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Unlocking the Root Cause of Sudden Lowering Wellhead Pressure in Well EPT-L/2

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ABSTRACT

EPT-L/2 is one of production well in geothermal prospective area to support steam supply into the existing power plant. During its production period, the well had a quite rapid decline among other wells due to scaling formation in this well. Hole cleaning and acidizing conducted to break the scale and the well was automatically shut-in during and after both treatment when the well had heated up, the discharge test was trying to asses well EPT-L/2 producibility. But, this well has decreased WHP during the discharge test rapidly, causing the well to not flow. Based on the latest Pressure & Temperature measurement data, it is known that there is a very significant increasing in temperature at depth of 230 mMD. Preliminary analysis of the possibility of a water pocket at that depth is heated by steam-heated water in a shallow aquifer. There is an indication of casing leak namely: There are 2 inflow points on the 13-3/8" casing which are at a depth of 223 mMD and 932 mMD and There is a temperature anomaly that is probably associated with cold water inflow into the casing 13-3 / 8 "at a depth of 223 mMD and 932 mMD. Another survey is needed to ensure that there is a leak/damage to the casing at the depth of the suspected damage to the casing. Well integrity surveillances have been conducted to unlock the root cause such as PTS Survey, Magnetic Thickness Detection survey. Acoustic Leak Flow Analyzer, Caliper Logging, and Downhole Sampling. Based on all the well integrity surveillance, those survey can confirm that there are some casing damage at depth 223 mMD, 390 mMD, 650 mMD, 932 mMD, which is characterized by the inflow of cold water appearance in production casing based on metal loses, soundwave sensor, and caliper data. The acid content of fluid either from steam-heated water or acid dumping during acidizing is negligible based on downhole sample analysis. Eventually, EPT-L/2 suggested being worked over for maintaining the production of the well.

1. INTRODUCTION

Indonesia is one of the countries with the largest geothermal reserves in the world which is currently always developing this industry massively. In addition to supporting the energy transition phase from fossil energy to renewable energy, PT. Pertamina Geothermal Energy as one of the national growth milestones in clean and green energy to meet the energy needs, especially electricity for the people, is always committed to increasing the installed generation capacity. Along with geothermal production activities. various characteristics of existing geothermal well production wells have been identified.

The issue that is often found in geothermal wells is related to well integrity. In general, damage to casings in geothermal wells is caused by the heat exposures/contacts that occurs during the production period of the well which causes the strength of the casing, cement and other components to decrease over time. This becomes an important lesson learned for geothermal drilling activities because drilling materials are needed as well as good drilling planning.

2. OBJECTIVE

The main survey objectives are Well integrity surveillance:
1. Evaluate Profile inside diameter of 13-3/8" casing and the thickness of 13-3/8" & 20" casing in the well.
2. Locate source of the cold water inflow to 13-3/8" casing causing the well is stop to produce.

After completing the well surveillance work, it can further assist in the planning of work to be carried out to repair the wells such as workover of well EPT-L/2 and work programs in accordance with the well's problems.

3. WELL HISTORY

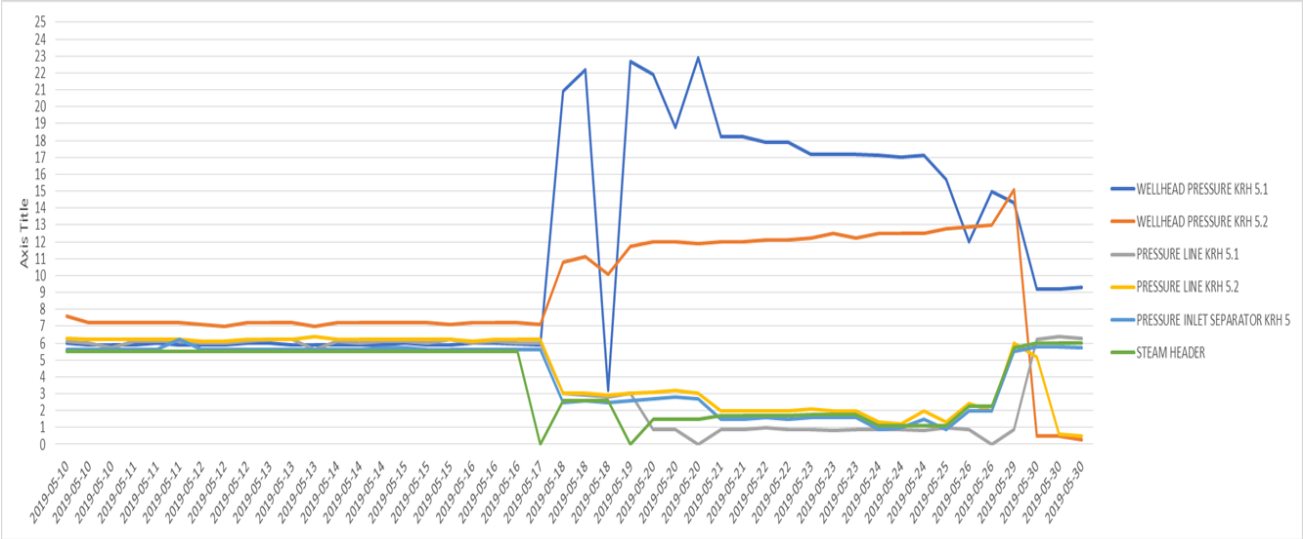
EPT-L/2 is steam producer and experiencing of cooling from shallow reservoir cold water inflow. PTS has been ran and suggested that there are two inflow spot in 13-3/8" Casing at 220 m and 932 mMD.

