

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

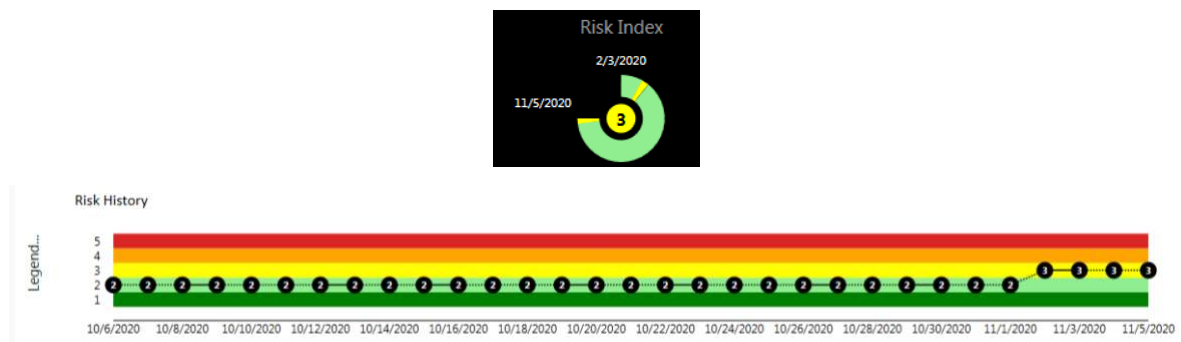


Figure 1 : Risk Index of TR 4 Under Study.

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 | | |

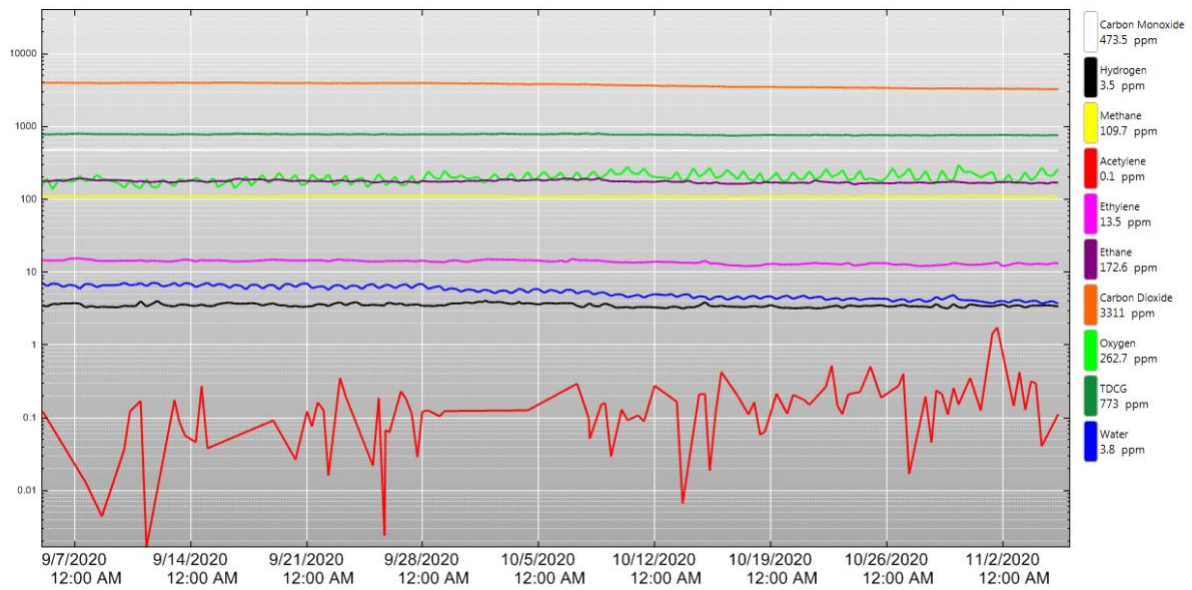


Figure 2 : DGA Trend Chart for TR 4.

