Proc. 6th NZ Geothermal Workshop 1984

DETERMINATION OF CASING CONDITION USING MECHANICAL AND ELECTRIC LOGS

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ABSTRACT

Recent work in several New Zealand geothermal fields has shown severe casing deterioration on wells only 12-15 years old. Casings have been examined using Otis casing caliper, Kinley microscopic caliper, Schlumberger ETT-A (Electromagnetic Thickness Tool) and CBL-VD (Cement Bond) logs, flow logs and pressure tested using casing packers. Analysis of the corrosion products indicates that attack commences at the outer surface, limiting the effectiveness of mechanical casing caliper techniques. The electromagnetic thickness tool has been successful in identifying zones of severe corrosion.

INTRODUCTION

A routine casing caliper survey in 1983 on Broadlands BR25 showed severe corrosion had occurred in parts of the 8-5/8 inch production casing. This well was completed in 1971 and was one of the larger producers (350 t/h at 1260 kJ/kg, fig 4) Broadlands. It is located near the centre of the eastern production area, so that any such rapid casing deterioration could have serious implications for other nearby wells. To obtain as much information as possible about the corrosion problem, considerable time was spent during a workover/repair operation investigating the reasons for corrosion and testing methods of casing examination.

During the BR25 workover the following casing examination methods were used:

- Otis casing caliper (mechanical)
- Kinley microscopic casing caliper (mechanical)
- Electromagnetic thickness tool*
- Flow logs
- Packer tests

Other electrical logging methods which were not available in New Zealand at the time of the BR25 workover are discussed briefly, these include:

- Pipe analysis tool*
- Cement evaluation tool*

MECHANICAL CASING CALIPERS

Ministry of Works & Development at Wairakei have operated an Otis 64F088 casing caliper since 1958. This is a 30 arm tool which records the maximum outward deflection of any one of the 30 arms on a metal chart. It has been successfully operated at temperatures up to 260°C. The tool is very robust and can retract to 5 inch OD while running into the hole, allowing it to be used in quite badly deformed casing.

Recently a Kinley Microscopic Casing Caliper has been used on several wells at Wairakei and Broadlands to evaluate its performance compared with the Otis tool. The Kinley caliper has 15 arms, the movement of each arm being independently recorded. This gives a good three-dimensional picture of the internal surface of the casing, which for example allows the difference between an isolated corrosion pit and a horizontal fracture to be determined. The Kinley caliper has been used in wells up to 230°C but cannot be used where the casing is badly deformed as it has a six inch diameter skirt and centralisers which hang up on small obstructions. There is also the danger of losing the tool which is used on a rental basis.

ELECTRICAL LOGGING SYSTEMS

The only casing examination tool which was available at the time of the BR25 workover was the Schlumberger electromagnetic thickness (ETT-A) tool. This tool measures the phase change between a transmitting and a receiving coil to determine the amount of steel nearby. As the tool is located centrally in the casing, the signal can be related to casing thickness. The ETT log is best used in conjunction with the pipe analysis tool (PAT). The PAT log examines the casing for small defects on the inner and outer walls using magnetic flux leakage and eddy current distortion measurements. Both the ETT and PAT logs are generally only suitable for qualitative interpretation. If base line surveys are done soon after installing the casings, repeat surveys can be used to give a quantitative estimate of metal loss.

The cement evaluation tool (CET) can also be used to determine the condition of the inside surface of the casing. Using sonic techniques four caliper measurements are made, allowing more thorough analysis than with the PAT survey where only maximum readings are recorded.

Cable and tool limitations restrict all the above logs to a maximum temperature of about 150°C, so wells must be quenched.

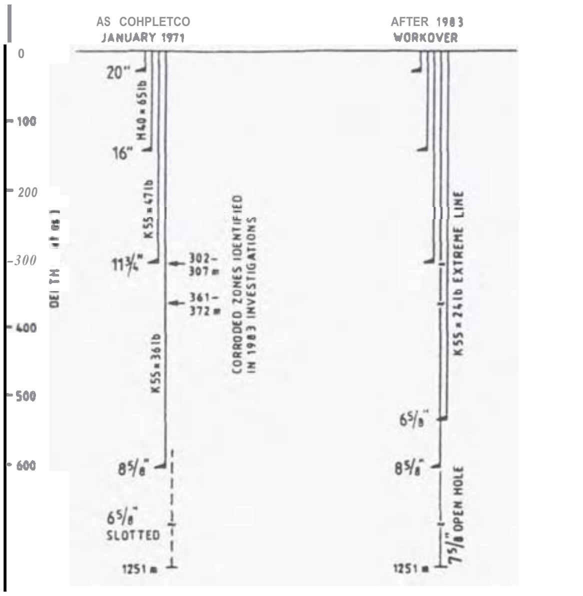


figure 1. BR25 well details before and after the 1983 workover.