History :

17 - 28 May 2019 : power plant trip occurred
May 16, 2019 : WHP at 7 barg with MV 100% open
May 17-28 , 2019 : WHP ranges from 10-13 barg with MV 30% open

May 29, 2019 : 50% opening of TKS to 15 barg, at 12.00 the opening of the Upstream gate valve from 30% to 0% and CV bypass opened 30% WHP becomes 5.7 barg

May 30, 2019 : WHP dropped to 0.5 barg, the well stop to produce suddenly.



Whe the well is in shut in condition, PTS shut in was conducted to investigate the sudden lowering pressure of the well. Then, from PTS log suspected that:

1. There is two inflow spot in 13-3/8" casing
   - 220 m MD
   - 932 m MD

2. From Temperature log, there is cooling temperature anomalies which may associated with the active reservoir charging the cold water to annulus of 13-3/8" Casing, which are:
   - 65 – 130 m MD → exit point at 220 m MD. Potentially the 20" casing is damage as well.
   - 530 – 550 m MD → exit point at 932 m MD

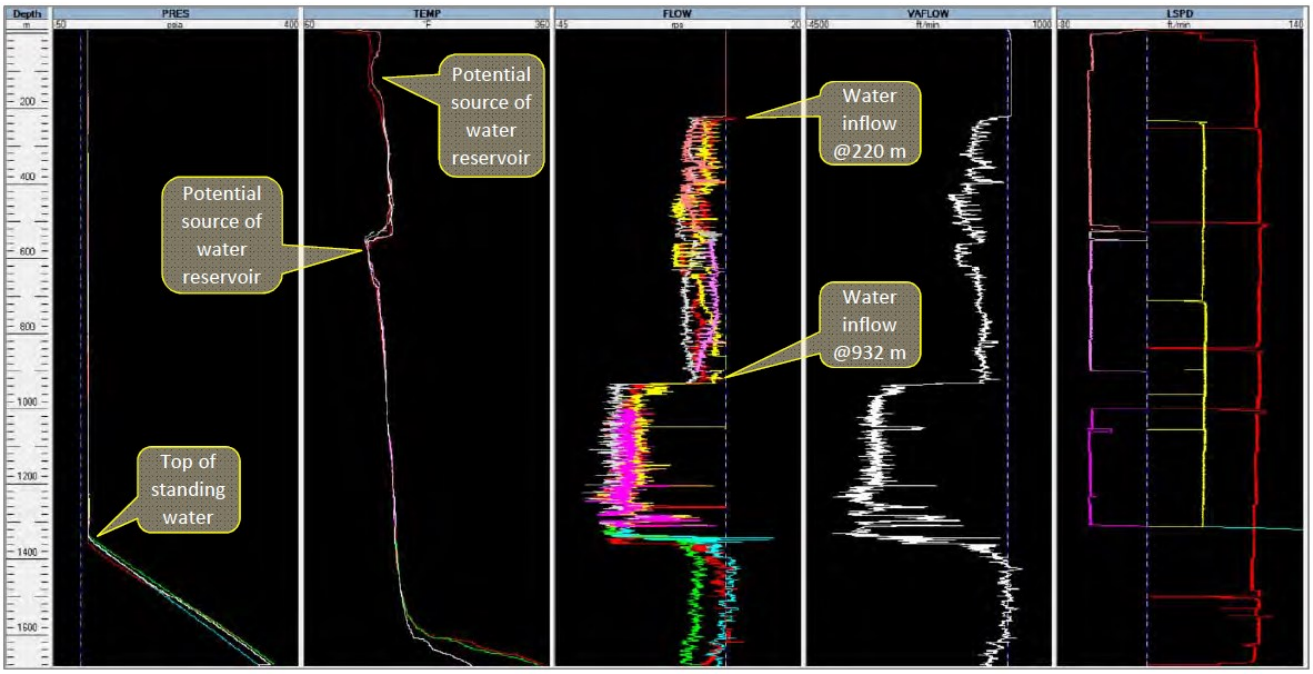


Figure 1. Pressure, Temperature & Spinner under Shut In condition of Well EPT-L/2

