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Magnetic Thickness Detector (MTD) and Multifinger Caliper (MFC) Tool for Well Integrity Assurance in PHE ONWJ

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MAGNETIC THICKNESS DETECTOR (MTD) AND MULTIFINGER CALIPER (MFC) TOOL FOR WELL INTEGRITY ASSURANCE IN PHE ONWJ

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Abstract

The paper will present case study of well integrity issue in well ED-2ST, PHE ONWJ. Well ED-2ST is located in E-Main structure at Echo field, PHE ONWJ. The well has been producing since 1990 before shut in due to fish problem in March 2015. The well last production test was 250 bopd and 56% WC. The well was proposed to be recompleted to recover the remaining reserves.

Magnetic Thickness Detector (MTD) and Multi Finger Caliper (MFC) tools were run after POH tubing string to inspect the 7" liner and 9-5/8" casing. Both tools were run from 3355' MD to surface. The MTD tool will provide the metal thickness or metal losses of the tubular, while the MFC will provide the tubular inside diameter which later on can be compared to its nominal value.

Based on both tools inspection, there was clear casing integrity issue in ED-2ST. The MTD results suggest that metal thickness losses at interval 1429 – 1468' MD is 38% with maximum loss depth at 1465' MD. And the MFC result suggest that there is casing leak/ parted at interval 1464 – 1467' MD, at that interval all caliper finger (56 arms) showed the ID size is equal to OD size of the tubular.

Based on the well integrity, the recompletion of ED-2ST was postponed. Further integrated assessment is on-going to recover the remaining reserves from the well. Also, the well integrity inspection will be performed as best practice prior to major workover in "old wells".

Keywords: *well integrity, case study*

1. Introduction

The Offshore North West Java (ONWJ) field is operated by Pertamina Hulu Energi ONWJ since 2009. The area consists of several oil and gas fields and has been producing since 1971 with more than 700 wells and 150 production platforms which are connected by 350 pipelines with total length of 1700 km. The produce liquid is collected and processed at single Central Plant.

The biggest hydrocarbon production field in PHE ONWJ is the Echo field, located in Arjuna Basin, 150 km North East Jakarta (Figure 1). The field was discovered in 1969, and started production in 1971 with peak production 97,000 BOPD in 1983. The field is separated into five structures of E-Main, E-East, E-South, ESRA and E-West. Currently Echo field produces 8,500 bopd and 8 mmcfd from 13 platforms, 45 active wells. Gas lift is the main artificial lift method in Echo field.

Well ED-2ST is located in E-Main structures. The well has been producing since 1990 before shut in due to fish problem in March 2015. The well last production test was 250 bopd and 56% WC. The well was proposed to be recompleted to restore its production and recover the remaining reserves.

The pulling out of existing tubing operation has been completed successfully in series with data acquisition to identify and understand well and tubular integrity with Multi Finger Caliper (MFC) combined with Magnetic Thickness Detector (MTD). The acquisition was performed for further well

assurance prior to recomplete and produce the well.

2. Data and Method

2.1 Multi Finger Caliper (MFC)

MFC is a tool to identify well condition whether there is wall thickening or thinning by measuring the well inside diameter with its 56 finger/arm. Later on, the inside diameter measurement result can be compared to its nominal value.

The MFC tool has measurement and deviation accuracy of ±0.5 mm and ±5 degree, respectively. The tool has working pressure and temperature up to 350^{o}F and 15,000 psi respectively. The maximum logging speed is 32 ft/min. For the MFC 56 arm tool, the OD size is 3-1/2".

2.2 Magnetic Thickness Detector (MTD)

MTD is a tool that provides metal losses on certain interval through measurement of various voltages which later on provide information on the tubular integrity.

The MTD tool has pipe string measuring range 2.36 to 18.625 inch. The tool has working pressure and temperature up to 350^{o}F and 14,500 psi respectively. The maximum logging speed is 32 ft/min. The tool OD size is 1.69 inch.

The MTD makes multiple voltage measurements at various times during the decay of the received signal. Each measurement being sensitive to a different "depth of investigation" to the surrounding tubing and/or casing. Early time points (or channels) relate to thickness of the inner tubular, and later time is related to the thickness of outer tubular.

