ESSIAL has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 766437.

ESSIAL

WP5: Transformers Manufacturing

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IRT m2p INSTITUT DE RECHERCHE TECHNOLOGIQUE MATÉRIAUX MÉTALLURGIE ET PROCÉDÉS

Multitel INNOVATION CENTRE

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EREA TRANSFORMERS erea · energy · engineering

jeumont electric groupe altawest

EuraMaterials

andaltec CENTRO TECNOLÓGICO DEL PLÁSTICO

Fraunhofer IPT

LASEA

euronovia

Tasks of EREA within ESSIAL

Proof of Concept (WP4 / WP5)

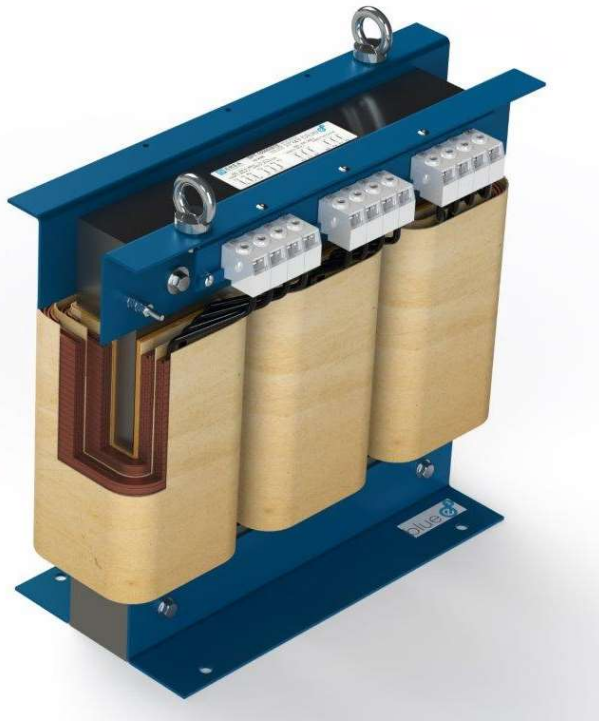
- Evaluating laser-, metallurgical and thermal treatments on GO (Grain Oriented) cores in transformers

Tasks in WP4:

- Building reduced size transformers
- Measurements (only for verification)

Tasks in WP5:

- Building industrial scale transformers
- Measurements



Comparison method **treated <–> not treated material**

Based on earlier experiences:

Large variations can be present in the quality (losses) of electrical steel

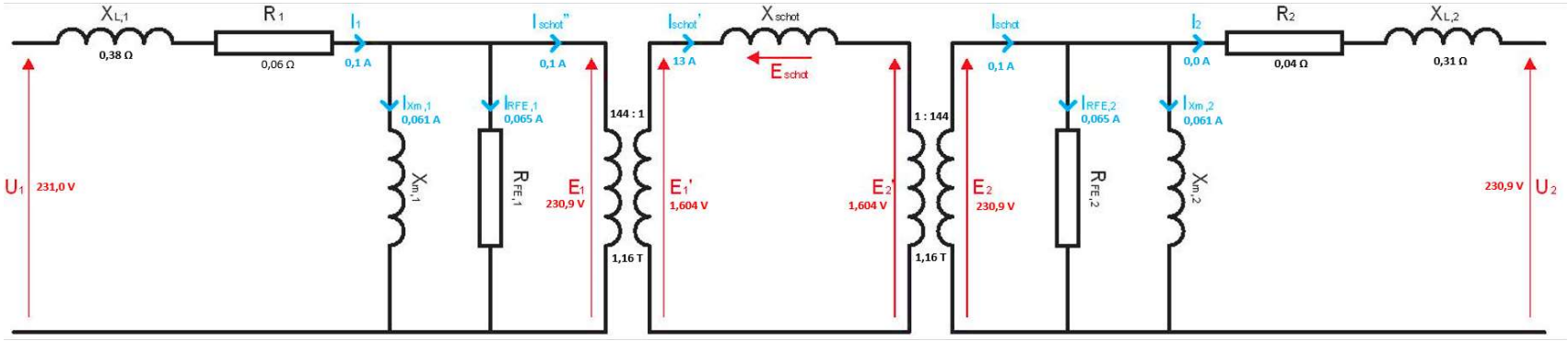
To avoid errors in Essial measurements:

same sheets before and after laser treatment

→ No influence of tolerances on the base material

Calculation

Based on equivalent circuit



Results

KLANT: **ESSIAL project**

INGEGEVEN WAARDEN

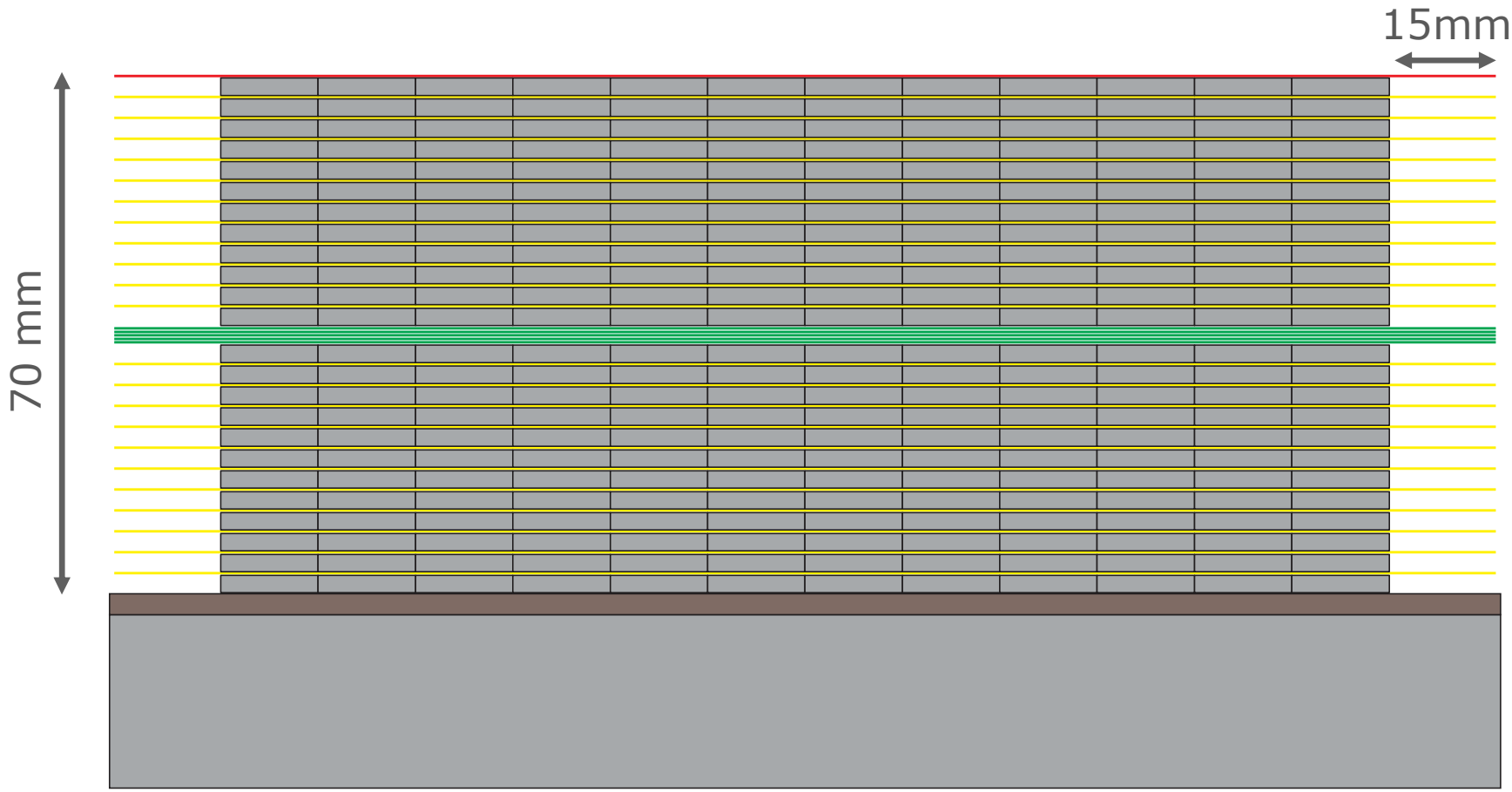
SPANNING PRIMAIR	(V)	231			
SPANNING SECUNDAIR	(V)	231			
STROOM SECUNDAIR	(A)	100			
VERMOGEN	(VA)	23100	FREQUENTIE	(Hz)	50
OMGEVINGSTEMP	(°C)	20	OPWARMING	(°C)	24,7
IJZER KWALITEIT	(W/kg)	1,1	INDUCTIE	(Gs)	11570
PAKDIKTE		65	BLIKFORMAAT		UI 400
KOELFACTOR		0,22425	VULFACTOR		96%
SCHOT		NEE	SCHERM		Nee
EERSTE WINDING		SECUNDAIR			