4. WELL INTEGRITY SURVEILLANCE

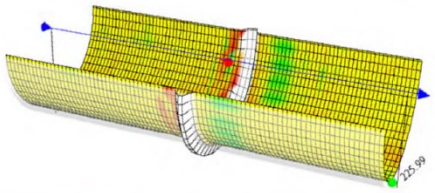
MFC (Multi-Finger Imaging Caliper 56) to evaluate obstruction inside casing

Measurement :

- 24/40/56 independent caliper logging curves
- Deviation
- Relative Bearing
- Temperature

Specification :

- Max Temperature : 350 F
- Max Pressure : 14.5 kPsi
- Radial Accuracy : 0.5 mm
- Resolution : 0.1 mm



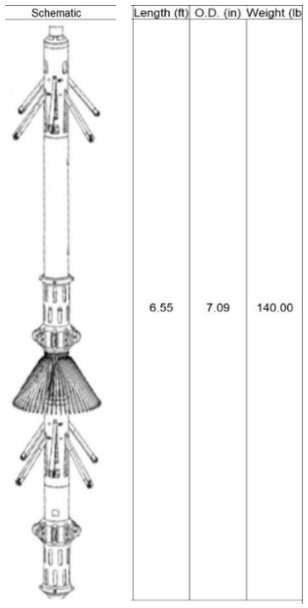


Figure 2. Tool Specification and Analytical Illustration of MFC

4.1.1 MTD (Magnetic Thickness Detector) - Pulsed Eddy Current tool

MTD is an instrument to measure the corrosion rate of the tubing. MTD tool can evaluate the quantitative thickness of tubing/casing. The state-of-the-art instrument combines a high power transmitter, improved signal-to-noise (SNR) electronics and fully configurable acquisition. This flexible approach allows a wide range of evaluations under different conditions and conveyance systems.

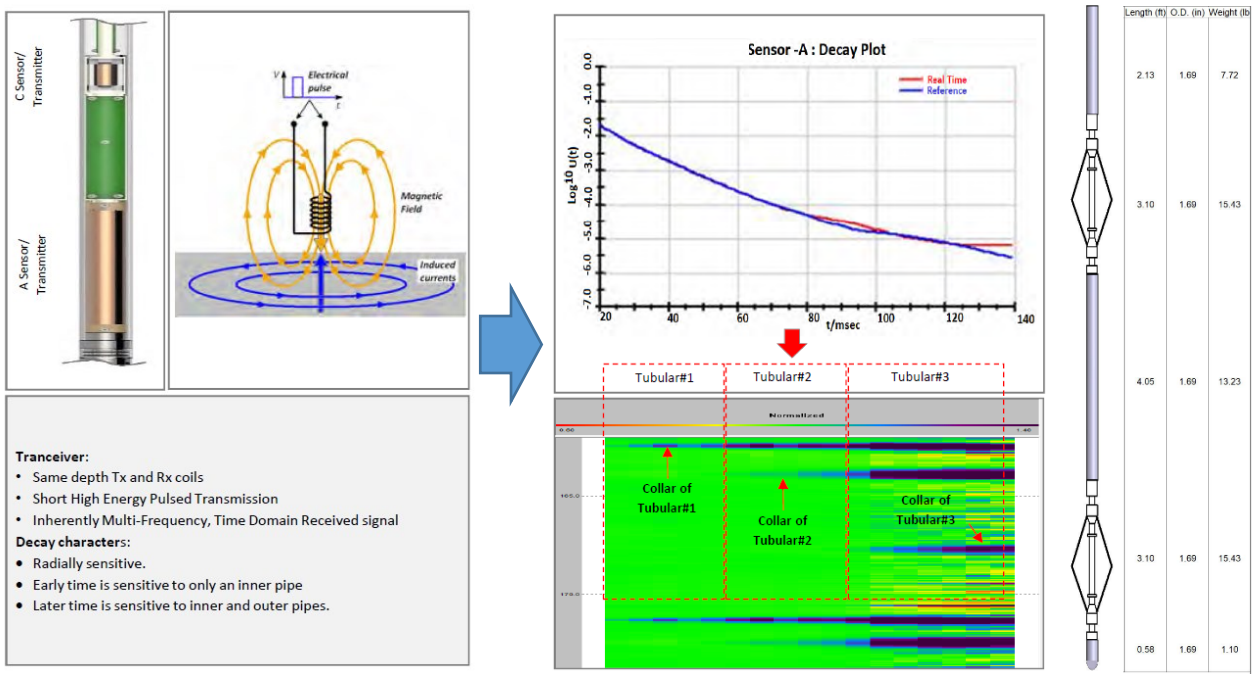


Figure 3. Tool Specification and Principle of MTD

4.1.2 ALFA (Acoustic Leak Flow Analyzer) – a spectral passive noise tool

Acoustic Leak Flow Analyser (ALFA) is a memory tool used to carry out various well diagnostic studies including Well Integrity Evaluation, Production Performance and Reservoir Monitoring. This device measures Acoustic Spectrum within the range of 8 Hz to 60,000 kHz with very high frequency resolution. The tool consists of Spectral Noise, Pressure, High Resolution Temperature and Casing Collar Locator sensors.