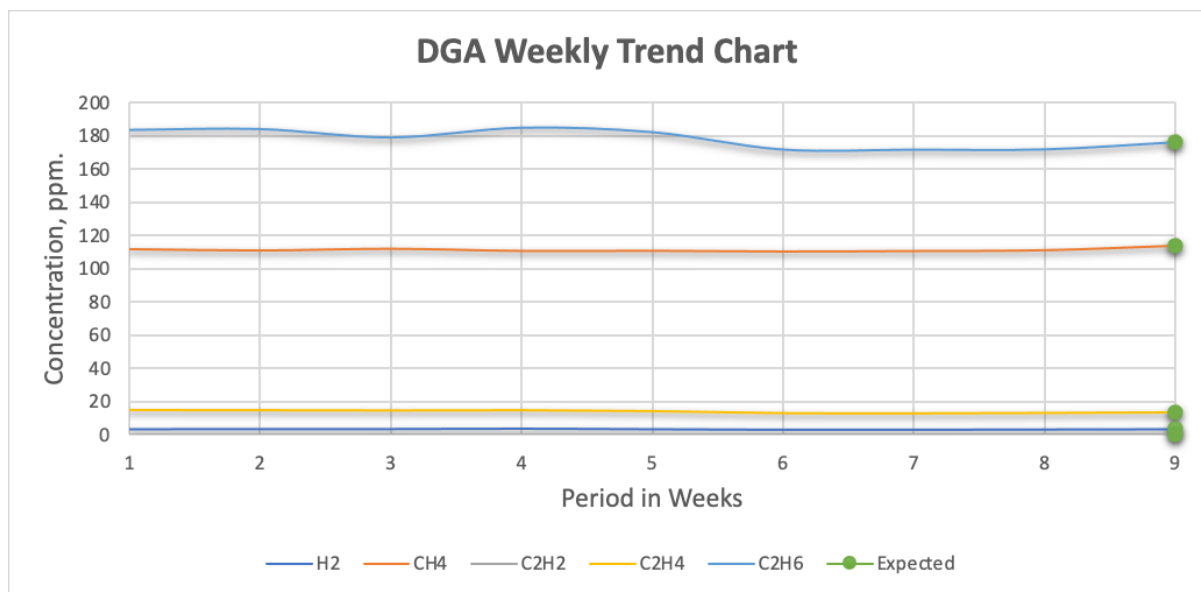


Figure 3: DGA Weekly Trend Chart (Gases) for TR 4.

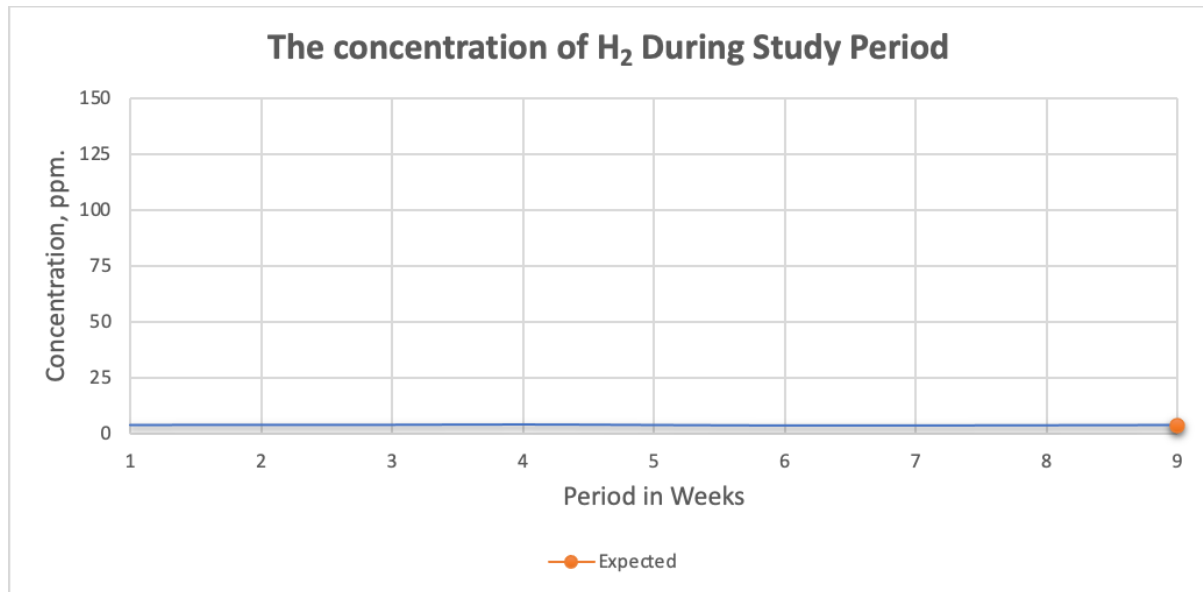


Figure 4: H_2 Concentration.

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.