2.2.1 MTD Log Interpretation Method

Figure 2 shows visualization of the responses in a color type map where the nominal response for each tubular is colored green. Positive values indicate thicker than nominal thickness is colored blue. And negative values indicate thinner than nominal thickness is colored yellow to red. While the color code provides a user-friendly visual identification of pipe anomalies, but this display is not quantitative.

The next step in log processing involves generating thickness values for the inner and outer tubular, typically the tubing and casing. As indicated in the Figure 2, the early time channels (inner pipe) are not affected by an outer pipe much and are only sensitive to inner pipe thickness variations approximately. Thus, by choosing channels in this early time region an inner pipe thickness is computed independently of any outer pipes present. The steps to compute an outer pipe thickness are similar, late time channels are chosen such that pipe collars are clearly detectable.

Figure 3 shows a typical presentation of MTD data interpretation:

- Track 1 - visualization of the responses in a color type map;
- Track 2 - wall thickness curves for the tubing, casing-1 and casing-2, with green shaded area between computed tubing wall thickness and nominal tubing wall thickness, red shaded area between computed casing-1 wall thickness and nominal casing-1 wall thickness and blue shaded area between computed casing-2 wall thickness and nominal casing-2 wall thickness.

Thus, from Track 2, changes to the left of the nominal thickness line represent metal loss or thickness reduction.

2.3 ED-2ST Recompletion Job

ED-2ST well is development well with 9-5/8" casing and 7" liner as production casing. The well was completed with 3-1/2" tubing. The ED-2ST well was planned to be recompleted by HWU (Hydraulic Workover Unit) with scope of work: sand clean out, cut and pull tubing, wellbore clean out, installation of new tubing spool and new completion string.

Prior to the recompletion job, the pressure mapping of tubing and casing string suggest that there is pressure build up from annulus

between tubing and casing which indicate anomalies in the annulus. The pressure anomalies may be caused by communication with existing reservoir due to packer or tubing leak, or integrity issue with the casing interval above packer. However, existing zones is quite depleted based on the last SBHP survey where the reservoir pressure is around 550 psi compare to its original pressure at 1400 psi. Therefore, the possibility of pressure builds up in the annulus casing is suspected due to integrity issue with the casing interval above packer. Thus, the data acquisition by combination of MFC and MTD was performed to understand further the well integrity issue.

After sand clean out, cut and pull tubing string, and wellbore clean out, the data acquisition or surveillance for well integrity is performed from depth 3355 ft md to surface. Table 1 shows casing specification from this well.

3. Result and Discussion

3.1 MFC Log Result

From full range of MFC measurement, the 9-5/8" casing showed very light to moderate penetration. However at the depth 1466.02 ft, MFC showed 100% maximum penetration (Figure 4).

Figure 5 shows the zoom in scale for MFC measurement result of casing 9-5/8" for interval 1451 – 1470 ft MD. Figure 6 and Figure 7 show the MFC cross-section and 3D visualization for the same interval.

The maximum diameter that was measured by the tool arms is 9.889 inch for one of the arm which is bigger than the nominal outer dimeter of the casing, i.e. 9.625 inch. Based on the cross section at 1466.02 ft, the casing inside diameter measurement is very near to nominal outer diameter. It suggests casing integrity issue.

Another interested interval in casing 9-5/8" is interval 1625 – 1665 ft. Figure 8, Figure 9, and Figure 10 show the measurement result for the interval. Based on the cross section at depth 1653.54 ft, the measurement result is similar to ellipse shape where the minimum measurement is close to nominal inner diameter but the maximum measurement is bigger than the nominal outer diameter.

Figure 11 dan Figure 12 show the MFC measurement result for interval 2290 – 2370 ft md in 7" liner. The color type code show relatively uniform light penetration. It also confirmed by the cross section where the maximum and average is close to the nominal inner diameter of the 7" casing. This result demonstrate good identification and comparison between "normal" weariness in the 7" casing and casing integrity issue in the 9-5/8".

3.2 MTD Log Result

From full range of MTD measurement data, the maximum wall loss is very light except at depth 1465 ft md where the wall loss is up to 37.87% (Figure 13). The damage interval depth is in line with the one measured by MFC tool. Thus the casing integrity issue in 9-5/8" casing is confirmed.