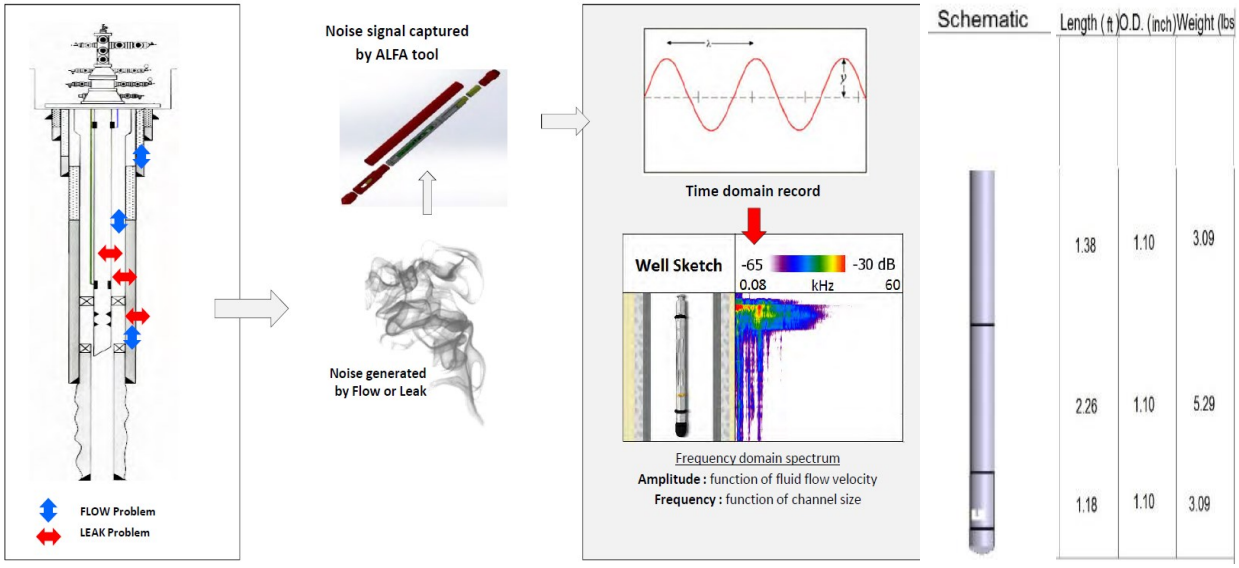


Figure 4. Tool Specification and Principle of ALFA

4.1 Logging Procedure

4.1.1 Multi Finger Caliper to to evaluate obstruction inside 13-3/8" casing

a. RIH from surface to 1380 m at maximum 60 m/min. Ensure MFC fingers are closed. Slow down when approaching restriction or TD.
b. Open MFC fingers. Log up repeat pass at 9 m/min over 30 m interval. Stop recording and close MFC fingers.
c. RIH to 1380 m. Slow down when approaching restriction or TD.
d. Open MFC fingers. Logging up to surface at 9 m/min
e. Anomalies encountered while logging the main pass should be repeated.

4.1.2 Magnetic Thickness Detector to evaluate casing Thickness conditions

a. RIH MTD Tool from surface to 1380 m at maximum 60 m/min. Slow down when approaching restriction or TD.
b. Log up repeat pass at 2.4 m/min over 30 m interval.
c. RIH to 1380 m/min. Slow down when approaching restriction or TD.
d. Logging up MTD-G on MODE#4 at 2.4 m/min (8 ft/min) logging speed to surface.
e. Anomalies encountered while logging the main pass should be repeated.

4.1.3 ALFA to evaluate B-Annulus Suatain Casing Head Pressure flow source

a. RIH from surface to 1380 m at maximum 60 m/min. Slow down when approaching restriction or TD
b. Rig up ALFA/Temperature/CCL Tool
c. RIH from surface to 1380 m at maximum 9 m/min, recording the temperature and CCL. Slow down when approaching restriction or TD.
d. Record up stationary for 32 second/station from 1380 mMD to surface on following steps

Table 1. Depth Target of ALFA Program

#	Bottom mMD	Top mMD	Stationary Spacing (m)	Total Stationary Levels
1	1380	1200	5	36
2	1200	1000	10	20
3	1000	500	2	250
4	500	300	5	40
5	300	50	2	125
6	50	0	5	10
			TOTAL	481

4.2 Data Processing

MTD, MFC and ALFA data were processed through MIPS program with the details as follow :

1) MTD processing workflow

Loading raw data into MIPS software is the first step for MTD interpretation. Then the data might be pre-processed including depth correction and abnormal value editing that are optional steps and not must be done. Collar detection is then used for the processed data from MIPS to locate the top and bottom depths for each joint. The next step is thickness calculation and right curves should be selected. And then make annotation for well schematic and pipe defect according to thickness calculation results. The last is outputting joints analysis tables for different pipes and result LAS file.

