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CASING INSPECTION CALIPER CAMPAIGN IN THE LEYTE GEOTHERMAL PRODUCTION FIELD, PHILIPPINES

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ABSTRACT

Casing inspection caliper surveys were conducted in ten (10) production wells in the Leyte Geothermal Production Field (LGPF) to examine possible deterioration of the production casing, which has been suspected as a result of long term continuous production of high velocity dry steam discharge. Surface manifestations of erosion were also observed at the wellhead and branchline. Casing deterioration compromises the integrity of the well that could result to casing bursting, collapse and even underground blowouts.

The caliper surveys were able to gather information on the internal casing condition which was used to determine the degree at which the casing was deteriorated or worn. The presence of inside casing wall anomalies was also detected. Considerable metal loss was measured in all the wells surveyed. Material deformation, scaling and even a possible wall opening were also detected in several wells. These data help define the physical integrity of the internal casing around which failure mechanisms or stresses that the well casing is subjected to under geothermal service conditions are evaluated.

The results of the caliper surveys serve as a reference for future well utilization and intervention strategies, which are preemptive measures to prevent further deterioration of the well and maximize, preserve or prolong the wells production capacity. Given the value of the caliper information, incorporating periodic caliper surveys in the long term monitoring and preventive maintenance program of wells should continue.

INTRODUCTION

The Leyte Geothermal Production Field, Philippines (shown in Figure 1), has been producing since late 1970's. Wells and surface equipment naturally experience deterioration as an effect of continuous discharge. The damage caused to wellheads and branchlines are more evident and easier to resolve compared to anomalies that may arise due to reduction in casing wall thickness especially in wells with high velocity dry steam discharge.

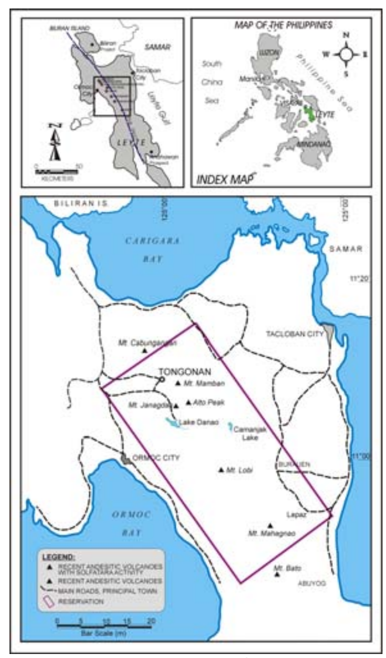

Figure 1: Location Map of Leyte Geothermal Production Field

The casing inspection caliper (CIC) survey is conducted to investigate internal casing condition. Material loss in the casing compromises its integrity which may eventually lead to casing breaks, collapse and significant reduction of the wells' output. Casing breaks at shallow depths may cause steam to seep in the formation and within the pad. Uncontrolled, it may lead to underground blowouts.

Monitoring casing integrity is necessary to avoid such incidents which may cause environmental and safety concerns.

CANDIDATE WELL SELECTION

A number of wells nominated from the different sectors of the Leyte Geothermal Production Field were considered for the casing inspection caliper campaign. Recommended wells were the long term continuously producing wells with high possibility of erosion due to high velocity dry steam discharge. Substantial weight was also given to the old wells that are due for workover and those where wellhead and branchline thinning were observed. Among the nominees are wells with previous CIC logs, to be able to compare and evaluate extent of material loss in comparison to the previous log.

After careful deliberations, ten (10) wells from the different sectors: Tongonan – 6, South Sambaloran – 2, Upper Mahiao – 2; were selected for the CIC campaign.

EQUIPMENT

The equipment used for the survey (Figure 2) is a mechanical 60-finger caliper tool run on a 5/16" mono-conductor wireline. Prior to run in of tool, an 8" blockage survey was run in hole to verify maximum clearance wherein the largest OD of the assembly is the 8" base plate. The tool is then lowered until the maximum depth, then the fingers are engaged to measure the inner diameter of the well while logging up.

