

A Study Report of Transformer No. (4) 300 MVA located in Jabrieh “W” 300 MVA

Abstract

Transformers No. 4 of 300 MVA is located in Jabrieh “W” is one from 26 transformers connected to a DGA analyzer in the electrical grid. The DGA analyzer triggered a caution alarm in the software for the transformer.

According to Figure 1, during the period from October 6th, 2020 to November 1st, 2020, TR 4 risk index is in the light green zone (2) indicating stable transformer condition. In November 3rd, 2020 a significant increase in the transformer risk index occurred. Turning from light green zone (2) to the yellow zone (3) which reveals a concern gas increase. This report will indicate the reasons to that increase in both transformers.

Risk and Ranking History

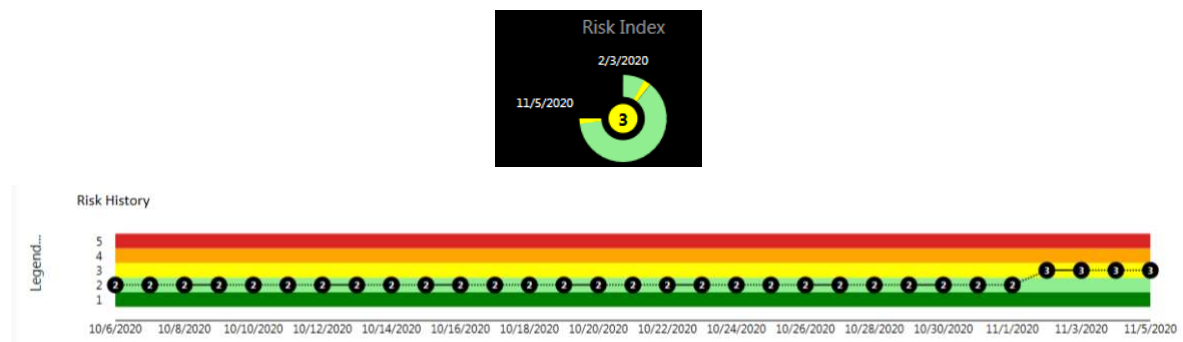


Figure 1 : Risk Index of TR 4 Under Study.

Overall DGA Analysis

There is a DGA analyzer installed on each transformer separately. The DGA analyst collected nine weeks data from the dissolved gases in the transformer oil (TR 4). These data were organized and averaged for nine weeks as shown in Table 1. Knowing that the DGA analyzer tests the transformer automatically **each 8 hours if the gases are in acceptable limits** and the sampling rate **changes** into each **two hours** when one of **the gases limits reaches the caution** setting.

Table 1: TR 4 Weekly Data Collected from DGA Analyzer.

Gas	Average Value of Week									Unit	NL	CL
	1	2	3	4	5	6	7	8	9 Expected			
H ₂	3.614	3.646	3.673	3.800	3.600	3.412	3.426	3.509	3.597	ppm	< 50	> 150
CH ₄	112.1	111.3	112.3	110.9	111.1	110.6	110.9	111.4	114.2	ppm	< 30	> 130
C ₂ H ₂	0.018	0.033	0.088	0.0115	0.080	0.135	0.160	0.340	0.349	ppm	< 2	> 20
C ₂ H ₄	14.77	14.68	14.55	14.67	14.19	13.08	12.97	13.18	13.52	ppm	< 60	> 280
C ₂ H ₆	183.8	184.3	179.3	185.1	182.5	172.0	171.9	172.1	176.4	ppm	< 20	> 90
CO	483.9	484.3	485.2	485.8	481.4	475.3	473.9	474.3	486.2	ppm	< 400	> 600
CO ₂	4047	4048	4012	3932	3750	3546	3424	3344	3428	ppm	< 3800	> 14000
O ₂	176.5	183.9	178.9	203.9	222.6	214.7	217.0	215.3	220.7	ppm		
H ₂ O	6.800	6.708	6.516	5.723	5.052	4.565	4.322	4.013	4.114	ppm		