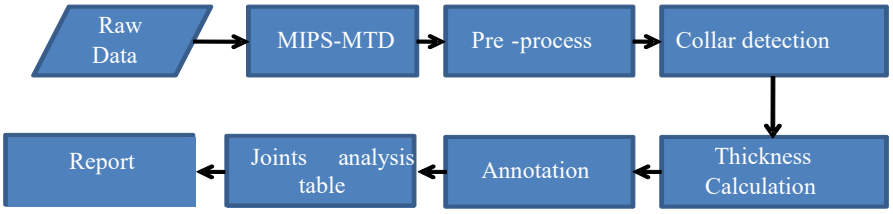


Figure 5 - MTD processing workflow

2) MFC processing workflow

Loading raw data into MIPS software is the first step of MFC interpretation. Then the data should be pre-processed including depth correction and abnormal value editing that are optional steps and not must be done, If necessary it also need to be centralized. Collar detection is then used for the processed data from MIPS to locate the top and bottom depths for each joint. And the average, minimum, and maximum radius are determined along with body loss for each joint. The results are stored in csv file for corrosion rating. Finally, MIPS can generate the 3D image of damaged interval.

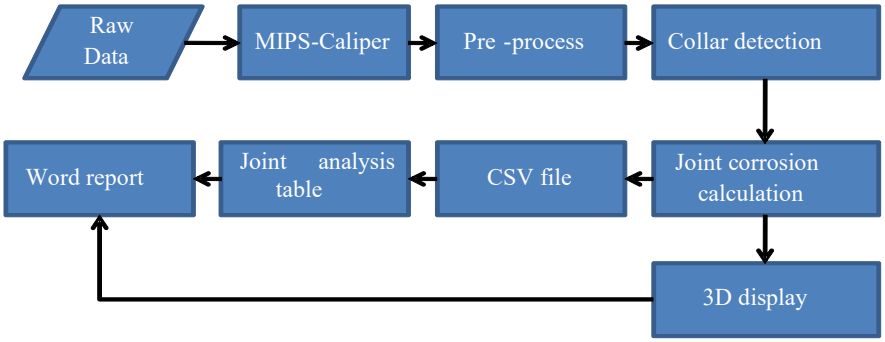


Figure 6 - MFC processing workflow

3) ALFA processing workflow

Loading raw data into MIPS software is the first step of ALFA interpretation. Then the data should be pre-processed including depth correction and abnormal value editing that are optional steps and not must be done. Flow/leak of casing is generated by noise signal in time domain. Then, time to frequency conversion can be conducted to display the data based on frequency distribution along the wellbore.

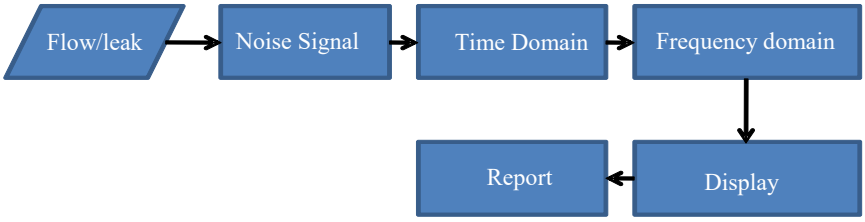


Figure 7 - ALFA processing workflow

RESULTS

Based on P&T, ALFA and Temperature data shows: The flow of water entering the depth of 145 mMD, flows behind the casing 20 "and goes to a depth of 223.8 mMD and out of the casing 13 3/8" to the wellbore.

There is a flow of water from the reservoir at a depth of 544 - 678 mMD, flowing behind the casing 13 3/8 "and out to the wellbore at a depth of 933 m where there is an indication of casing damage (casing 13 3/8")

Data from MFC (Caliper) shows the existence of casing damage at 223.8 mMD

Downhole sampling fluid in EPT-L/2 wells from 2 samples (940 and 1340 mmD) showed an increase in magnesium concentration accompanied by sulfate and bicarbonate which characterized the presence of surface fluid entering the EPT-L / 2 well.

This leakage results in a decrease in temperature and a decrease in production at EPT-L/2 wells, as well as the possibility of affecting nearby wells.

Referring to the results of the analysis, several work plans have been prepared in order to repair the well, i.e.

