Study Committee A2

Power transformers and reactors

10842_2022

QUALIFICATION TEST FOR POWER TRANSFORMERS GIC CAPABILITY

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Motivation

- GIC (quasi-DC induced current), a consequence of solar storms, would have significant effects on power transformers (Saturation ➔ harmonics and reactive power ➔ Thermal challenges).
- National authorities ask utilities to assess the GIC risk and the vulnerability of their electrical installations
- In terms of standardized tests on transformers GIC capability, there is a lack of normative references
- To develop a special test to characterize the limits and the capability of a 570MVA GSU design to withstand such DC current components.
- To compare the simulation results and to focus on the most constrained components of the active part to optimize the instrumentation for the transformer GIC capability test in the manufacturer high-voltage lab.

Objects of investigation

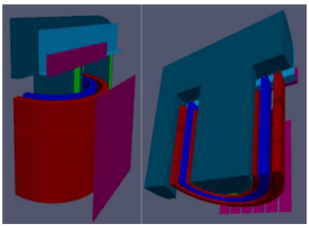
- The characterisation of the electromagnetic behaviour of the transformer under DC component
- The qualification of the transformer thermal and mechanical performances under GIC stresses
- Mastering and understanding better the limits and hypothesis taken for the simulations to qualify the GIC capability of the transformers
- Put guidance for the future work on power transformer GIC capability test standards.

Thermal simulations and modelling of the transformer under GIC

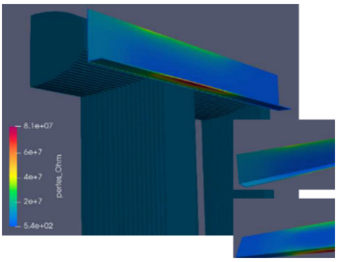
- Design data of the 570 MVA GSU transformer

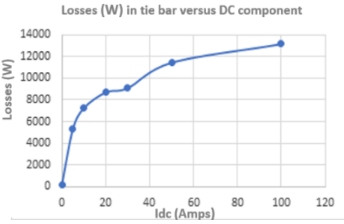
Design characteristics	
Type	Single-phase, oil immersed power transformer
Rated power/ voltage HV	570 MVA/405/√3 kV ± 2.47%
Frequency	50 Hz
Core type	4-leg core
Number of wounded legs	2

- Geometrical data for Finite Elements simulations



- Results: Losses calculations





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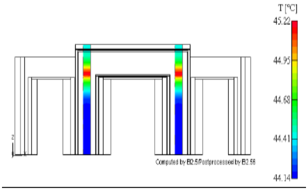
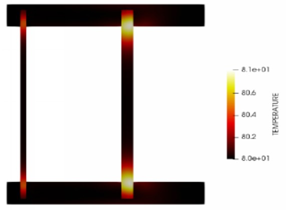
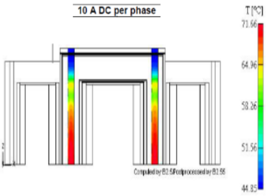
Temperature rise evaluation by simulation/Results:

- No load condition:

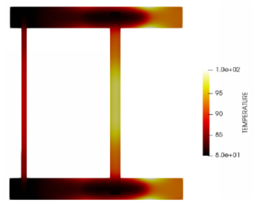


Unom (Hot Spot 1 K)



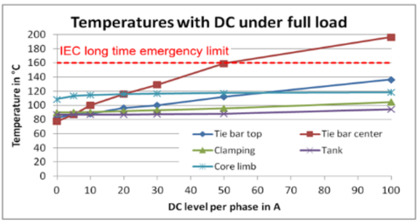


GIC 10 A (Hot Spot 17 K)



- Full load condition:

37K rise of Tie bar above top oil rise @ 20Amps DC

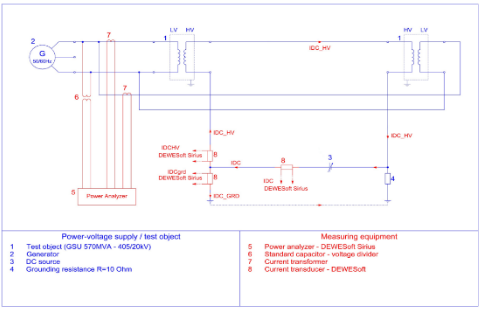


- Mechanical impact on core structural part of : Tie bar

The length extension of 3 mm impacts the clamping force with a decrease of 20% to 30%