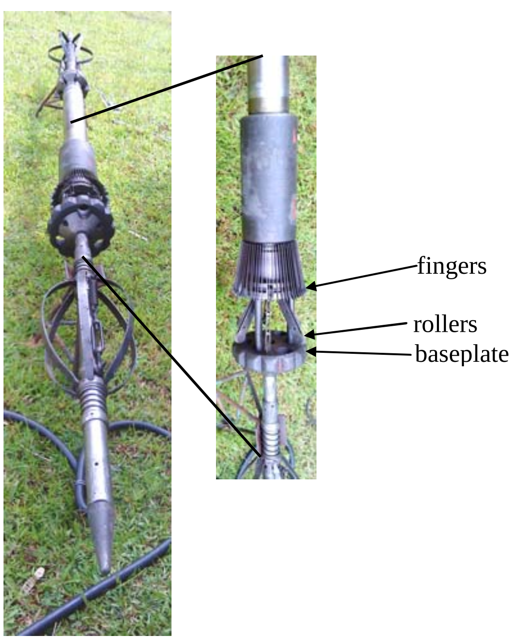

Figure 2: Casing Inspection Caliper Tool.

Out of the 60 fingers of the tool, only the data of the minimum and maximum wall thicknesses are recorded. These data are compared to the nominal casing thickness of the well. Signatures of pitting, deformation or ovalization, scaling and holes can also be detected from log.

RESULTS AND ANALYSIS

Out of the ten wells surveyed, only 2 wells, Well 209A and Well 103, will be discussed in depth in the following sections.

Well 209A has a previous log and rate of material loss will be evaluated.

Among the wells surveyed, Well 103 exhibits the worst condition. This is expected of the well as it has been producing since the 1970s and is evidenced in the log. Application for burst pressure analysis, which was also conducted for all of the wells surveyed, is best represented by this well.

Well 209A

Well 209A is located in the Tongonan sector of LGPF and has been producing since 1980.

CIC logged 633m to surface of Well 209A based on a maximum clear depth of 643m with the 8" blockage survey.

Shown on the left and right side of the graph in Figure 3 are the logs of the minimum and maximum remaining wall thickness measured, respectively. The survey conducted, represented by the black lines, is superimposed on the previous log in 2002, represented by the red lines.

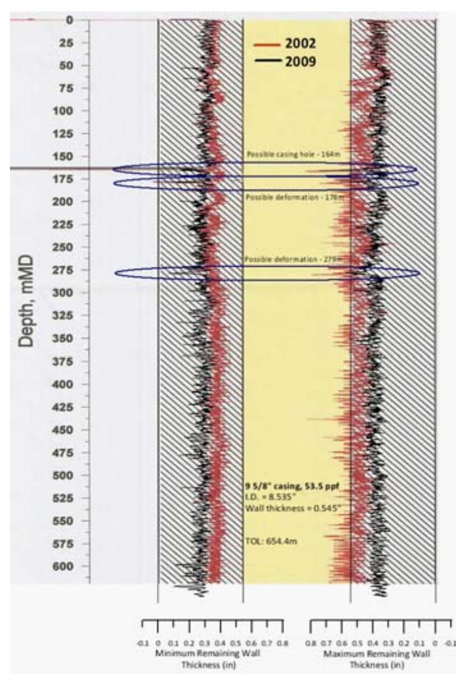

Figure 3: Well 209A CIC log superimposed on previous log (2002) showing significant thinning of casing wall.

In the 2002 log, it can be seen that reduction of casing wall thickness at the upper section (maximum remaining wall) may have been caused by the increased velocity of the solid particles in the discharge. In the 2009 log, a somewhat more uniform inner diameter can be seen with the material loss in the lower section of the logged depth.

Evaluating the wall thickness compared to the 2002 CIC log (Table 1), rate of material loss is 2.27 %nominal/yr.

Table 1: Well 209A Casing Inspection Caliper Comparison.

	Measured Average Wall Thickness (in)	Average Casing Wall Thinning (%)
2002	0.36 – 0.38	30.3 – 33.9
2009	0.28 – 0.38	30.3 – 48.6
Rate of material loss (%nominal/yr)		**2.27**

Well 103

Well 103 is located at the Tongonan sector. The maximum clear depth of the 8" blockage survey is 573m, tagging the top of liner. Consequently, the CIC logged from 560m to surface.