- Repair leaks that occur in casings 13-3 / 8 "with Cementing Plug & Squeeze (Milling Job if necessary)
- Remedial Case 13-3 / 8 "to 9-5 / 8"
- Fishing Job on routes 12-1 / 4 "

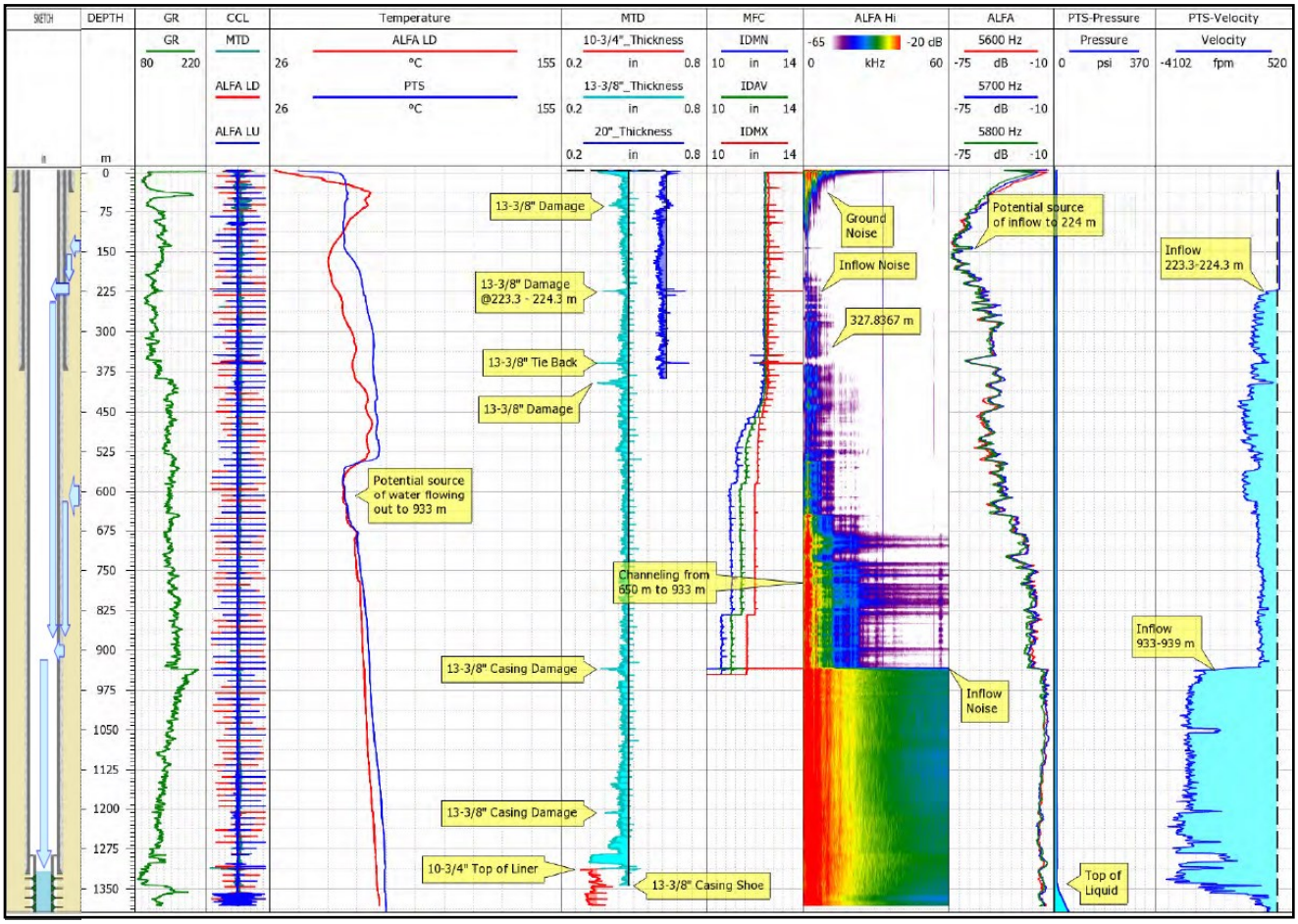


Figure 8. Integrated result analysis of well integrity logging in Well EPT-L/2

CONCLUSIONS

- From the MFC data within 0 -416m, the 13 3/8" casing shows light to intensive penetration%, and the maximum penetration% up to 100% at 223.8m. See figures 1a, 2-8b, and pages 7, 9-22.
- From MTD data, the maximum wall loss of 10 ¾" liner shows light to moderate corrosion and up to 14.5% at 1359.4m. See figures 1b, 9-11a, and pages 8, 23-30.

- From MTD data, the maximum wall loss of 13 3/8" casing shows light to significant corrosion, the maximum wall loss up to 40.9% at 223.9m. See figures 1b, 9-11a, and pages 8, 23-30.
- From MTD data, the maximum wall loss of 20" casing shows light to moderate corrosion and up to 11.1% at 86.8m. See figures 1b, 9-11a, and pages 8, 23-30.

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REFERENCES

Garcia, J., Yateem K., Sethi, N., Guergueb, N., Zhang, P., Succesful Application of a New Electromagnetic Corrosion Tool for Well Integrity Evaluation in Old Wells Completed with Reduced Diameter Tubular, presented at International Petroleum Technology Conference held in Beijing, China, 26-28 March 2013.

GoWell Research Team, Well Integritty Evaluation, GOWell International LLC, August 2017.