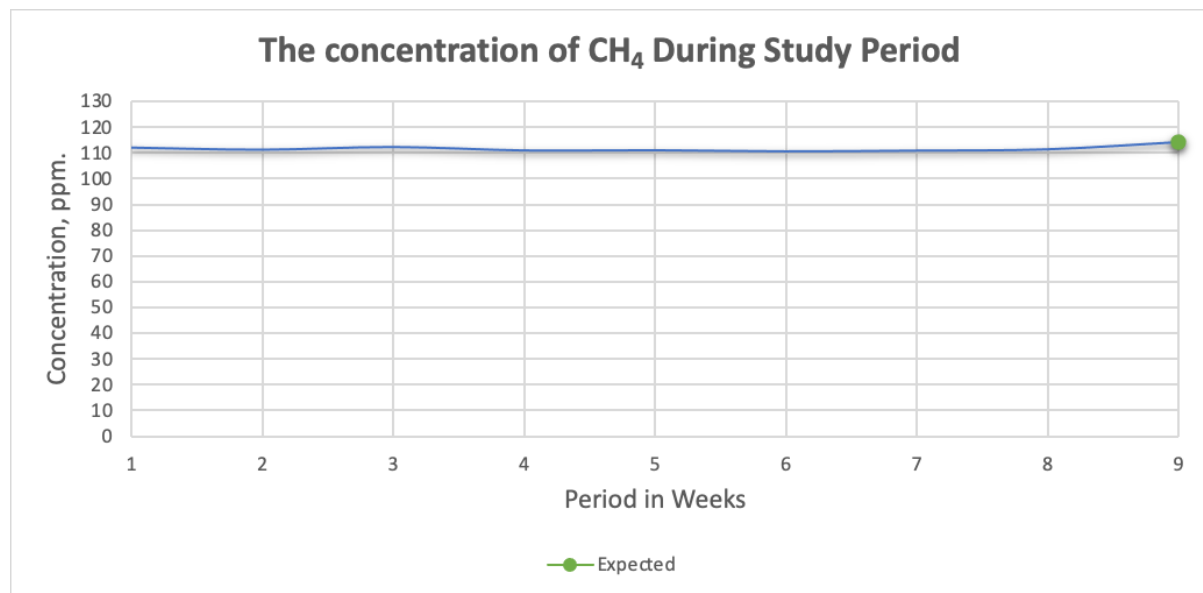


Figure 5: CH_4 Concentration.

The graph above shows the behavior of Methane Gas (CH_4), and it did not reach the caution limit, but it was nearly to it (130 ppm).

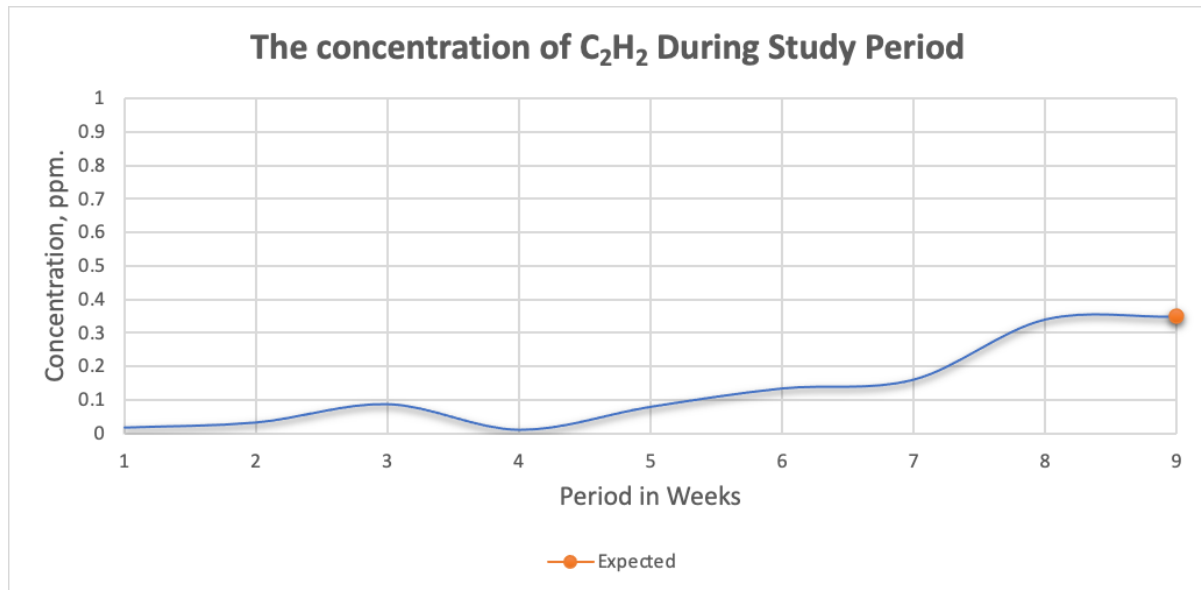


Figure 6: C_2H_2 Concentration.