Meanwhile, the MTD measurement in 7" liner shows that the maximum wall loss is very light to moderate corrosion and up to 5.70% at 3094.4 ft (Figure 14).

4. Conclusion

Based on the acquired data and analysis, following conclusions are derived:

1. Multi Caliper Fingers (MFC) and Magnetic Thickness Detector (MTD) can be used to determine well integrity issue with good accuracy, both in different tubular size and pin point depth interval.
2. Although MFC and MTD tool can be run separately to identify well integrity problem, it is best to combine both measurement to complement each other.

Forward plan and lesson learnt from MFC and MTD measurement in ED-2ST are:

- The recompletion of ED-2ST was postponed. Further integrated assessment is on-going to recover the remaining reserves from the well.

- The well integrity inspection will be performed as best practice prior to major workover in “old wells”.

5. References

Baker Hughes, “Multi Finger Caliper Manual Book”

Baker Hughes, “Magnetic Thickness Detector Manual Book”

PHE ONWJ, ED-2ST well files, 2017

List of Figures

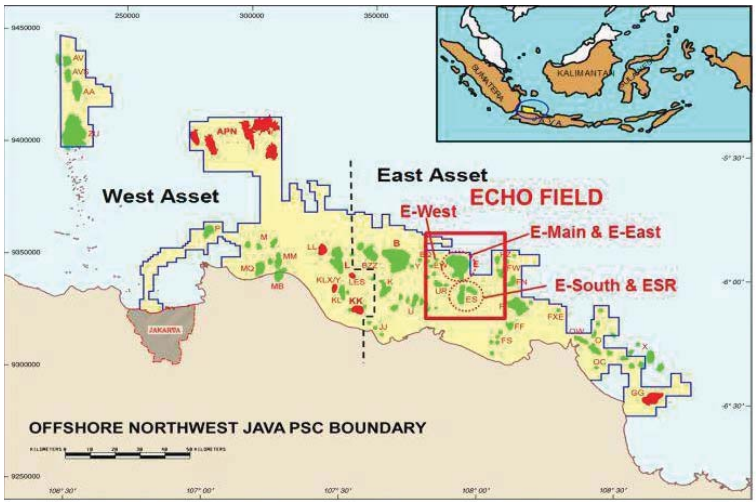

Figure 1. ONWJ Field