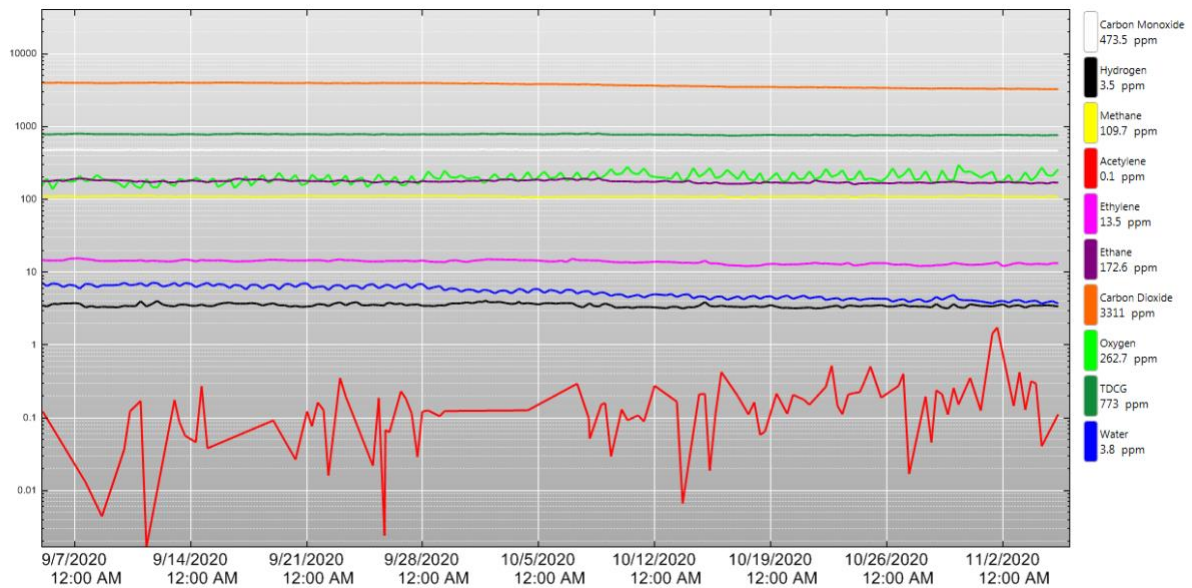


Figure 2 : DGA Trend Chart for TR 4.

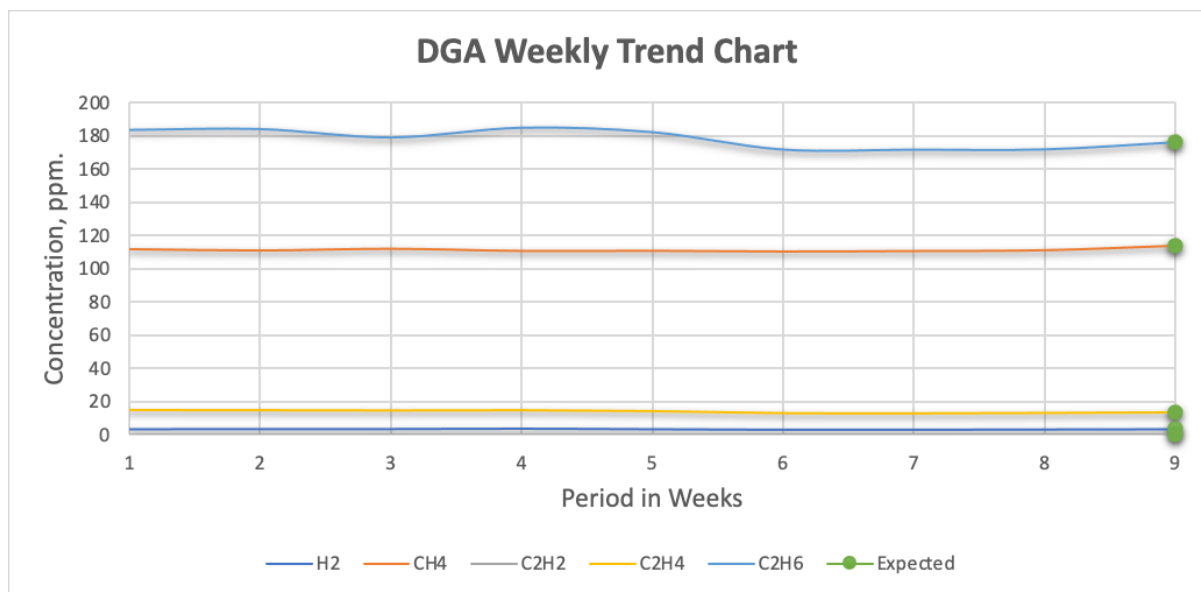


Figure 3: DGA Weekly Trend Chart (Gases) for TR 4.