The graph above shows the behavior of Acetylene Gas (C_2H_2), 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%).

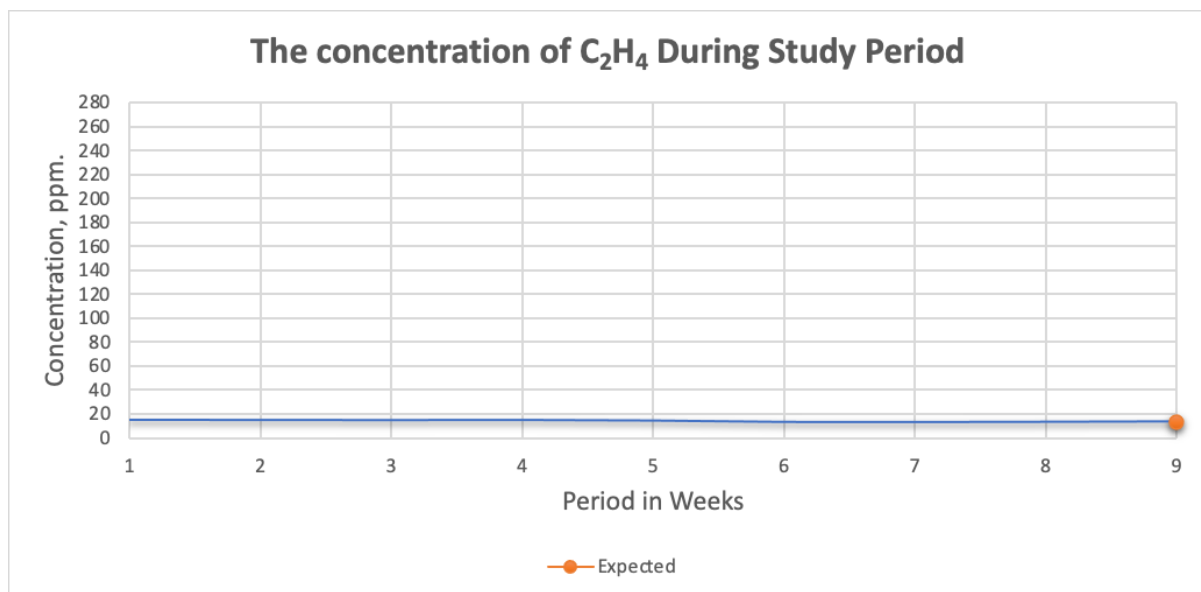


Figure 7: C_2H_4 Concentration.

The graph above shows the behavior of Ethylene Gas (C_2H_4), and there is no concern about it.