ALGEMENE GEGEVENS

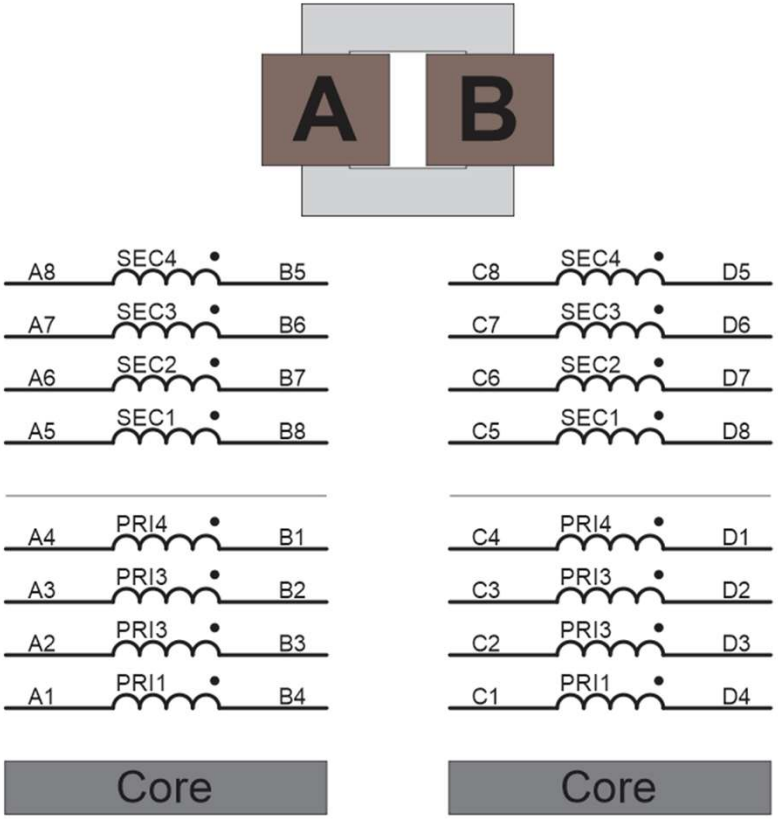
INDUCTIE	(Gs)	11297	KOELOPPERVLAK	(dm²)	55
KOPERVERLIES (Tomg)	(W)	228,5	KOPERVERLIES (Warm)	(W)	276,31
LEEGLOOPVERMOGEN K	(VA)	41,3	LEEGLOOPVERMOGEN K	(W)	30,22
LEEGLOOPVERMOGEN W	(VA)	38,0	IJZERVERLIES (Warm)	(W)	28,25
RENDEMENT	(%)	96,21%	COSFI		1,00
SPOELDIKTE 1	(mm)	69,5	SPOELDIKTE 2	(mm)	34,2
WIKKELBREEDTE PR	(mm)	170,2	WIKKELBREEDTE SEC	(mm)	170,2

50 Hz Industrial scale (WP5)

Current density	: 1,45 A/mm²
Cu losses PCu	: 275W
Wire section	: 14mm x 2,5mm
Amount of turns	: 144
	12 layers
	12 turns/layer



Properties of the WP5 transformer



Connector configuration

(WP5_1ACT50_A)