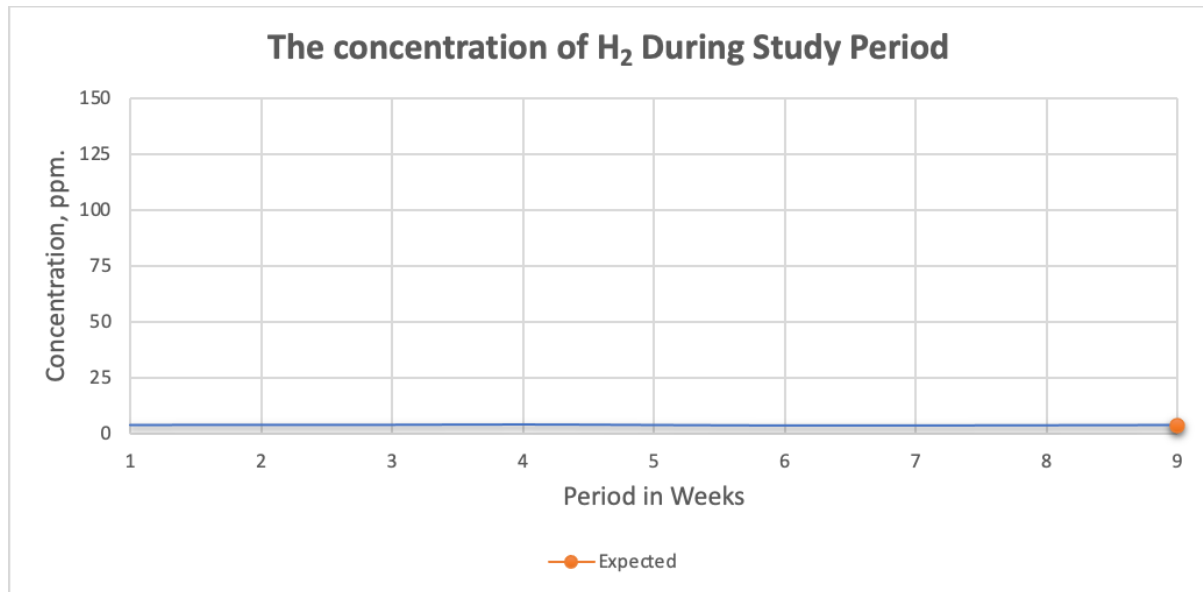


Figure 4: H_2 Concentration.

The graph above shows the behavior of Hydrogen Gas (H_2) among two months (September 5th to November 5th, 2020). As shown, there is no concern about it.

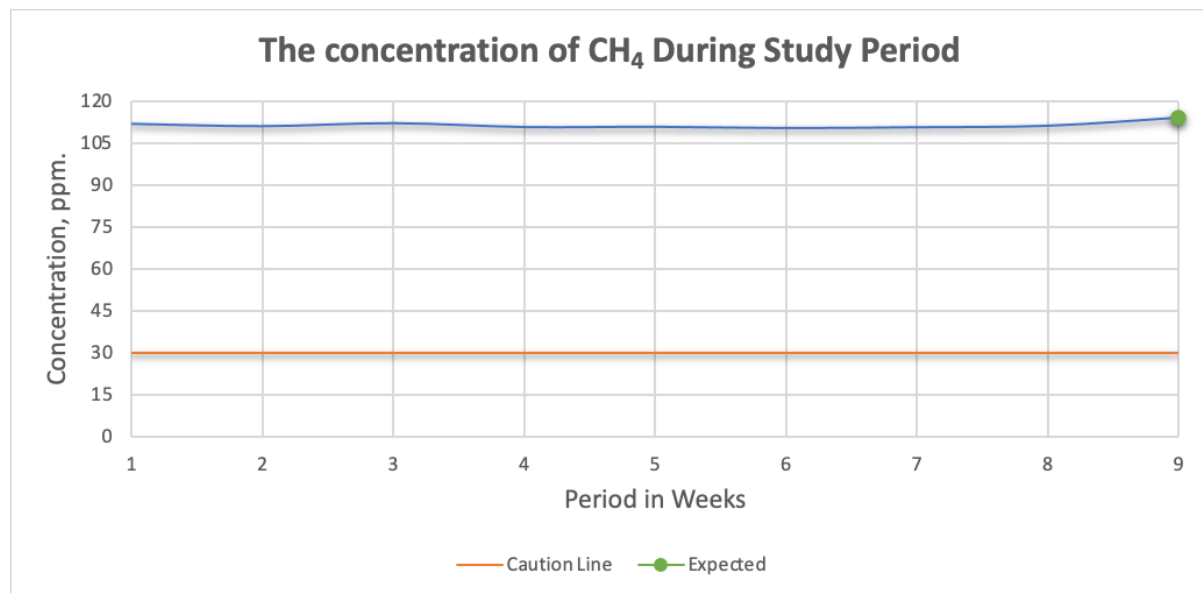


Figure 5: CH_4 Concentration.

The graph above shows the behavior of Methane Gas (CH_4). The gas concentration exceeded the caution limit (> 30). But throughout the period the increase was almost constant.

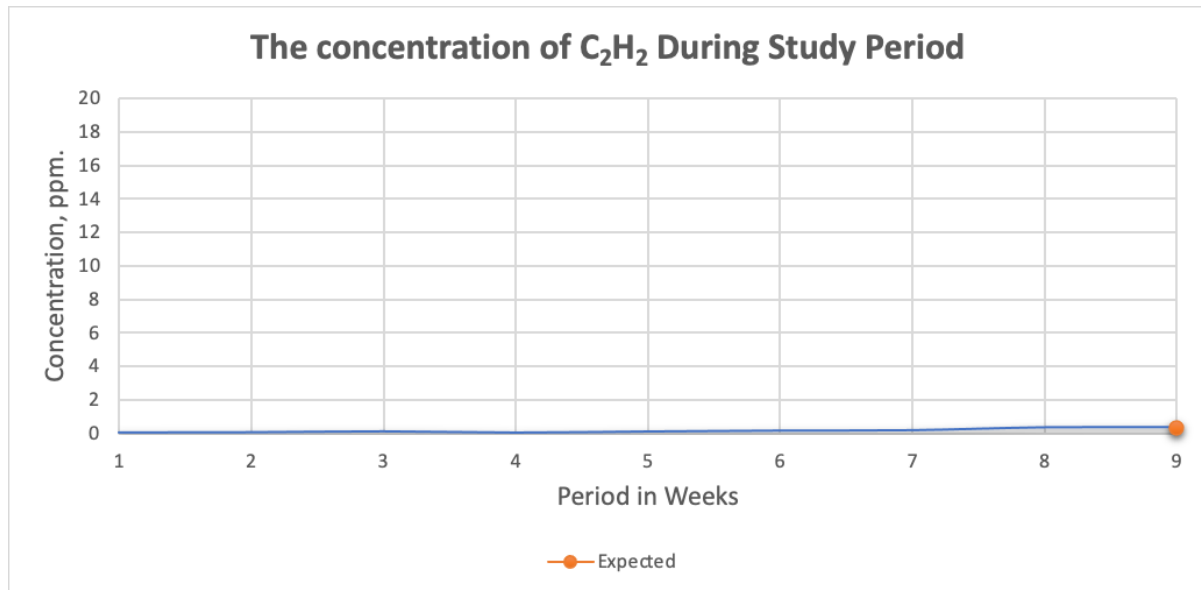


Figure 6: C₂H₂ Concentration.