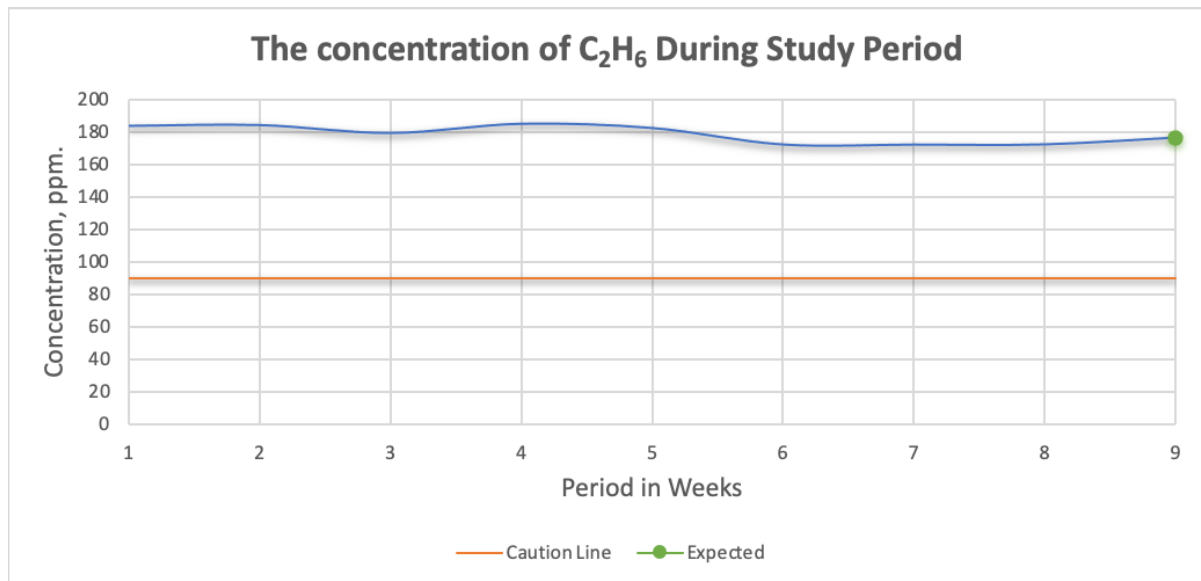


Figure 8: C₂H₆ Concentration.

The graph above shows the behavior of Ethane Gas (C₂H₆). 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 C₂H₆ considered normal.

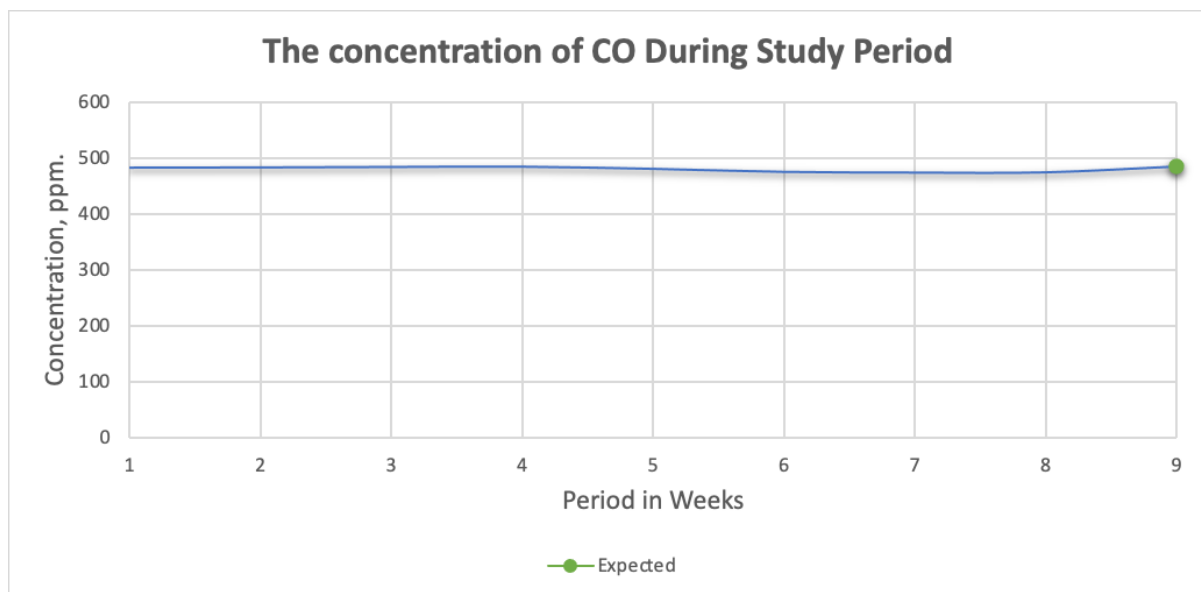


Figure 9: CO Concentration.

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.