GIC test circuit

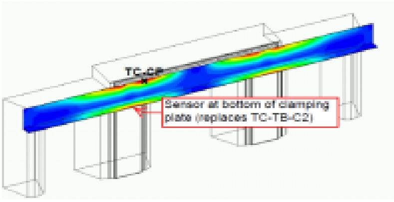
- Back-to-back configuration for single phase units:

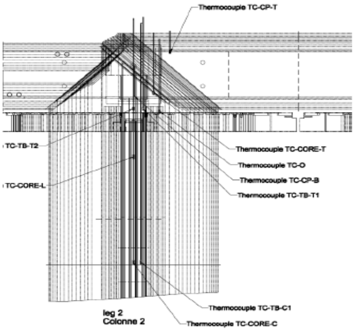


Temperature sensors locations for GIC capability test

The sensor locations in the 570 MVA transformer are as follows:

- ✓ Tie bar surface in the axial center
- ✓ Tie bar surface in the height of upper core limb end
- ✓ Clamping plate/beam
- ✓ Smallest core package in axial center
- ✓ Smallest core package on top
- ✓ Top of the smallest core package oil duct





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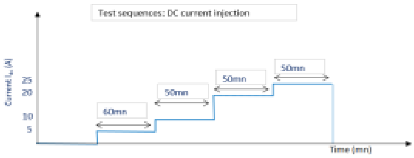
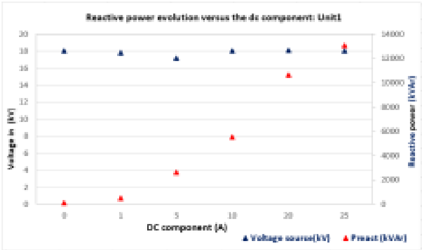
GIC test sequence

Time sequence	Voltage supply (p.u.)
07:15pm-03:00am	1.1
03:00am-08:00am	1.0



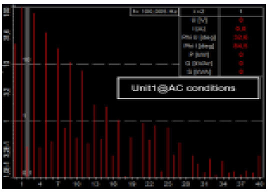
Reactive power evolution versus DC component

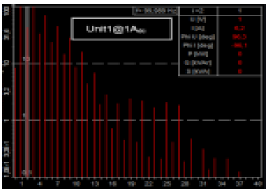
Significant increase of the reactive power consumption:



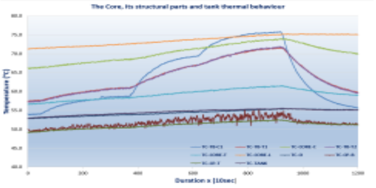
Characterization of the excitation current harmonics

A significant increase of the even harmonics in the current spectrum:

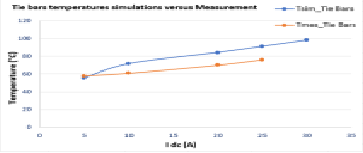




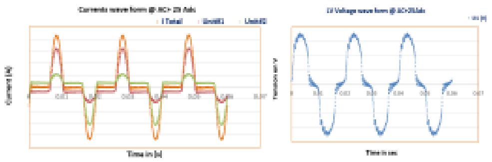
Core and structural part temperature measurements under GIC



The simulations show a conservative approach:

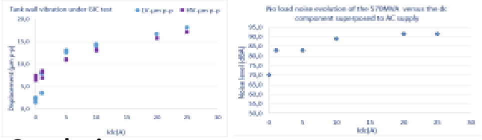


Test voltage and current under 25Amps DC components:



Core and structural part mechanical behavior under GIC

Tank vibrations and generated noise increase depending on the GIC magnitude:



Conclusion

- The transformer GIC capability can be demonstrated by a computational approach supported by a special test at the manufacturer's test bay.
- Although the back-to-back test is not completely representative of the operating conditions, the obtained test results allow the validation and evaluation of the performed simulations with the used calculation model.
- Mechanical impact of GIC evaluation requires test when the simulations seems difficult and heavy to perform.
- The first data are available to support the standardization.

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