The graph above shows the behavior of Acetylene Gas (C₂H₂), and it did not reach the caution limit. There was a small increase in week 8 by 6% which is more than the expected weekly increase (2.5%).

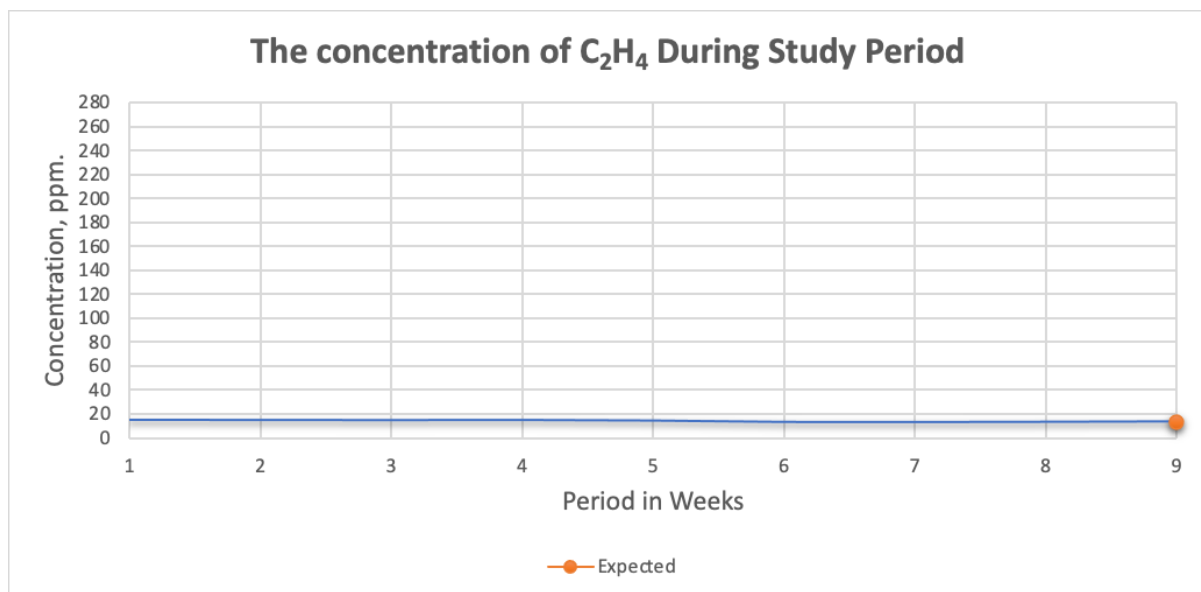


Figure 7: C₂H₄ Concentration.

The graph above shows the behavior of Ethylene Gas (C₂H₄), and there is no concern about it.

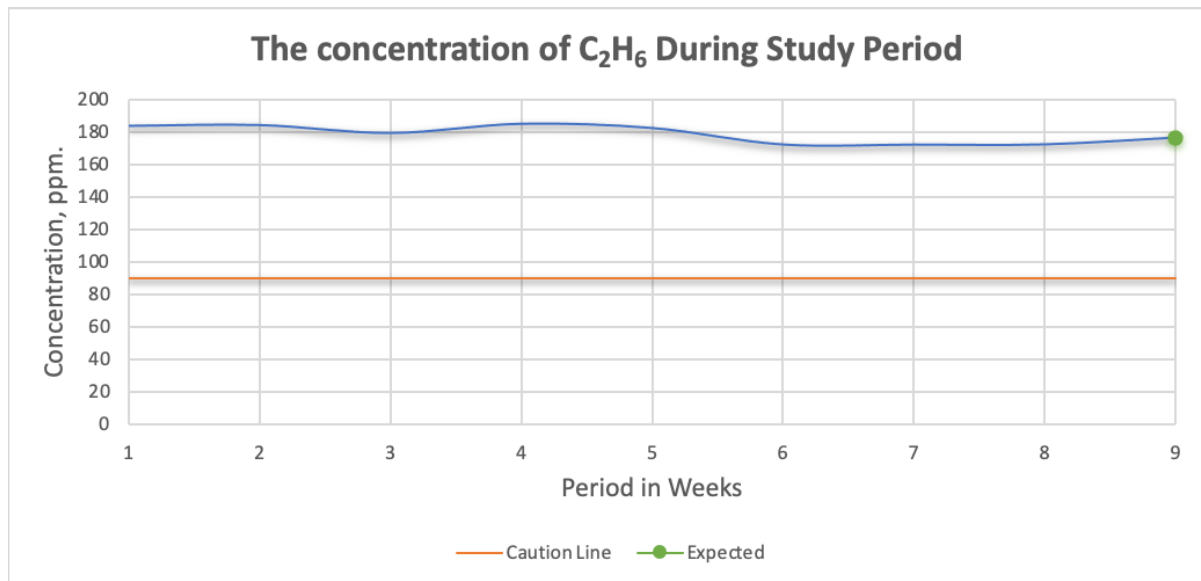


Figure 8: C_2H_6 Concentration.