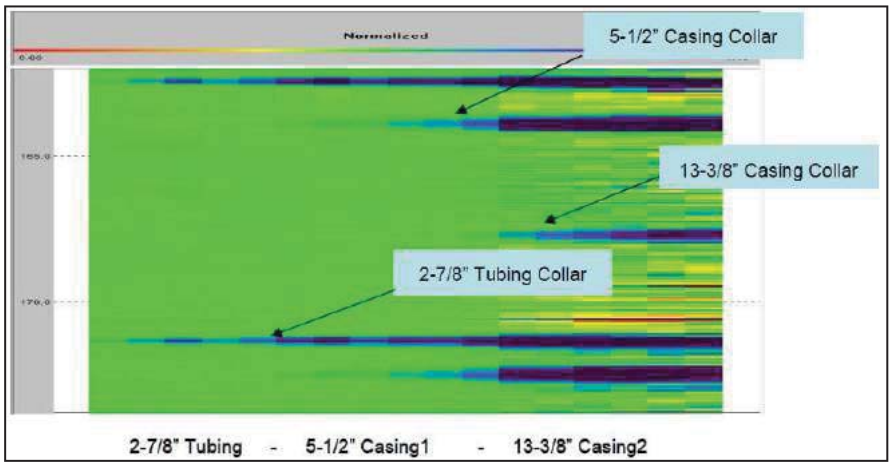

Figure 2. MTD color type map visualization

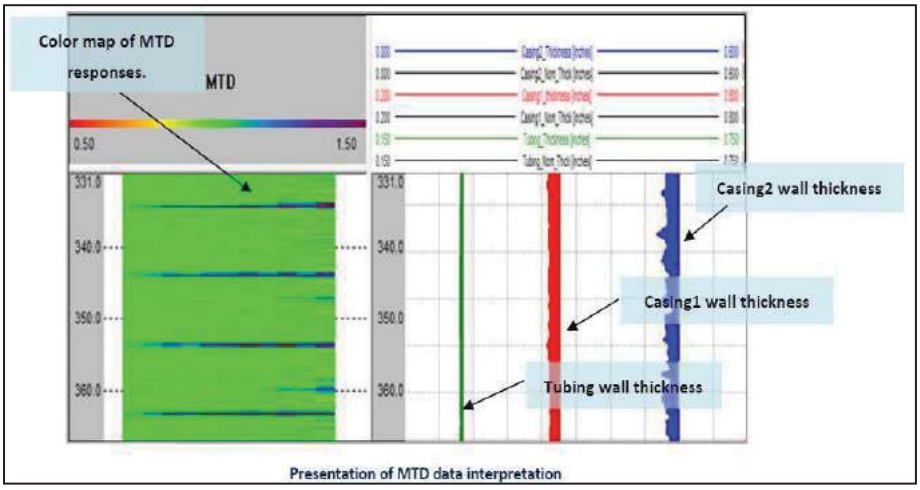

Figure 3. Example of MTD data presentation and interpretation

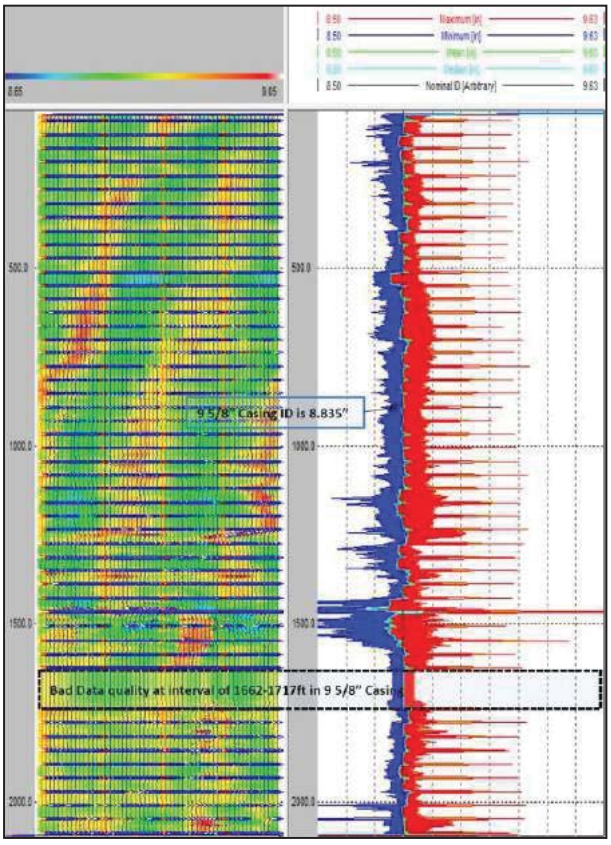

Figure 4. Casing 9-5/8" MFC measurement result

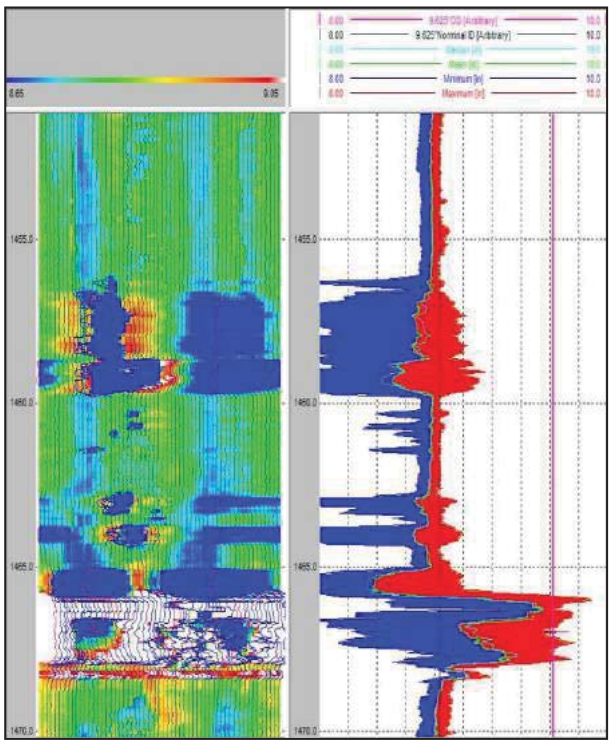

Figure 5. MFC Data interval from 1451 – 1470 ft MD

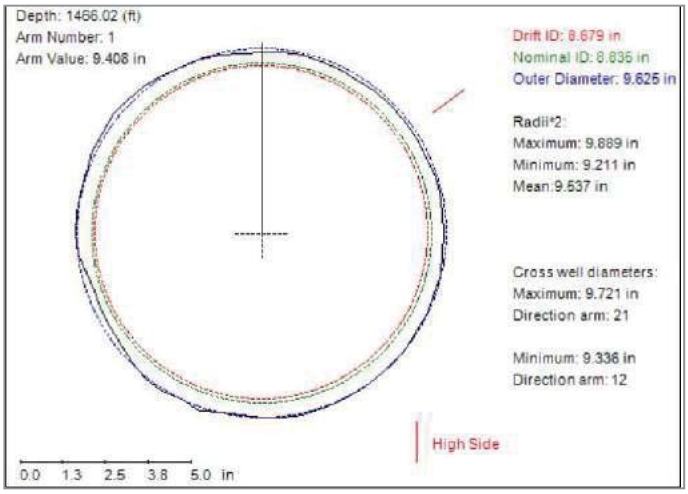

Figure 6. MFC data Cross-Section view at the depth 1466.02 ft MD

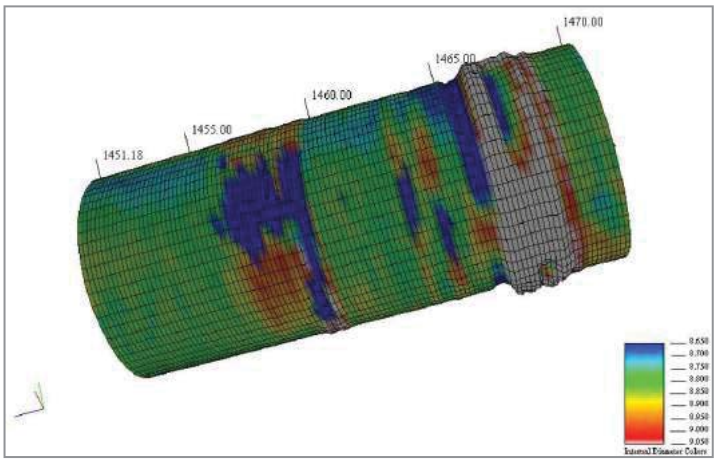

Figure 7. MFC data 3D visualization from 1451-1470 ft MD