PRI4°	PRI3°	PRI2°	PRI1°	SEC4°	SEC3°	SEC2°	SEC1°
B1	B2	B3	B4	B5	B6	B7	B8

PRI4°	PRI3°	PRI2°	PRI1°	SEC4°	SEC3°	SEC2°	SEC1°
D1	D2	D3	D4	D5	D6	D7	D8

PRI1	PRI2	PRI3	PRI4	SEC1	SEC2	SEC3	SEC4
A1	A2	A3	A4	A5	A6	A7	A8

PRI1	PRI2	PRI3	PRI4	SEC1	SEC2	SEC3	SEC4
C1	C2	C3	C4	C5	C6	C7	C8

ESSIAL WP5 transformer vs commercial transformer

320x380x415 mm

Commercial Transformer (20 kVA)

600x350x390 mm

ESSIAL WP5_1ACT50_B (22 kVA)

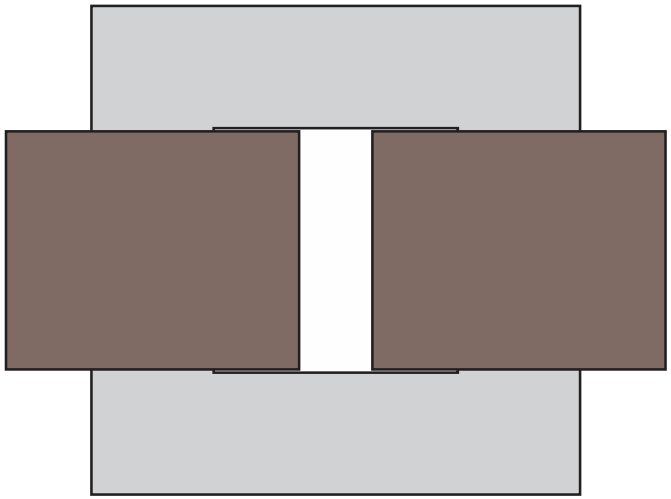
Realistic model of a 22kVA monophase transformer