The graph above shows the behavior of Ethane Gas (C_2H_6). The gas concentration exceeded the caution limit (> 90). But throughout the period the increase was almost constant. However, TR 4 is a Japanese transformer, so this generation of C_2H_6 considered normal.

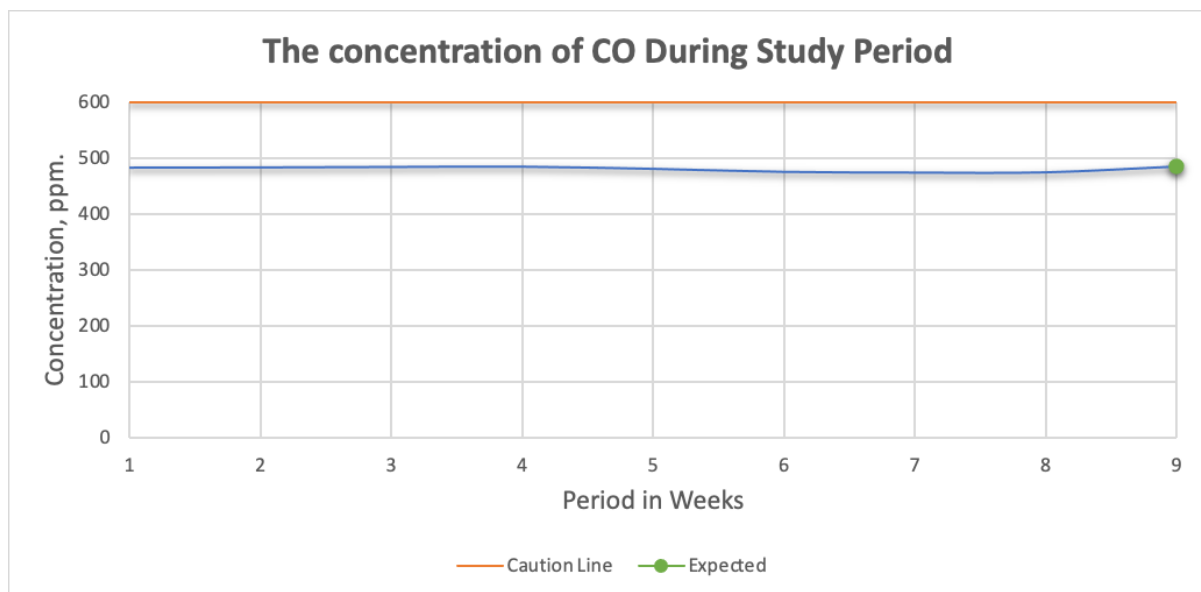


Figure 9: CO Concentration.

The graph above shows the behavior of Carbon Monoxide Gas (CO), and it did not reach the caution limit, but it was nearly to it.

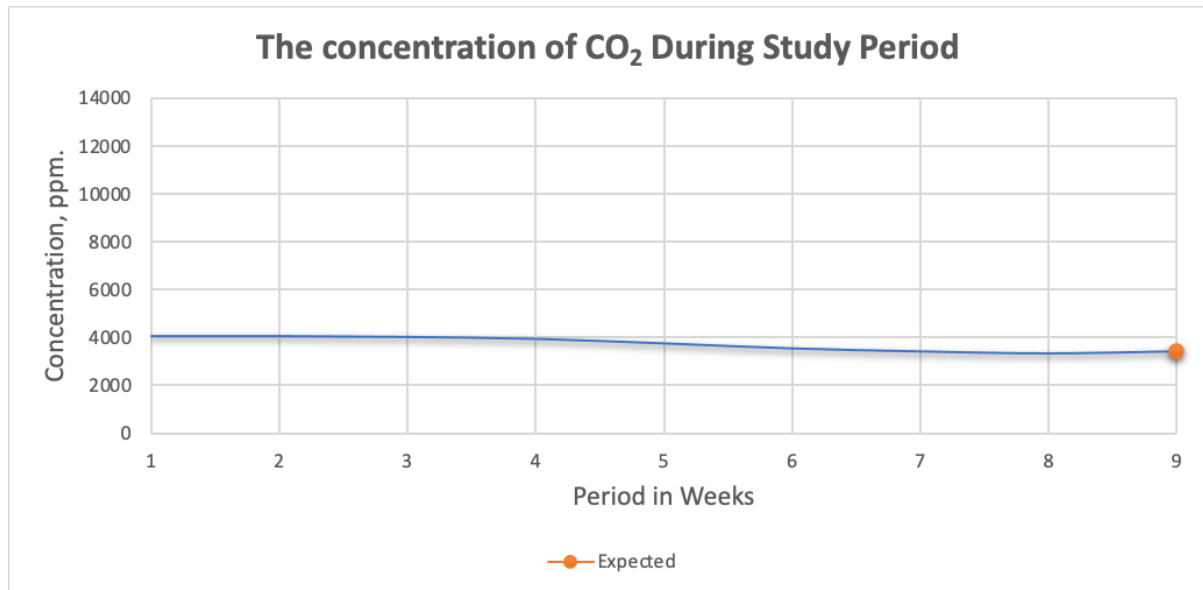


Figure 10: CO₂ Concentration.

