Transformer Health Index Monitoring Formula

Introduction:

Transformers are critical components in the power transmission and distribution systems that help convert high-voltage to low-voltage power suitable for end-users. These transformers operate under harsh environmental conditions and may undergo various mechanical and electrical stresses, leading to deterioration and eventual failure. Therefore, it is crucial to monitor the health of transformers regularly to avoid any significant losses or disruptions in power supply. In this report, we present a formula for transformer health monitoring that uses various performance indicators and their corresponding weights to calculate the transformer's health index.

Performance Indicators:

The transformer health monitoring formula considers several performance indicators to calculate the transformer's health index. These performance indicators include temperature at the R phase, Y phase, and B phase, current at the R phase, Y phase, and B phase, and oil temperature. These indicators are crucial in determining the transformer's health, as they provide insights into various mechanical and electrical stresses the transformer undergoes during its operation.

Weights:

Each of the performance indicators considered in the formula has its corresponding weight, which reflects its importance in determining the transformer's health. The weights assigned to each indicator in the formula are as follows: TR: 0.2, TY: 0.2, TB: 0.2, IR: 0.15, IY: 0.15, IB: 0.1, TO: 0.1. The weights are chosen based on their significance in detecting the faults and the criticality of the indicators in transformer health monitoring.These weights are taken as one seventh of the total capacity.

Indicator Scores:

To calculate the health index, each performance indicator's score is calculated using its minimum and maximum values observed in the transformer. The scores are normalized between 0 and 1, where 0 represents the minimum value observed in the transformer, and 1 represents the maximum value observed. For example, TR score is calculated as (TR - TR_min) / (TR_max - TR_min), where TR is the temperature at the R phase, and TR_min and TR_max are the minimum and maximum temperatures observed in the transformer, respectively. Similarly, scores for other indicators are calculated.

Health Index:

The health index is a composite score calculated as the weighted average of the scores of all the performance indicators. The formula for calculating the health index is as follows: Health Index = (0.2 x TR score) + (0.2 x TY score) + (0.2 x TB score) + (0.15 x IR score) +

(0.15 x IY score) + (0.1 x IB score) + (0.1 x TO score). The health index is also normalized between 0 and 1, where 0 represents poor health, and 1 represents excellent health.

Formula :

Identify Performance Indicators:

Temperature at R phase (TR)
Temperature at Y phase (TY)
Temperature at B phase (TB)
Current at R phase (IR)
Current at Y phase (IY)
Current at B phase (IB)
Temperature of oil (TO)

Assign Weights:

TR: 0.2
TY: 0.2
TB: 0.2
IR: 0.15
IY: 0.15
IB: 0.1
TO: 0.1
Calculate Indicator Scores:

TR score = (TR - TR_min) / (TR_max - TR_min) where TR_min and TR_max are the minimum and maximum temperatures observed in the transformer, respectively.
TY score = (TY - TY_min) / (TY_max - TY_min) where TY_min and TY_max are the minimum and maximum temperatures observed in the transformer, respectively.
TB score = (TB - TB_min) / (TB_max - TB_min) where TB_min and TB_max are the minimum and maximum temperatures observed in the transformer, respectively.
IR score = (IR - IR_min) / (IR_max - IR_min) where IR_min and IR_max are the minimum and maximum currents observed in the transformer, respectively.
IY score = (IY - IY_min) / (IY_max - IY_min) where IY_min and IY_max are the minimum and maximum currents observed in the transformer, respectively.
IB score = (IB - IB_min) / (IB_max - IB_min) where IB_min and IB_max are the minimum and maximum currents observed in the transformer, respectively.
TO score = (TO - TO_min) / (TO_max - TO_min) where TO_min and TO_max are the minimum and maximum temperatures observed in the transformer oil, respectively.
Calculate Health Index:
The transformer health index can be calculated as the weighted average of the indicator scores:

Health Index = (0.2 x TR score) + (0.2 x TY score) + (0.2 x TB score) + (0.15 x IR score) + (0.15 x IY score) + (0.1 x IB score) + (0.1 x TO score)

The health index will range between 0 and 1, where 0 indicates poor health and 1 indicates excellent health.

Temperature: Transformer life decreases with increasing temperatures. The IEEE standard recommends that the maximum operating temperature of a transformer should not exceed 65°C for mineral oil and 90°C for ester-based fluids.

Loading: Transformer life is also affected by the amount of current flowing through it. Higher currents lead to increased heating and faster degradation of insulation materials. The IEEE standard recommends that transformers should be operated at no more than 75% of their rated capacity.

Ambient conditions: The surrounding environment can also affect transformer life. Extreme temperatures, humidity, and other factors can accelerate aging and reduce the life expectancy of the transformer.

Conclusion:

The transformer health monitoring formula presented in this report provides a comprehensive and reliable approach to regularly monitoring transformers' health. The formula considers various performance indicators and their corresponding weights, which help detect faults and critical issues in transformers early. The formula's health index provides a straightforward and intuitive way to understand the transformer's health status, which can be used to take corrective actions before significant losses or disruptions occur. Therefore, the transformer health monitoring formula can be a valuable tool in maintaining the reliability and availability of power supply systems.