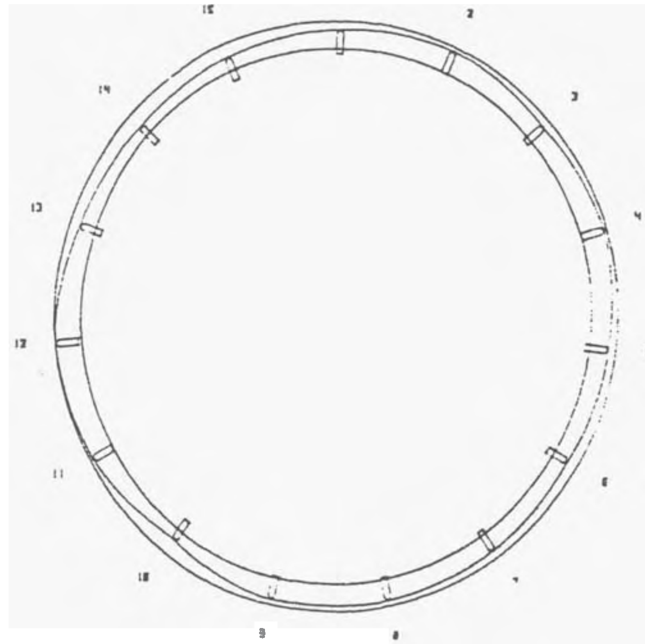


figure 3. Casing cross-section at 370m depth. The two concentric circles represent original casing ID and OD, and the irregular line the measured ID from the Kinley survey.

Continuous flow logs are also very useful for precisely locating casing breaks which have connections to permeable formation.

PACKER TESTS

For the BR25 tests a drillable plug was placed at the bottom of the 8-5/8 inch production casing (about 600m), and a retrievable casing packer was set at various levels to allow pressure tests above and below the packer.

This is a potentially risky procedure as pieces of damaged casing can fall on top of the packer and the action of the slips may further damage already "fragile" casing.

BR25 RESULTS

The BR25 well details before and after the December 1983 workover to repair the production casing are shown on figure 1. The first indication of a problem was an Otis caliper run in May 1983 which showed severe damage over length 18 (361-373m) and moderate deformation on length 23 (296-309m). A Kinley survey in September confirmed the Otis survey that damage was confined to two lengths only (figure 2). Two cross-sections taken off the Kinley record are shown on figure 3.

The ETT log of the same lengths is shown on figure 4.

Flow logs made while the well was plugged at the bottom of the 8-5/8 casing showed losses at 303 and 370m. Pressure measurements showed this zone to have an injectivity of 2 t/h.b (less than 10% of that obtained from normal high-producing wells at Broadlands).

Packer tests showed a leak in the casing between 281 and 319m. This method can only identify the shallowest leak. This method was also used to obtain samples from the 370m break.

Following the packer tests the Otis caliper was rerun, but would not pass through 299m. This confirmed the ETT log but this level was seriously damaged, while the pre-workover Otis-Kinley runs indicated that at this level the casing, although fractured, was still intact. (It appears a "window" had been made in the casing due to running drilling tools in the hole).

The cement bond log indicated there was no remaining bond between the grout and production casing, although a "satisfactory" job had been made of the original cementing. This was the first CBL on BR25. Samples of casing recovered during the workover indicated that the grout, at least at the damaged zones, had been completely converted to calcite.