The graph above shows the behavior of Carbon Dioxide Gas (CO₂), and it did not reach the caution limit. As shown, from the 3rd week the amount of it starts to decrease.

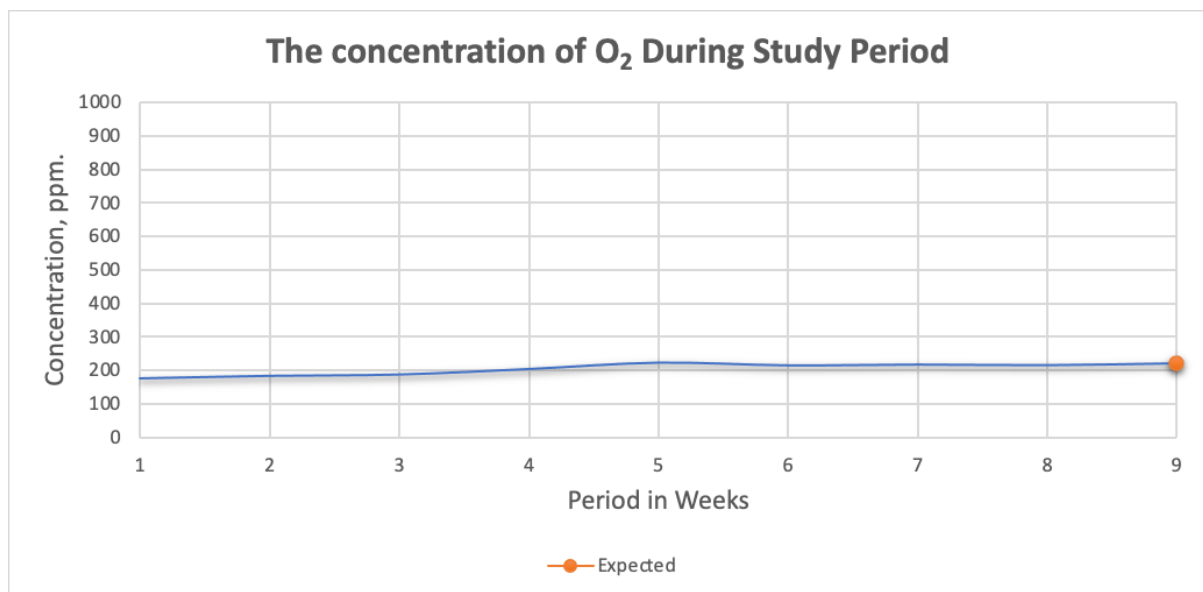


Figure 11: O₂ Concentration.

The graph above shows the behavior of Oxygen Gas (O₂), and it did not reach the caution limit. As shown, the amount of it is increasing during the period.

Paper Condition

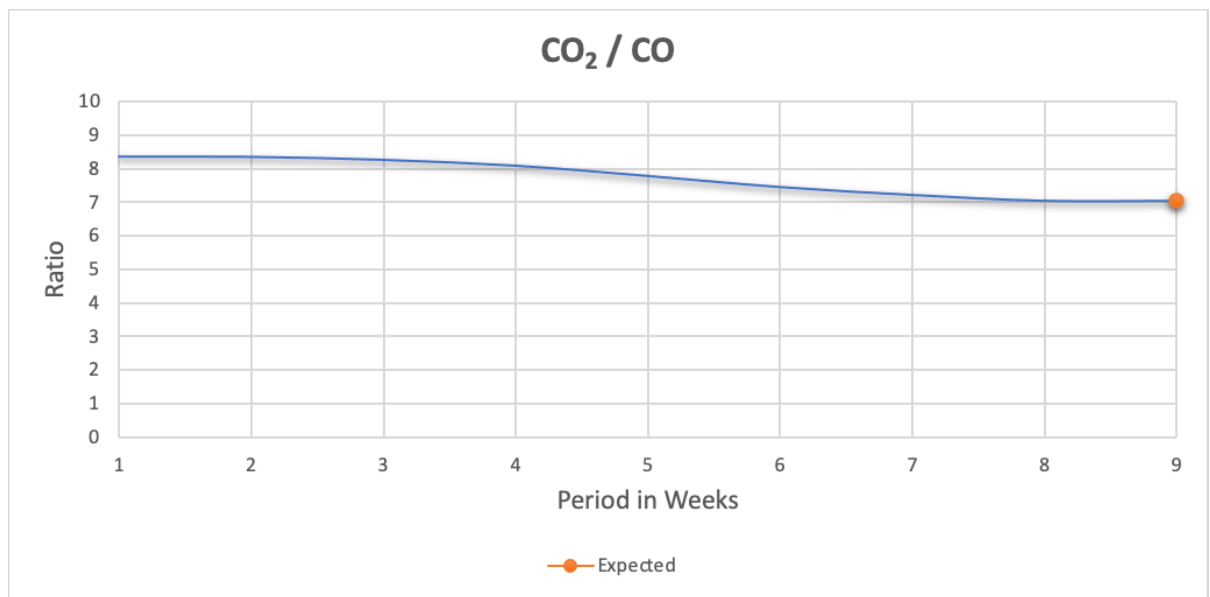


Figure 12: CO₂/CO Ratio.

