AMP211 PLANT DISTRIBUTION OIL-COOLED TRANSFORMERS NOT SUBJECT TO ENVIRONMENTAL QUALIFICATION REQUIREMENTS (VERSION 2021)

Programme Description

The purpose of the AMP described herein is to provide reasonable assurance that the intended safety functions of plant distribution oil-cooled transformers non-grid connected are maintained consistent with the current licensing basis through the end of service life. The insulation paper, transformer oil, and polymer seals or gaskets of transformer instrumentation that are susceptible to age-related thermal degradation resulting in reduced insulation resistance, or increased resistance of connection due to corrosion or loosening, or loss of sealing are therefore to be monitored and periodically checked [1-3].

The ageing management described herein is concentrated on oil-cooled transformers installed in plant power distribution systems. Compared to high power class transformers (unit generator transformers, auxiliary power transformers, and standby auxiliary power transformers), safety related transformers are usually smaller in size and power and are characterized by a small load during normal operation and an increase of load on demand e.g. during surveillance tests or a loss of coolant accident.

Age related components of oil-cooled transformers are primarily the bushings, the winding insulation, insulating fluids and tap changers (tap changers are not typical of this size transformer). The transformer tank and the core are of less importance. Therefore, testing of the oil has the highest relevance [4]. Instrumentation such as Buchholz relay for transformer protection and monitoring instrumentation for condition monitoring help determine how the transformer is ageing.

Whereas at the tank and the cooling system, the mechanisms corrosion, ageing of sealing, and contamination occur, the depolymerization of the paper at the winding’s insulation and the power factor at the voltage bushings are relevant.

Moreover, the contamination of the bushing’s insulator might lead to a reduced insulation resistance.

Ageing effects due to electrical and thermal loads are dominant compared to mechanical and chemical loads. Thermal loads may lead to chemical loads by development of copper sulfide that decreases the insulation characteristics of the paper.

Hydrogen release is a first and concise indicator for a thermal load of oil or for partial discharges. Although other gases identified by dissolved gas analysis (DGA) such as methane and ethylene (hot metal gasses) or acetylene (arcing) as well as carbon monoxide, carbon dioxide are released as well, hydrogen detection is easier and more common.

The programme was written specifically to address oil-cooled plant distribution power transformers. Dry type, air-cooled transformers have sometimes been installed for the same purpose, but their ageing management is covered under a specific AMP.

Evaluation and Technical Basis

1. Scope of the ageing management programme based on understanding ageing:

Oil-cooled transformers, operating in emergency power distribution systems, are in the scope of this AMP.

1. Preventive actions to minimize and control ageing degradation:

This is a condition monitoring program, and no actions are taken as part of this programme to prevent or mitigate ageing degradation.

1. Detection of ageing effects:

This AMP focuses on the demands for the inspections and the surveillance test programme.

Periodic visual inspection programme for power transformers involves checking the oil level, inspecting the silica gel for changes in color and phase bushings for oil leaks. The changes in oil level may be an indication of gas being generated due to internal failure or oil leakage.

The programme for the emergency power transformers includes primarily oil tests at regular intervals. Dissolved gas analysis, furan analyses and the test of the insulating fluid (breakdown voltage, moisture in oil, interfacial tension, neutralization value, oxidation stability inhibit or content, tan δ, color) are performed following national or plant specifications; recommendations for test frequencies are listed in[1].

For example, results of a furan analysis give details for the deterioration state of the insulation paper of the transformer and hence the condition of the transformer. For some analyses, the fraction of methanol and ethanol are measured as well.

Periodic electrical testing (i.e. winding resistance, turn to turn testing) are performed as well as monitoring and trending of winding and oil temperatures can provide indication of thermal ageing. Further electrical tests (i.e. frequency response analysis, impulse test, no-load and short-circuit measurements) of the transformer or bushings are only performed after incidents, like short circuits or direct lightning strikes into the associated nearby transmission lines to ensure the transformer will continue to perform its function for the intended period of operation.

1. Monitoring and trending of ageing effects:

Trending actions (offline monitoring) are included as part of this AMP in order to cover the potential increase of gases detected by the dissolved gas analyses and the test of insulation fluid. Winding temperature and oil temperature trending as well as trending of on-line monitoring systems and electrical tests are also part of monitoring and trending. These measurements provide adequate information on the rate of transformer ageing degradation.

1. Mitigating ageing effects:

This programme is primarily a condition monitoring programme. This programme has no specific operations, maintenance, and repair aspects and no actions are taken as part of this programme to prevent or mitigate ageing degradation.

1. Acceptance criteria:

Monitored parameters are within the predicted acceptance criteria, as set out in plant procedures.

Deviations of the expected trends can provide significant information concerning the rate of ageing degradation. Evaluations are then performed and appropriate corrective actions can be taken.

1. Corrective actions:

An engineering evaluation is performed that considers the extent of the condition. Corrective actions such as further diagnostic tests and trouble-shooting are implemented when parameters monitored or test results do not meet the acceptance criteria.

If the test values or monitoring trends values are above than normal condition, then increased test frequency might be an appropriate measure. Dissolved gas analyses and the test of insulation fluid performed in the laboratories are only part of an overall assessment of the transformer. Prompt verification is required after indication of a significant change in a measured value (warning threshold overshot) [1].

One of the possibilities for a corrective action after a confirmed exceedance of one parameter is oil cleaning or oil replacement.

If the corrective action (e.g., oil exchange), is not sufficient, additional corrective actions are performed. This may include repair or replacement of the affected transformer. In some instances, if winding and tank of the transformer are intact and furan are increasing to the danger zone then rewinding of the transformer with new insulation paper would be the best option.

1. Operating experience feedback and feedback of research and development results:

This AMP addresses the industry-wide generic experience. Relevant plant-specific operating experience is considered in the development of the plant AMP to ensure the AMP is adequate for the plant. The plant implements a feedback process to periodically evaluate plant and industry-wide operating experience and research and development (R&D) results, and, as necessary, either modifies the plant AMP or takes additional actions (e.g. develop a new plant-specific AMP) to ensure the continued effectiveness of the ageing management.

Operating experience has shown that most of the incidents in the past resulted in a prompt catastrophic failure of a transformer, at least within the high power class. For relatively new transformers, a fault or manufacturing flaw may be the cause of failure. However, for older transformers the failure may be caused by any reason such as a long-term thermal degradation of the winding insulation, sudden shock due to abrupt loading, short circuit, grid issues (frequency/voltage) or reverse feeding.

An event due to faults inside the transformer occurring spontaneously is neither predictable nor avoidable with the currently practicable monitoring and test scope.

For the emergency power transformers in the scope of this AMP, these kinds of failures are not common but still can occur. Nevertheless, the test programme is incorporated to ensure high reliability within the safety system. At the time when this AMP was produced, no relevant R&D was identified.

1. Quality management:

Site quality assurance procedures, review and approval processes, and administrative controls are implemented in accordance with the different national regulatory requirements (e.g., 10 CFR 50, Appendix B[5]).

References

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3. ELECTRIC POWER RESEARCH INSTITUE, Large transformer end-of-expected-life considerations and the need for Planning, EPRI report 1013566, EPRI, Palo Alto, CA, December 2006.
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6. ELECTRIC POWER RESEARCH INSTITUTE, Medium voltage Transformer end of life Guidance. EPRI, Palo Alto, CA: 2012. 1025261.