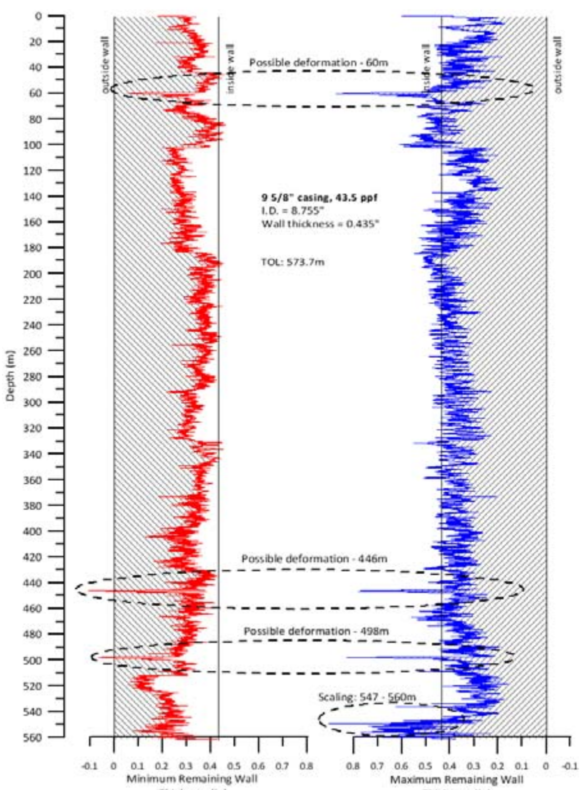

Figure 4: Well 103 CIC log of two casing showing significant thinning of casing wall

As seen in the log of the well (Figure 4), irregular wall thicknesses and very jagged log shows a rough, pitted surface. Casing deformities are apparent at 60m, 446m and 498m. Thicker sections at 547 – 560m with wall gain of 0.09 in. can be attributed to scaling.

Burst Pressure

Casing design must ensure that adequate safety margins exist against internal yield or burst resulting from high internal fluid pressure due to a range of situations that occur during and after the cementing of the casing. After well completion, the maximum differential burst pressure will occur at the wellhead and will be the result of the wellhead pressure (Hole, 2008).

Analysis of burst pressure using data from the caliper survey was used to compute pressure limitations in the operation of the well.

The internal yield pressure of the pipe is calculated using Equation (1).

$$P_B = 0.875 \frac{2Y_P t}{OD} \qquad (1)$$

where
P_B = burst pressure, psi
Y_P = specified minimum yield strength, psi
t = nominal wall thickness, in
OD = nominal outside diameter, in

A design factor is recommended by Hole (2008) whereby the ratio of casing internal yield pressure and maximum wellhead pressure shall not be less than 1.8.

The maximum shut pressure of the well is 4.2 – 4.9 MPag. Applying the design factor of 1.8 to the maximum shut pressure will result to 7.6 – 8.8 MPag. This exceeds the burst pressure at the thinnest section, 512 – 522m, which is calculated to be 5.9 MPag.

CONCLUSION

Data gathered from the casing inspection caliper logs indicate remaining wall thickness. Reduction of wall thickness of the casing translates to weakening of the casing from pressures being exerted in the well. Caution should be taken during well movements such that the shut-in pressures would not exceed the pressures that the casing can withstand. Although straightforward analysis was conducted for evaluation of burst pressure, numerous factors should also be considered, such as lithostatic pressure, collapse pressure and presence of permeability behind the cased off section for complete analysis for intervention strategies. Most wells that have been used in long-term production that experiences decrease in output are recommended for workovers. Workovers entail mechanical stress and casing wear which enhances potential of failure for thinner casings which have less tolerance.

Repeat CIC surveys will continuously monitor rate of material loss in wells and be used for recommending preemptive measures that should be undertaken to ensure safety in operations and productivity of the well. CIC logs should also be proposed for wells exhibiting high potential of casing deterioration.

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