The above graph shows the paper condition through the period. There was no concern about the paper condition, but it shows a small decrease in the ratio.

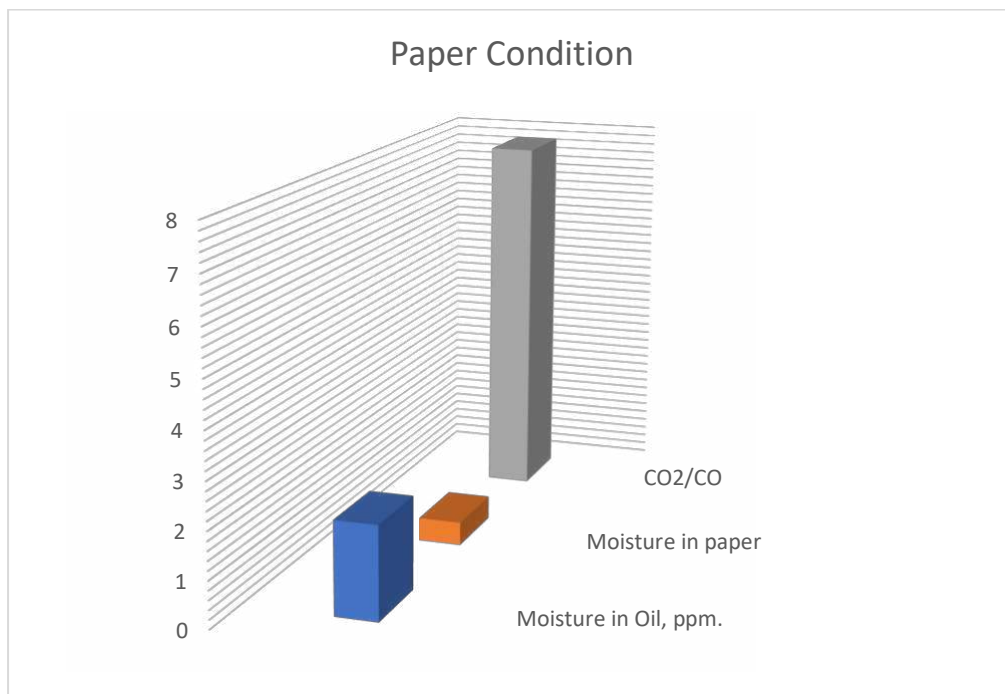


Figure 13: Paper Condition.

Water Content

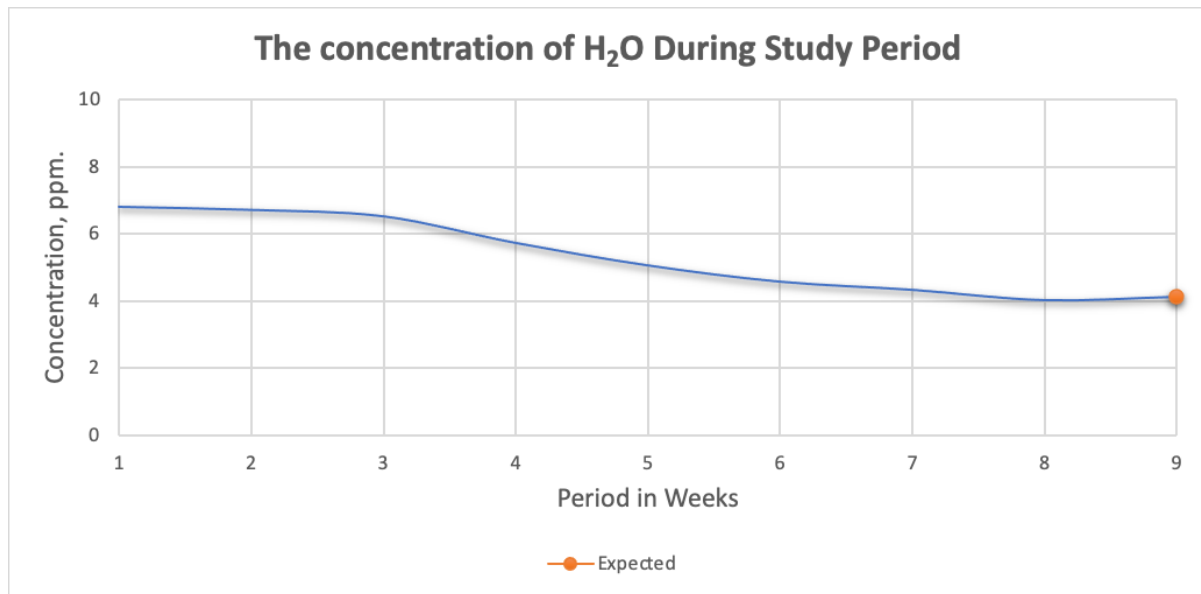


Figure 14: H₂O Concentration.