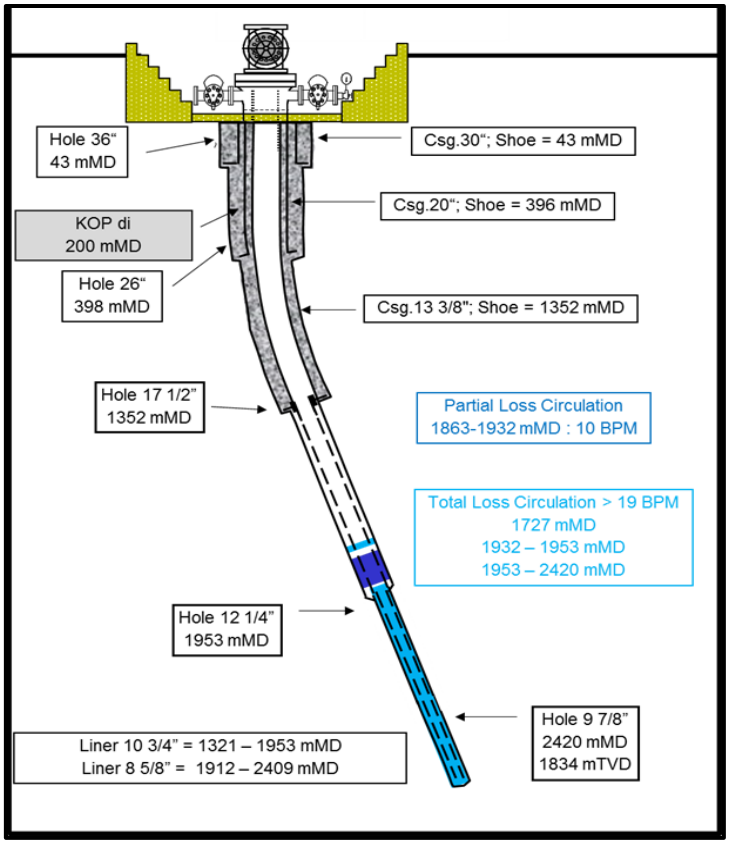
Riaz-ud-Din, A. and Arif Rana, M.: "Effective and Eco-efficient Pipe Inspection in Heavy Mud Environment Using Induced Electro-Magnetic (EMDS), " paper SPE 156207 presented at the SPE/PAPG Annual Technical Conference held in Islamabad, Pakistan, 22-23 November 2011

Wheeler, R.R.: "Improving Field Economics Through the Use of Modern Casing-Corrosion Logging Tools and Techniques," paper SPE 49297 presented at the 1998 SPE Annual Technical Conference and Exhibition held in New Orleans, Lousiana, 27-30 September 1998

Xingfu, Z., Yingxiang, W., Qiang, L., and Xiwei, Y.: "Multi-Pipe String Electromagnetic Detection Tool and Its Applications, " paper presented at the 8th International Conference on Electronic Measurement and Instrument held in Xian, China, 16-18 August 2007.

ENCLOSURE

Well Profile EPT-L/2



ALFA Specification

	ALFA
GENERAL SPECS	
Maximum Operating Pressure	15,000PSI (103 MPa)
Maximum Operating Temperature	302°F (150°C)
Diameter	1-1/2 in (38 mm)
Length	2.6 ft. (0.8 m)
Weight	8.8 lbs (4.0 kg)
Housing Material	Titanium
ACOUSTIC SENSOR	
Dynamic Range	90 dB
Operating Frequency Range	8 Hz to 60,000 Hz
Operation Mode	Stationary
Number of Spectral Channels	1024 (512 + 512)
PRESSURE SENSOR	
Accuracy	0.02% FS
Resolution	0.0001% FS
TEMPERATURE SENSOR	
Accuracy	0.2°C
Resolution	0.001°C
Response Time	0.4 sec
MEMORY	
Capacity	2 GB
Sampling	.5 to 255 sec