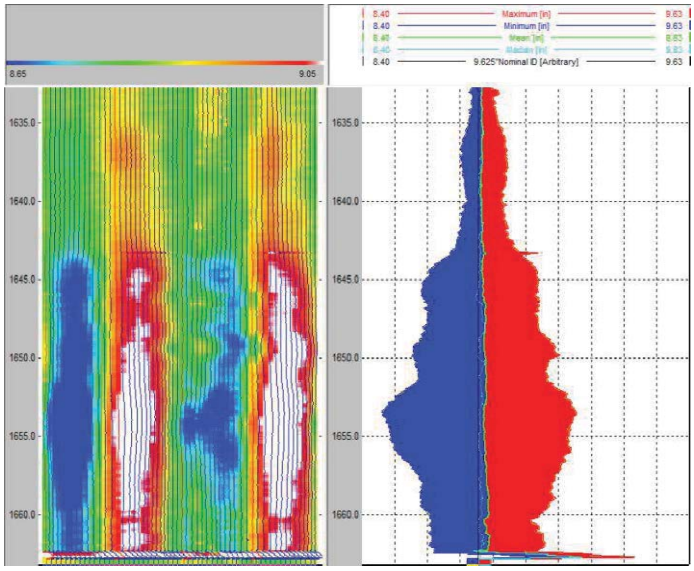

Figure 8. MFC data interval 1625-1665 ft MD

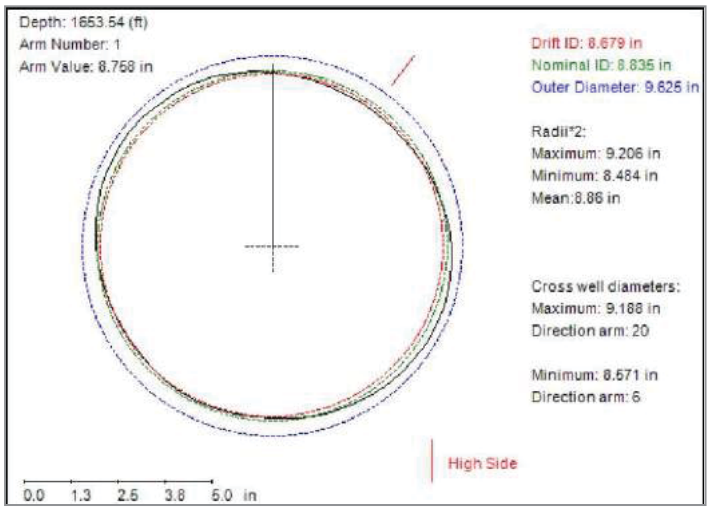

Figure 9. MFC data Cross-Section view at the depth 1653.54 ft MD

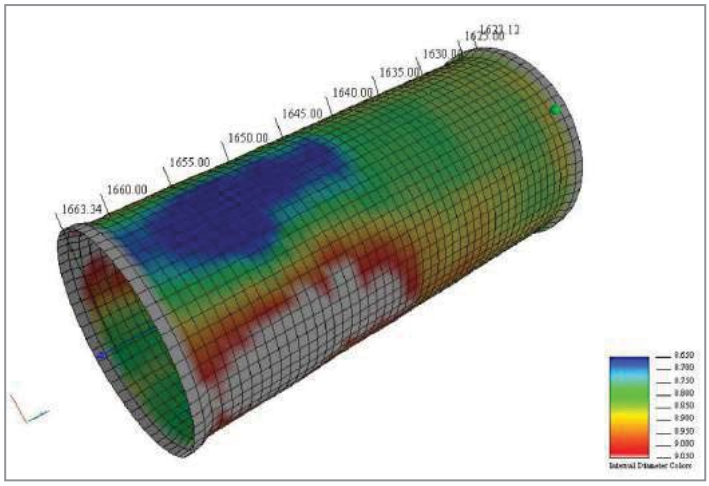

Figure 10. MFC data 3D visualization from 1625-1665 ft MD

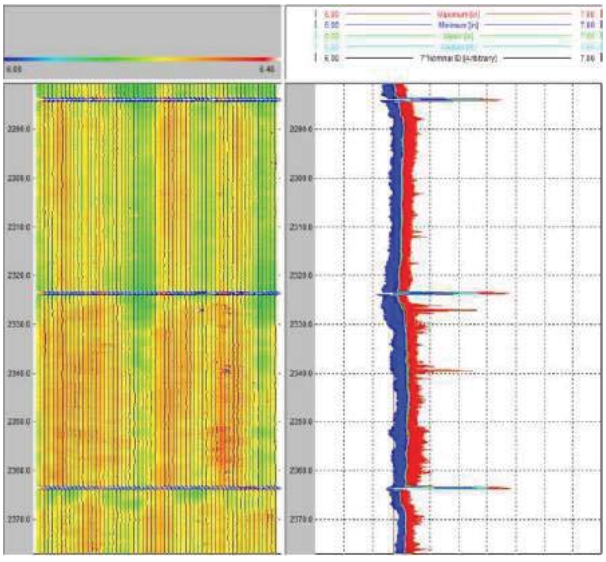

Figure 11. MFC data interval 2290 – 2370 ft in 7” liner

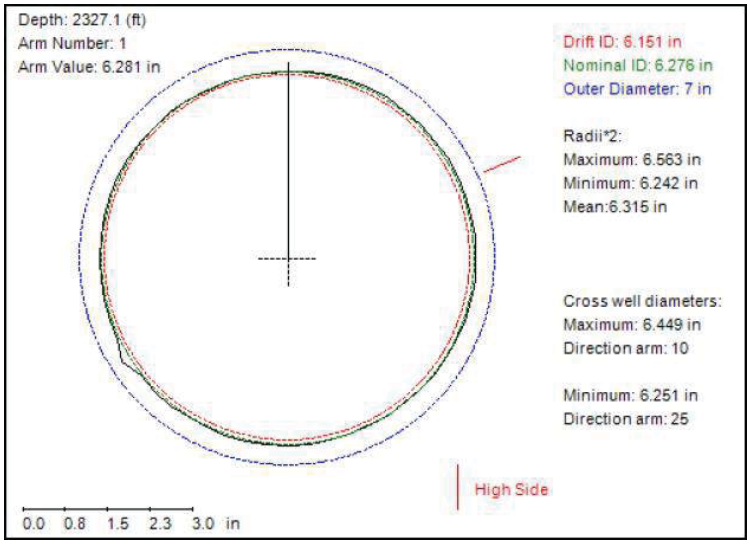

Figure12. MFC data Cross-Section view at the depth 2327.1 ft MD

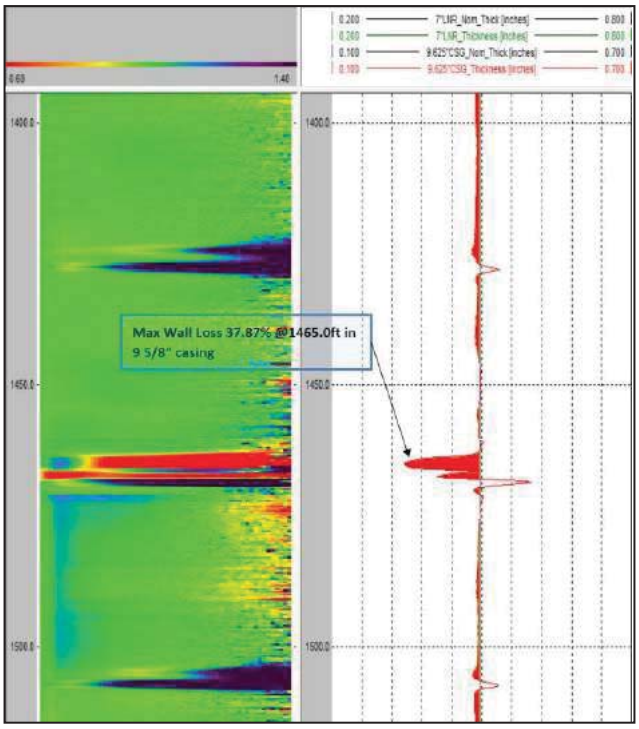

Figure 13. MTD data interval 1400-1520 ft MD