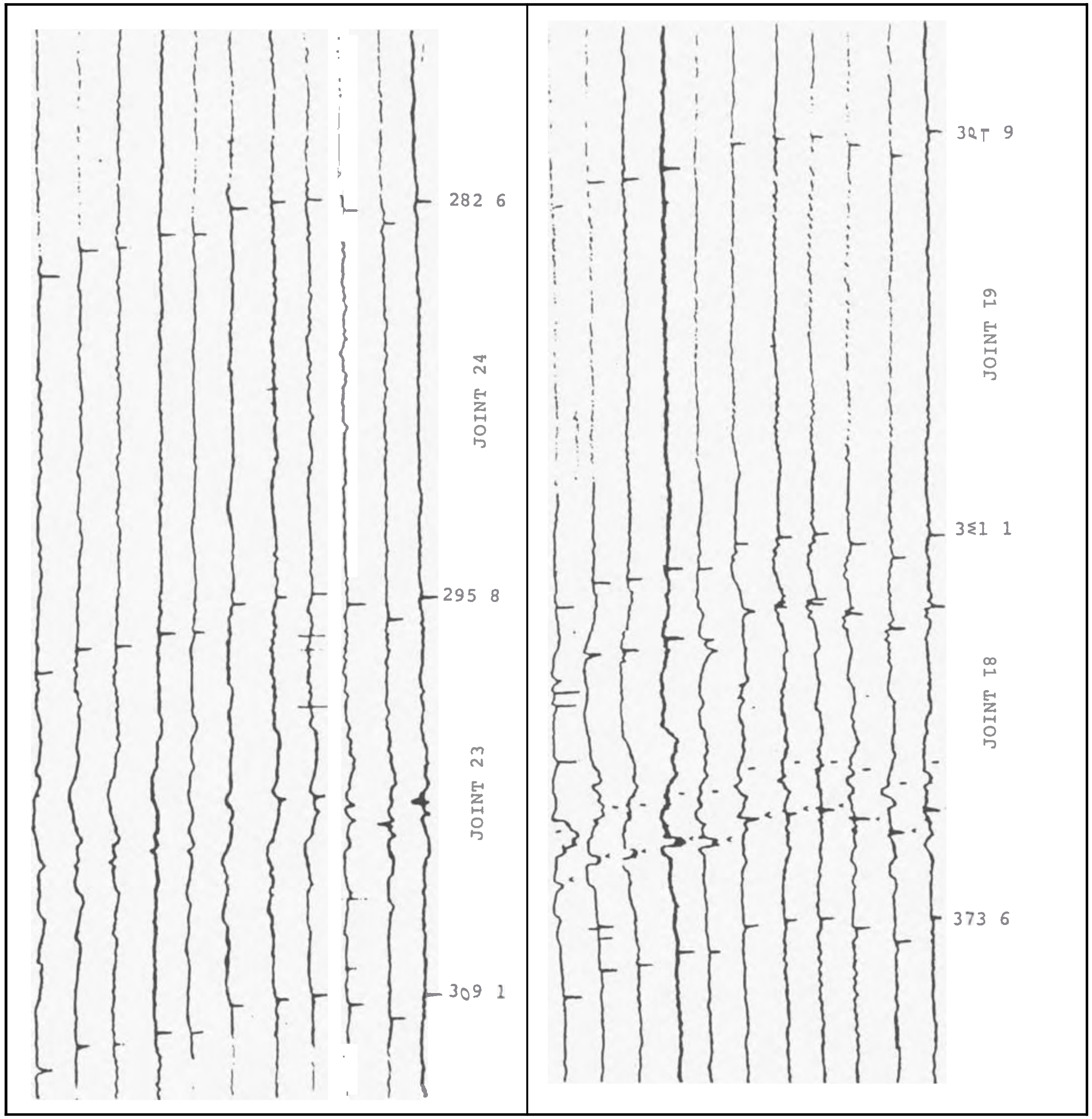
After casing investigations had been completed, the bottom plug was drilled out and the 6-5/8 inch slotted liner removed. After placing a drillable plug at 600m a 6-5/8 inch extreme line casing was run and cemented to 540m.

A comparison of well output before and after the workover is shown on figure 5. There is an overall reduction in mass flow of 20-22%.

CORROSION MECHANISM

Samples of corroded casing recovered during the workover have been analysed by Industrial Processing Division of DSIR and reported by Driver and Wilson. In brief, sections of casing have been completely converted to magnetite. Corrosion appears to have commenced at the outer casing wall, with recovered samples indicating a minimum corrosion rate of 0.7 mm/year. To corrode the complete casing wall in 12 years (1971-83) would require a rate of 0.8 mm/year.

Corrosion is attributed to high bicarbonate,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