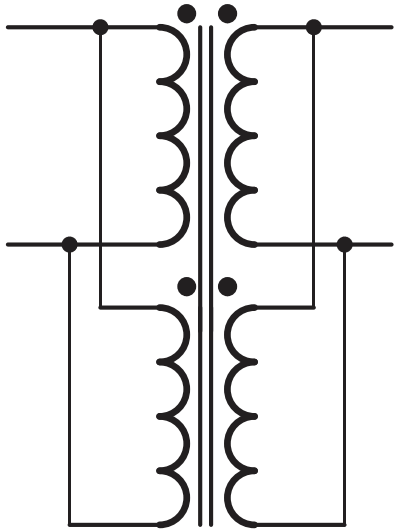
→ More connectors for flexibility

→ Rectangular core vs square core

Step 2: Construction of the transformer

Rectangular core with two identical coils

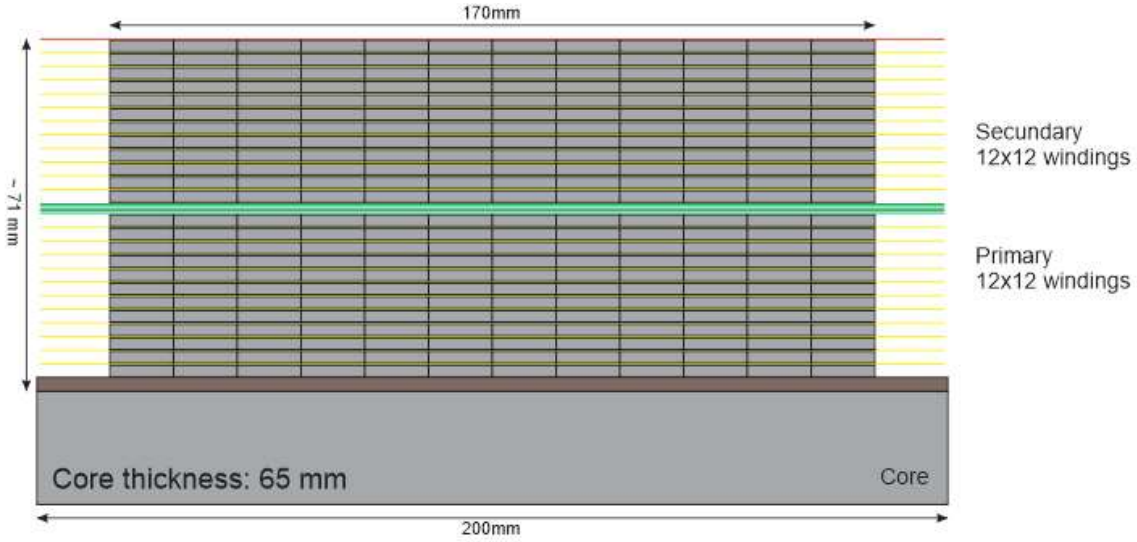




2 coils (each: ½ primary and ½ secondary)

Placed in series or parallel (or combination)