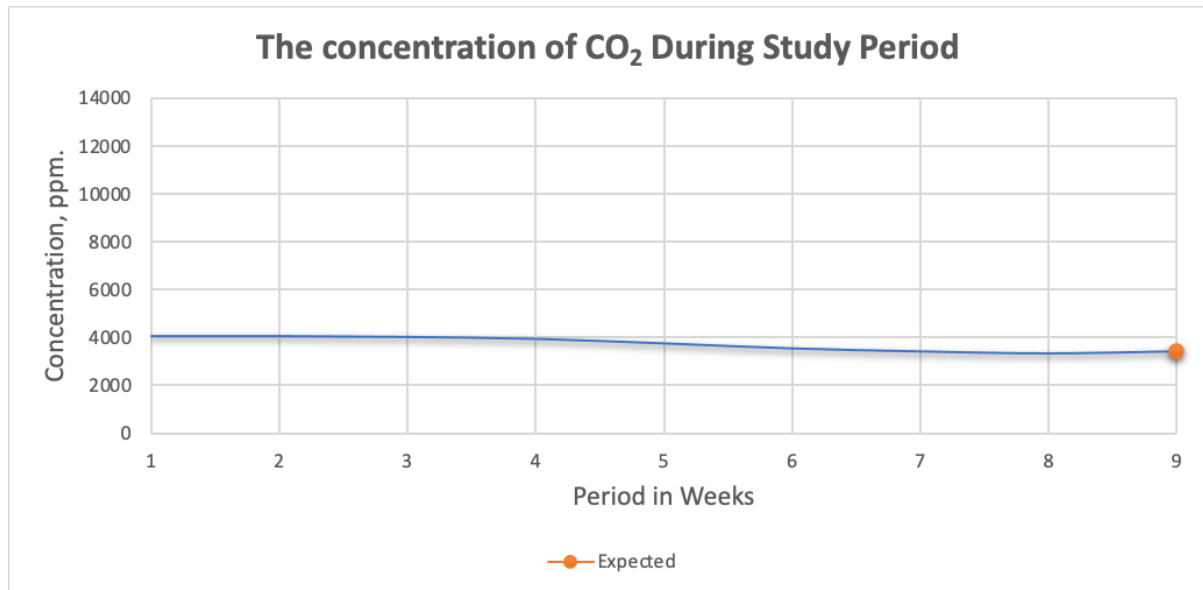


Figure 10: CO₂ Concentration.

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.

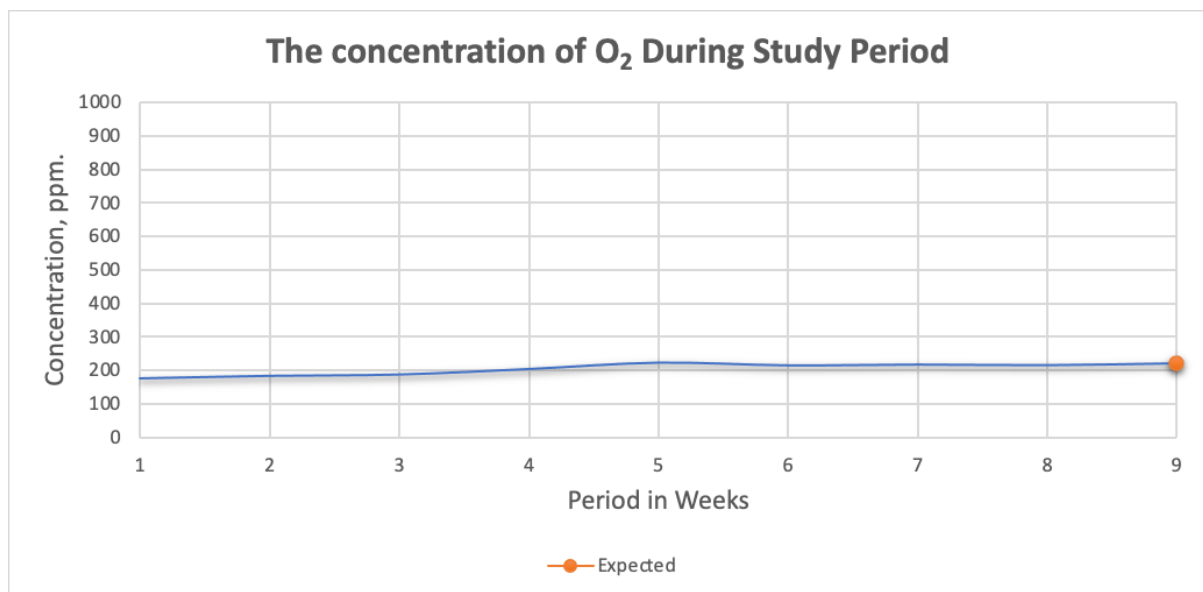


Figure 11: O₂ Concentration.