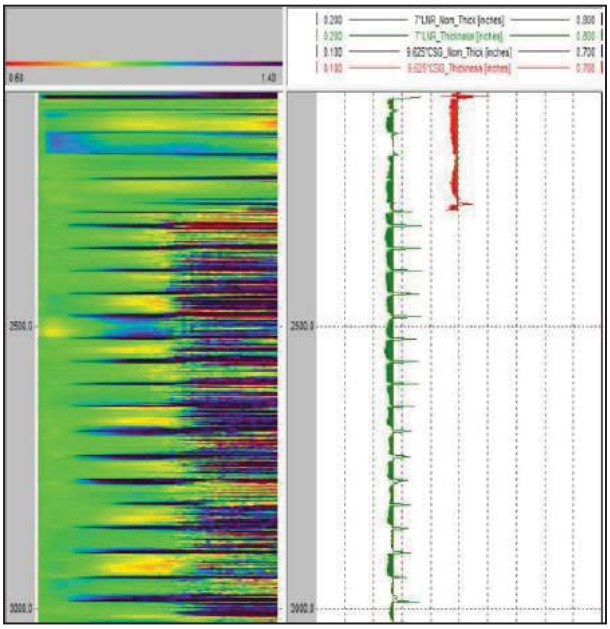

Figure 14. MTD data interval from 2100 to 3000 ft MD

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Table 1. Casing specification in ED-2ST well

Intervals	Interval 1	Interval 2
Start Depth(ft)	82	2093
End Depth(ft)	2093	2285
Tubular size	9.625" CSG-0.395"@40ppf	7" LNR-0.362"@26ppf
	13.375"- 0.48"@68ppf	9.625" CSG-0.395"@40ppf
	/	13.375"- 0.48"@68ppf
Intervals	**Interval 3**	**Interval 4**
Start Depth(ft)	2285	2299
End Depth(ft)	2299	3365
Tubular size	7" LNR-0.362"@26ppf	7" LNR-0.362"@26ppf
	9.625" CSG-0.395"@40ppf	/