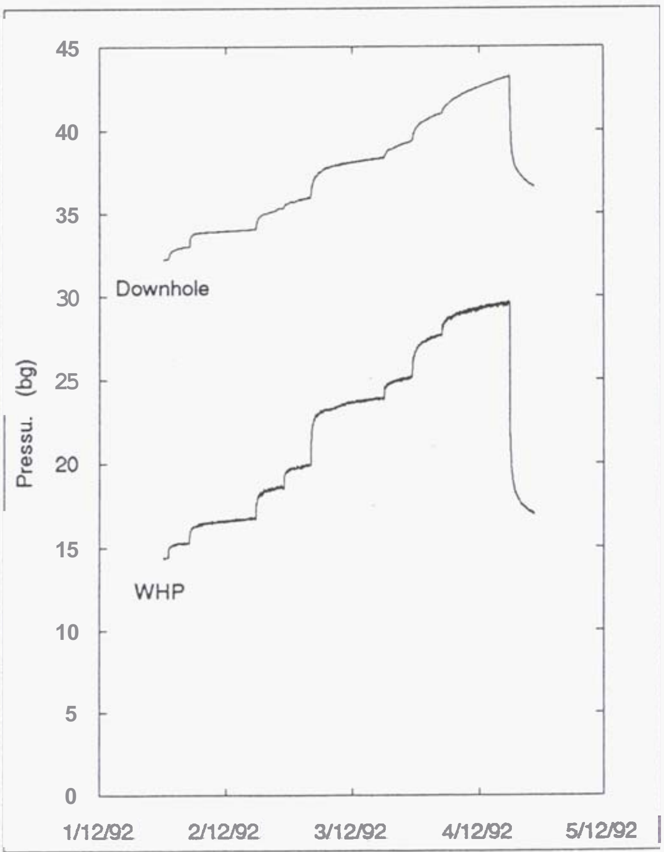

Figure 6- WHP and downhole tubing pressure.