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

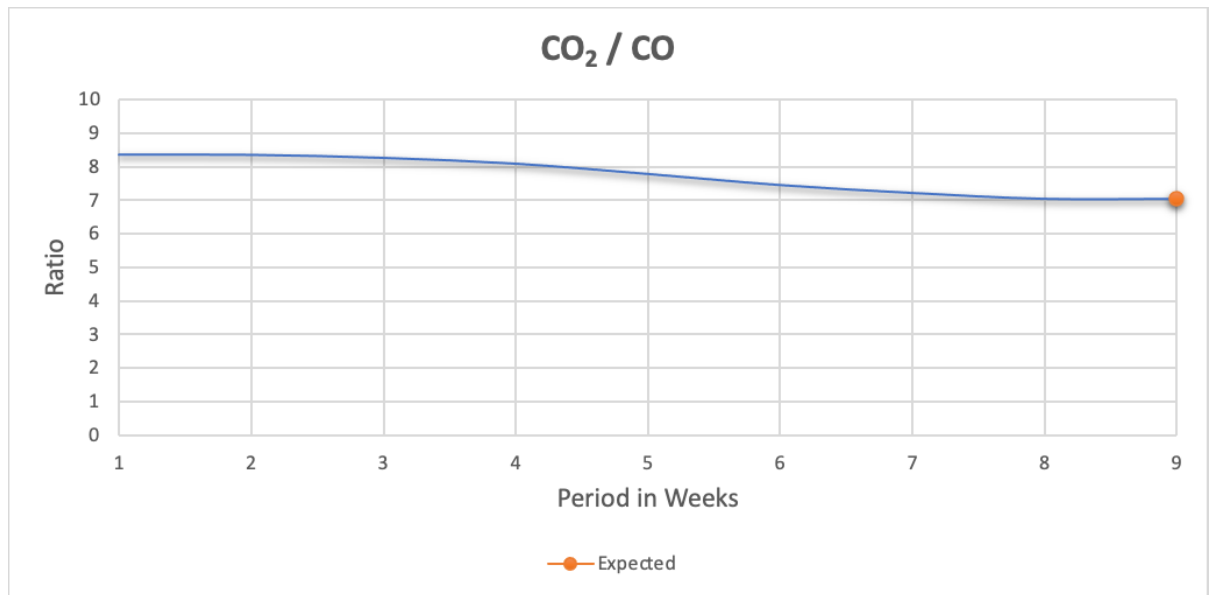


Figure 12: CO₂/CO Ratio.

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.

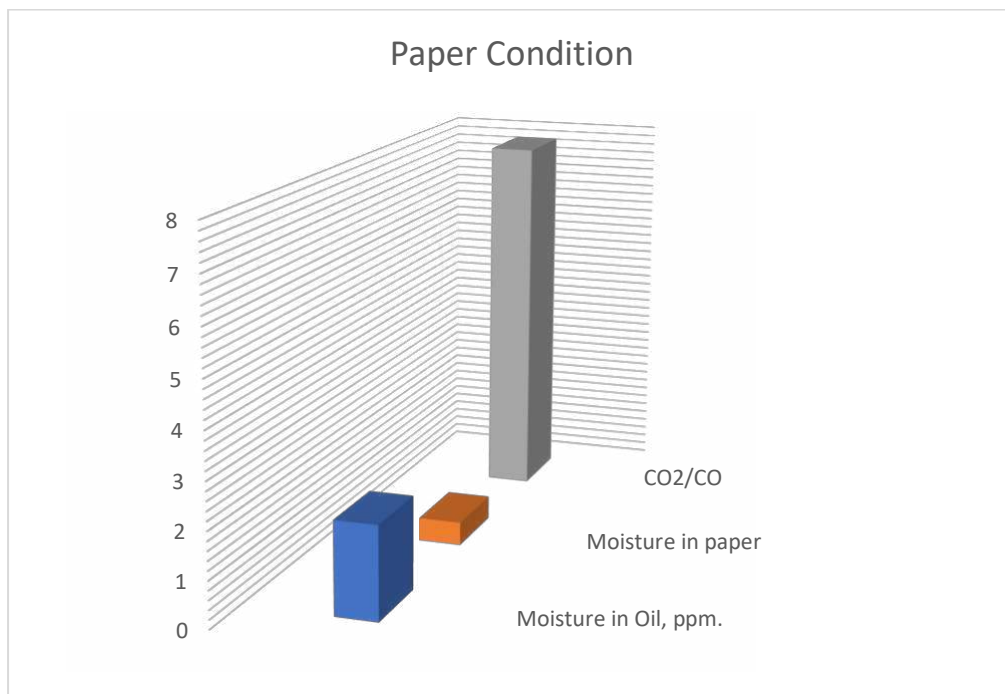


Figure 13: Paper Condition.

