



# 11108 – Thermal Performance For Three-Winding Transformers With Axially Stacked Windings

Pablo PACHECO RAMOS  
Doble Engineering, Spain

Jason VARNELL  
Doble Engineering, USA

Miguel MARTINEZ RONDEROS  
Iberdrola I-DE, Spain

Inna GERASIMOVA  
Faramax Trafo, Spain

Ester ESTEBAN CABELLOS  
Iberdrola Renovables, Spain

Sergey SNAGOVSKOY  
Faramax Trafo, Spain

## Introduction

A special thermal model is applied for a **3-winding core-form transformer with axially stacked windings**. Direct HS measurements were performed for all 3 windings.

The **special thermal model** uses different average (E and D) and top (B and A) oil rises for each winding, resulting in more accurate winding average (E' and D') and HS (H and K) rises than traditional thermal model.

## Test Requirements

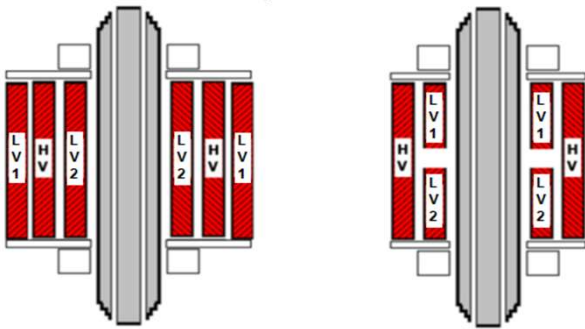


Figure 1 – Typical winding arrangement for 3-winding core-form transformers (right: axially stacked windings under analysis)

## Specimen Unit

TRANSFORMER MAIN DATA	
Reference Standard	IEC 60076
Number of Phases	3
Vector Group	YNd11d11
Windings Designation	<b>HV / LV1 / LV2</b>
Rated Power (MVA)	ONAN: 96 / 48 / 48 ONAF: 128 / 64 / 64 <b>ONAF: 160 / 80 / 80</b>
Rated Voltage (kV)	<b>400 / 30 / 30</b>
Frequency (Hz)	50
Cooling Mode	ONAN/ONAF/ONAF
Guaranteed Top Oil Rise (°C)	60
Guaranteed Av. Wind. Rise (°C)	65
Guaranteed Hot Spot Rise (°C)	78

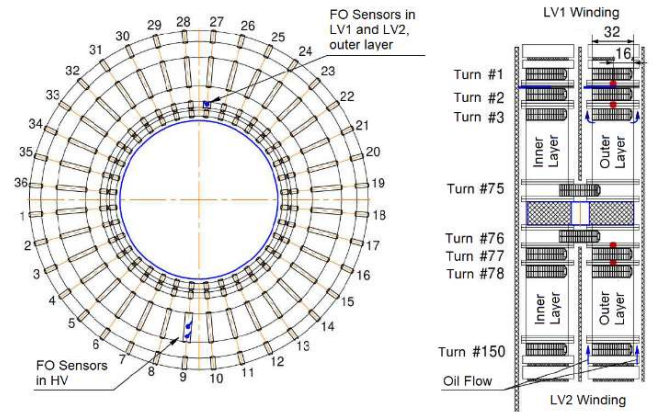


Figure 3 – Fiber Optic HS Sensors location in LV coils

## Calculations VS. Test Results

TEMP. RISES AT 160/80/80 MVA	TRAD. LV1 & LV2		SPECIAL LV1			SPECIAL LV2		
	Calc.	Point	Calc.	Test	Point	Calc.	Test	Point
Top Oil Rise	40.4	A	40.4	46.2	A	25.9	31.0	B
Av. Oil Rise	25.9	B	33.1	38.6	D	18.7	23.4	E
Av. Wind. Rise	49.9	B'	56.1	<b>55.9</b>	D'	43.7	<b>42.4</b>	E'
Av. Wind. Grad.	24.0	B'-B	23.0	17.3	D'-D	25.0	18.9	E'-E
Bot. Oil Rise	11.5	C	25.9	31.0	B	11.5	15.8	C
Wind. HS Rise	71.6	K	70.3	<b>68.7</b>	K	58.4	<b>55.6</b>	H
Hotspot Grad.	31.2	K-A	29.9	22.5	K-A	32.5	24.6	H-B

## Special Thermal Model

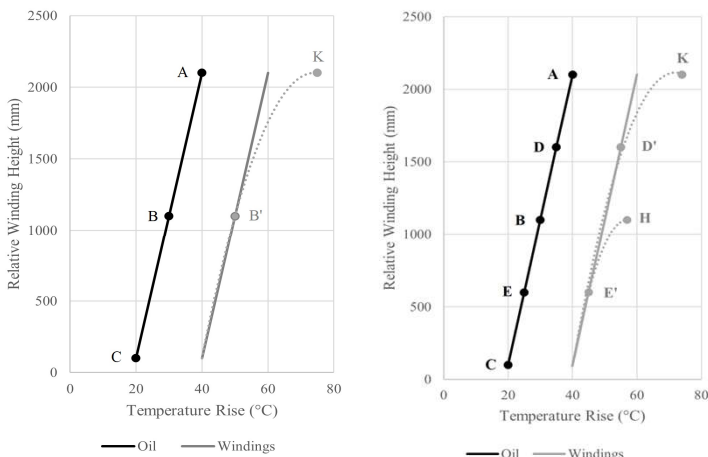


Figure 2 – Traditional (left) and special (right) thermal models

## New Available Loading Scenarios

Scenario	Load [MVA] LV1 / LV2	Loading Time	LV1 Life [Years]	LV2 Life [Years]
1	80 / 80	Permanent	34.1	169.4
2	62.25 / 97.75	Permanent	70.5	70.5
3	128 / 0	Permanent	18.3	>10000
4	0 / 139	Permanent	>1000	18.3

Other **metallic elements hot spot absolute temperature is calculated below 130°C** for all scenarios.

## Conclusions

Better loading split between LV windings to **maximize overall transformer life expectancy** (scenario #2) and **minimization of loss of delivered load** in case one LV winding needs to be unloaded (scenario #3 and #4).