The graph above shows the behavior of Water Content (H₂O). As shown, the amount of it was decreasing among the period and that because of the winter season.

Gas Generation in Transformer Oil

With regards to Table 1, a study was done on the average concentrations. Since that the amount of Methane Gas (CH₄) is greater than the Hydrogen Gas (H₂), an indication of increasing temperature ($\approx 300^\circ\text{C}$) was found in Figure 15.

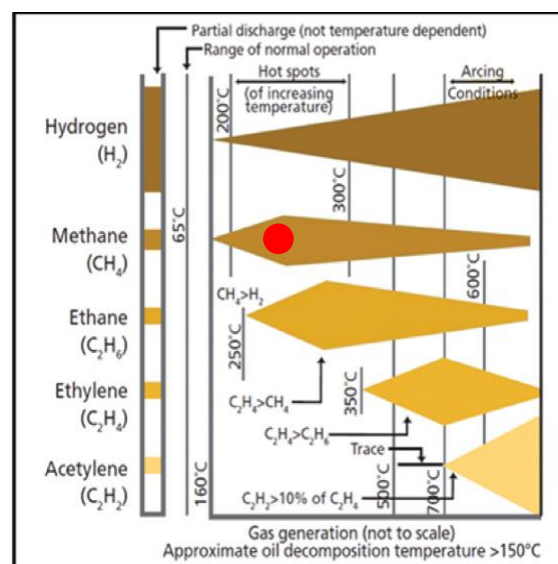


Figure 15: Gas Generation in Transformer Oil.

Duval Triangle

As shown in Figure 16, and after analyzing the three gases; Methane, Acetylene, and Ethylene. A thermal fault $\leq 300\text{ }^{\circ}\text{C}$ in the transformer was indicated.

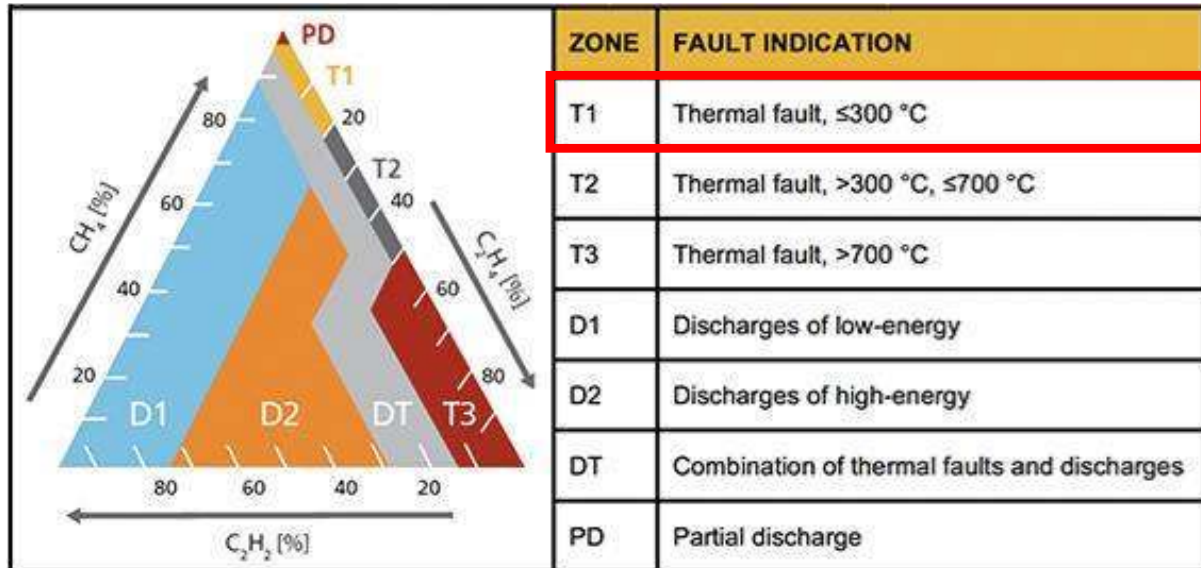


Figure 16: Duval Triangle, TR 4 Area.

Evaluation

After analyzing the data, there is an increase in Methane Gas (CH_4) content. That may lead to the overheating inside the transformer. With regards to Acetylene Gas (C_2H_2), there is an increase in week 8 as shown in Figure 6. Also, that may lead to the overheating inside the transformer. There is no concern in Ethylene Gas (C_2H_4), Carbon Monoxide/Dioxide Gas (CO & CO_2), Oxygen Gas (O_2), and Water (H_2O) in the transformer. However, there is a **significant increase** in Ethane Gas (C_2H_6) in the transformer and it was stable among the period as it shown in Figure 11. That increase will lead to the overheating inside the transformers. Finally, according to Duval Triangle, a thermal fault with temperature $\leq 300\text{ }^{\circ}\text{C}$ was indicated for both transformers.

Recommendation

New sample for DGA test after one week and monitor the gas trend (CH_4). An increase in gas concentrations of more than 2.5% per week is generally consider the fault as active.