Water Content

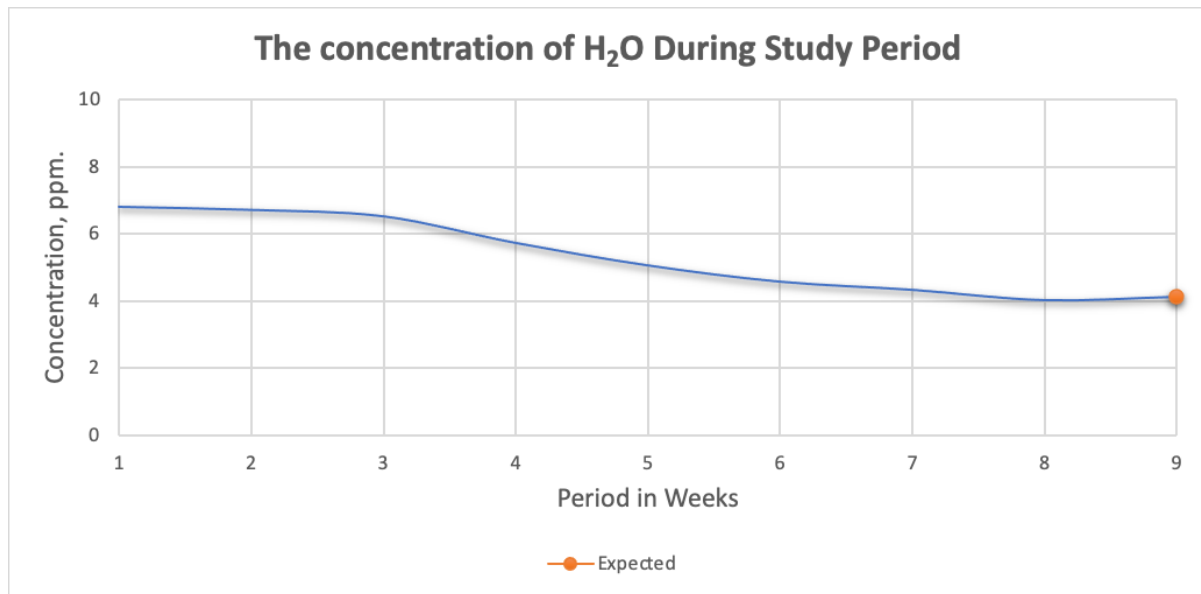


Figure 14: H₂O Concentration.

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), and the amount of Ethane Gas (C₂H₆) is high, an indication of increasing temperature in the transformer was found in Figure 15.

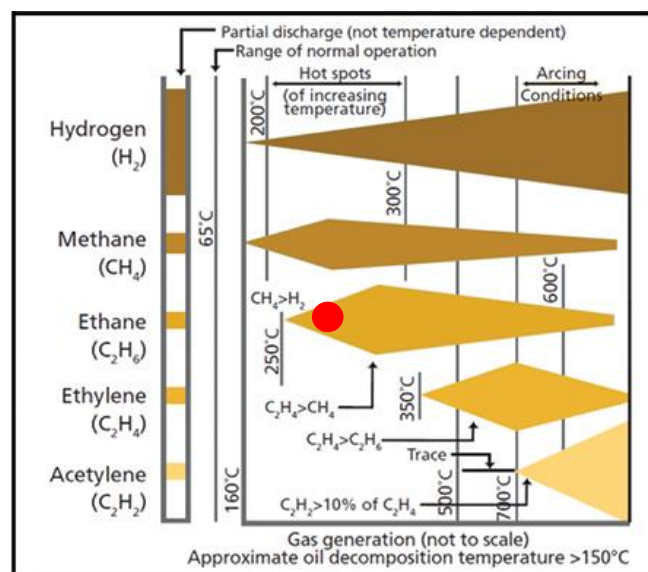


Figure 15: Gas Generation in Transformer Oil.

Duval Triangle

After analyzing the three gases; Methane, Acetylene, and Ethylene. And since none of them has reached the caution limit. Therefore, Duval Triangle is Unapplicable.

Evaluation

After analyzing the data, there is an increase in Acetylene Gas (C_2H_2) in week 8 as shown in Figure 6. That may lead to the overheating inside the transformer. There is no concern in Hydrogen Gas (H_2), Methane Gas (CH_4), 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 the gas generation, a thermal fault was indicated in the transformer.

Recommendation

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