MFC Specification

	MFC24C-C	MFC40C-B	MFC56C-C
	P/N 100504389	P/N 100507120	P/N 100505339
General Specs			
Maximum Pressure	14,503 PSI (100 Mpa)	14,503 PSI (100 Mpa)	14,503 PSI (100 Mpa)
Maximum Temperature	350 °F (177 °C)	350 °F (177 °C)	350 °F (177 °C)
Diameter	1.7 in. (43 mm)	2.9 in. (73 mm)	3.5 in. (90 mm)
Length	65 in. (1651 mm)	78.1 in. (1980 mm)	83.7 in. (2086.5 mm)
Caliper Measure Point	33.9 in. (861 mm)	28.7 in. (729.5 mm)	27.7 in. (704.3 mm)
Weight	28.7 lbs (13 kg)	81.6 lbs (37.0 kg)	138.9 lbs (63.0 kg)
Steel Grade	17-4 SST, Titanium & Al-Bronze	17-4 SST, Titanium & Al-Bronze	17-4 SST, Titanium & Al-Bronze
Caliper Measurement			
Number of arms	24 arms	40 arms	56 arms
Minimum	1.96 in. (50 mm)	3.14 in. (80 mm)	3.94 in. (100 mm)
Maximum	7.09 in. (180 mm)	8.26 in. (210 mm)	9.65 in. (245 mm)
Finger Force	3.15 - 4.63 N	4.64 - 7.44 N	3 - 4.54 N
Accuracy	±0.02 in. (0.5 mm)	±0.02 in. (0.5 mm)	±0.02 in. (0.5 mm)
Resolution	0.0039 in. (0.1 mm)	0.0039 in. (0.1 mm)	0.0039 in. (0.1mm)
Sensor Type	Linear Displacement Sensor	Linear Displacement Sensor	Linear Displacement Sensor
Temperature Measurement			
Range	-13° F (-25° C) — 350 °F (177°C)	-13° F (-25° C) — 350 °F (177°C)	-13° F (-25° C) — 350 °F (177°C)
Accuracy	± 2° C	± 2° C	± 2° C
Resolution	0.05° C	0.05° C	0.05° C
Response Time	≤2 sec	≤2 sec	≤2 sec
Sensor Type	Platinum Resistor PT100	Platinum Resistor PT100	Platinum Resistor PT100
Inclination Measurement			
Minimum	0°	0°	0°
Maximum	180°	180°	180°
Accuracy	±5.0°	±5.0°	±5.0°
Resolution	0.1°	0.1°	0.1°
Relative Bearing Measurement			
Minimum	0°	0°	0°
Maximum	360°	360°	360°
Accuracy	±5.0° (Dev≥5.0°)	±5.0° (Dev≥5.0°)	±5.0° (Dev≥5.0°)
Resolution	0.1° (Dev≥5.0°)	0.1° (Dev≥5.0°)	0.1° (Dev≥5.0°)
Data Acquisition			
Typical Logging Speed	30 ft/min (9.14 m/min)	30 ft/min (9.14 m/min)	30 ft/min (9.14 m/min)
Vertical Resolution @100 samples/ft	0.12 in. (3.05 mm)	0.12 in. (3.05 mm)	0.12 in. (3.05 mm)
Power Requirements			
Voltage	18-36 Volts	18-36 Volts	18-36 Volts
Current	80 mA (±5 mA)	80 mA (±5 mA)	80 mA (±5 mA)
Extended Arms Option			
Tool OD	2.6 in. (65 mm)	4.7 in. (120 mm)	7.1 in. (180 mm)
Maximum Casing Size	9.7 in. (246 mm)	9.7 in. (246 mm)	13.78 in. (350 mm)

MTD Specification

	MTD43C-E P/N 100507229
General Specs	
Maximum Pressure	14,503 PSI (100 Mpa)
Temperature Range	-4°F ~ 350°F (-20°C ~ 177°C)
Diameter	1.69 in. (43 mm)
Length	44.3 in. (1125 mm)
Weight	12 lbs (5 kg)
Recommended Logging Speed	20 ft/min (7 m/min)
Max. Logging Speed	32 ft/min (10 m/min)
Thru-wired or bottom only	Thru Wired
Measuring Range	2.362 in. ~ 18.625 in. (60 mm ~ 473.1 mm)
Metallurgy	17-4 SST, Titanium & Al-Bronze
Total Pipe Wall Thickness	1.5 in. (38.1 mm)
Combinability	Pegasus Series and PegasusStar
Wall Thickness Measurement	
First Pipe Measurement	
Maximum Pipe Wall Thickness	0.9 in. (22.86 mm)
Thickness Accuracy	0.0075 in. (0.190 mm)
First Pipe (2-7/8") minimum aperture**	0.5 in. (12.7 mm)
Second Pipe Measurement	
Maximum Pipe Wall Thickness	1.2 in. (30.48 mm)
Thickness Accuracy	0.01 in. (0.254 mm)
Second Pipe (2-7/8" + 7") minimum aperture**	1.5 in. (38.1 mm)
Third Pipe Measurement	
Maximum Pipe Wall Thickness	1.5 in. @ 0.06 in. accuracy (38.1 mm @ 1.52 mm accuracy)
Thickness Accuracy	0.06 in. (1.52 mm)
Third Pipe (2-7/8" + 13-3/8") minimum aperture**	3 in. (76.05 mm)
Relative Bearing Measurement	
Measuring Range	0°~ 360°
Accuracy	±5° (deviation ≥5°)
Sensitivity	±0.1° (deviation ≥5°)
Deviation Measurement	
Measuring Range	0°~ 180°
Accuracy	±5°
Sensitivity	±0.1°
Power Requirements	
Voltage	18-38 Volts (Pegasus), 90 Volts (Conventional MFC)
Current	350 mA @ 18 Volts (Pegasus), 100 mA @ 90 Volts (Conventional MFC)