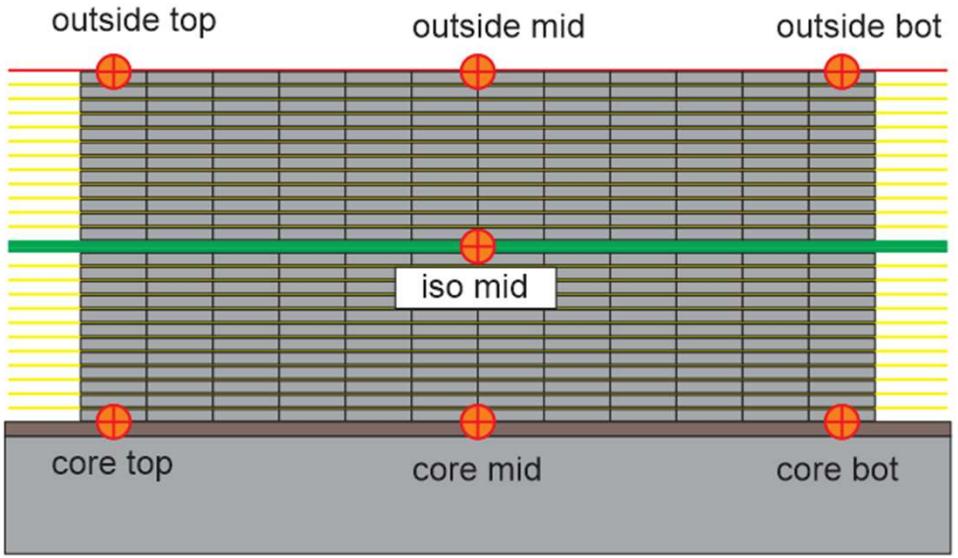
Winding of the coils

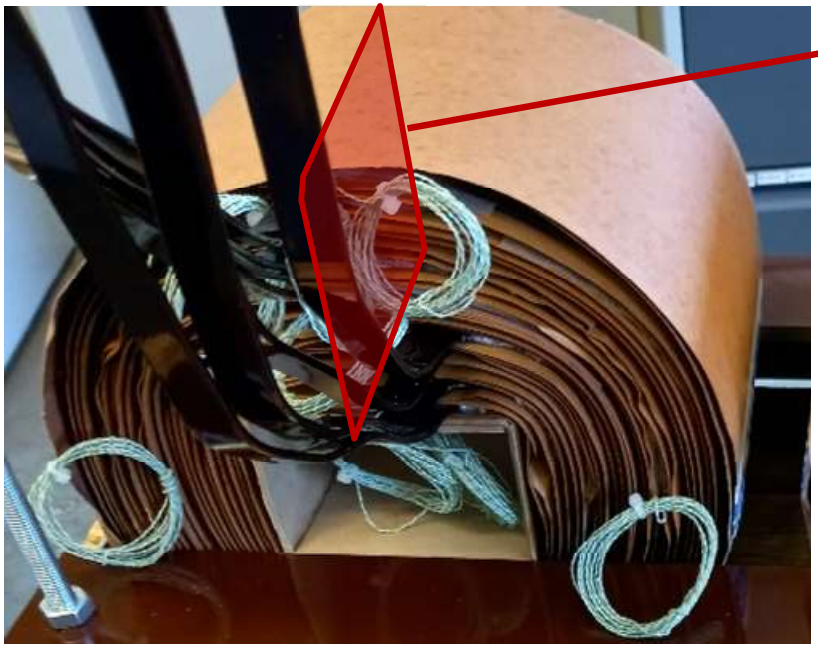


Thermocouples

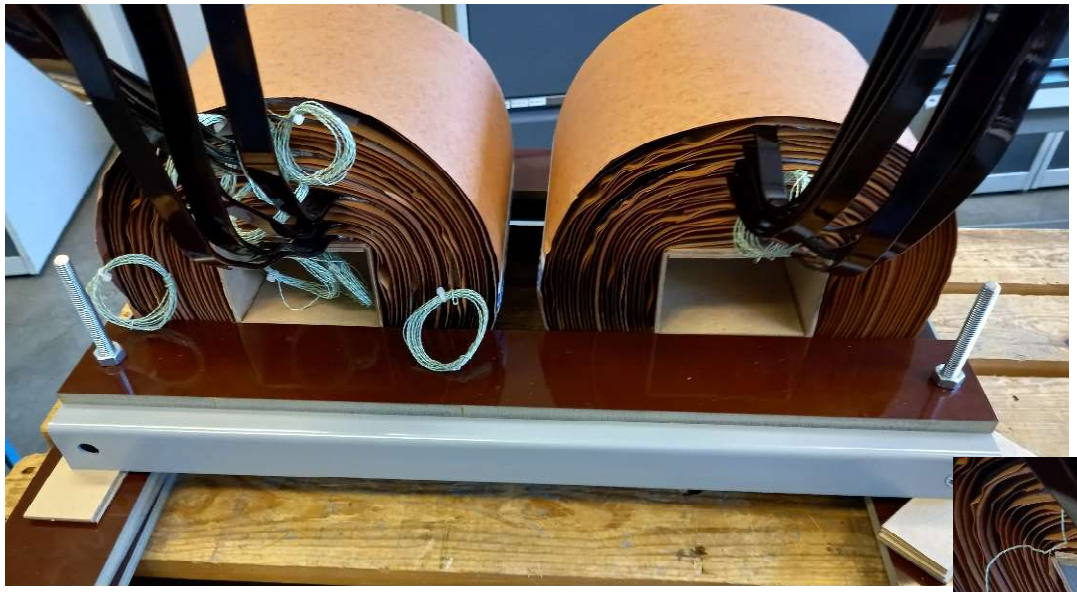
Amount of thermocouples

- Front: 7
- Left : 1
- Right: 1

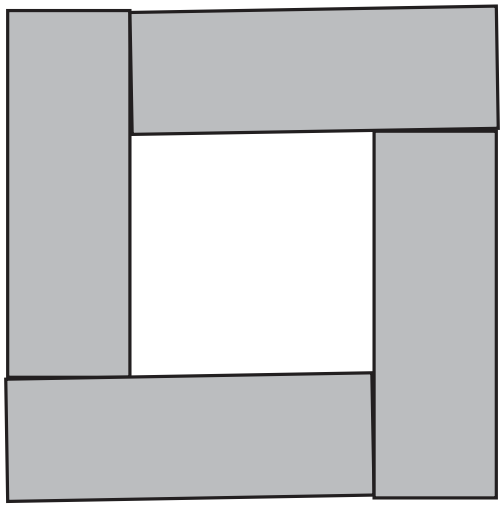




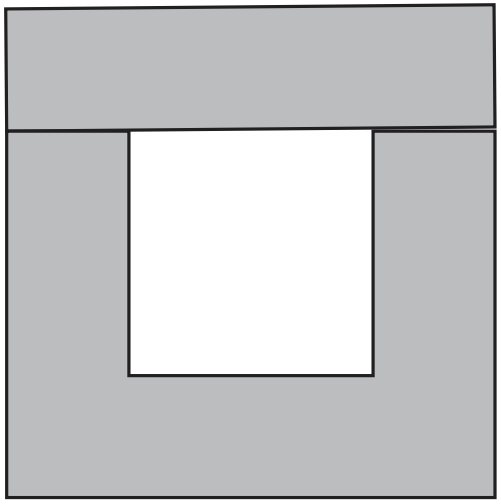
Assembling the core



Assembling the core



Essial stacking
more degrees of freedom



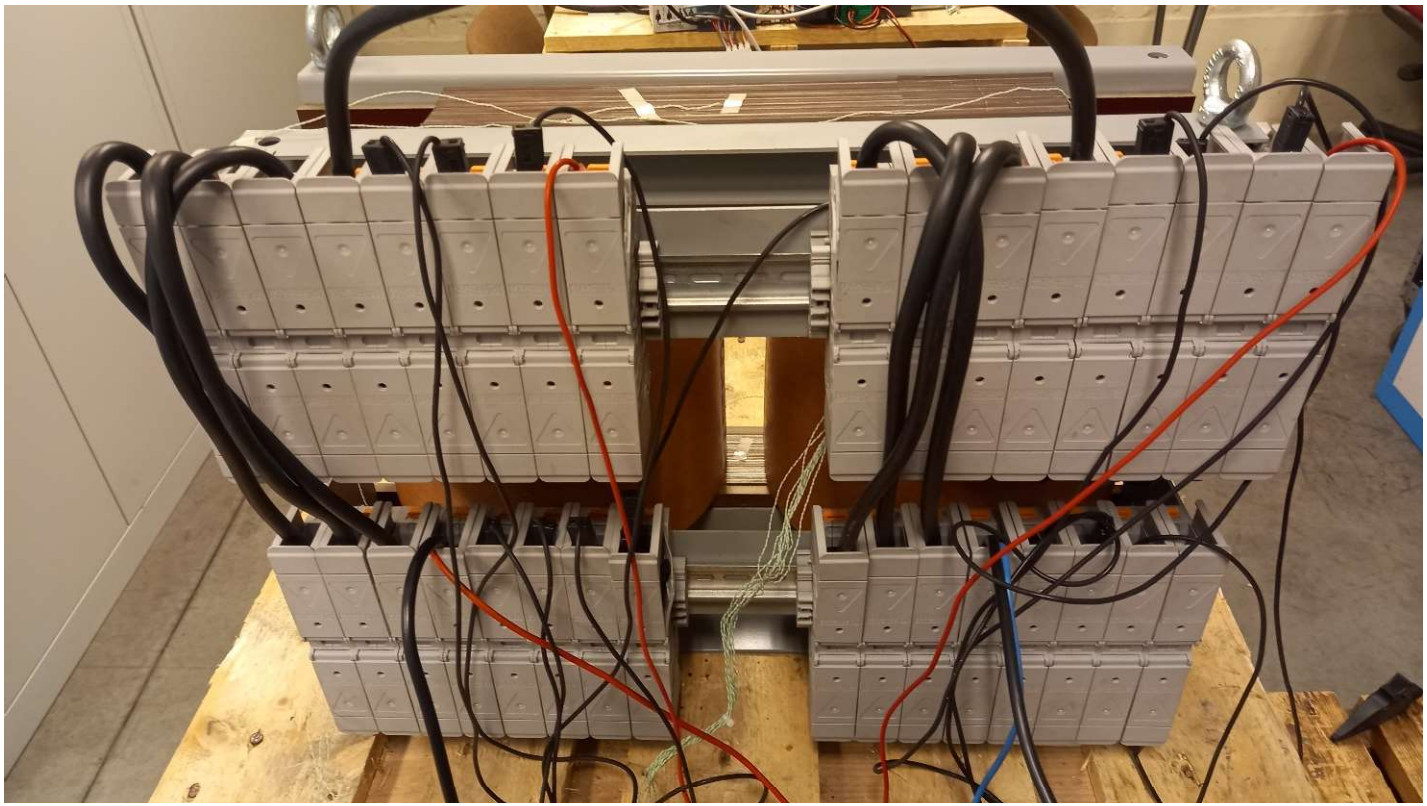
Traditional stacking (UI-core)
less degrees of freedom
→ easier to manage

- **Advantage Essial stacking:**
  - All flux in rolling direction

- **Disadvantage Essial stacking:**
  - More effort required to avoid air gaps

Finishing the transformer

Measurement WP5 transformers



Primary:
4-wire measurement
16mm² wiring

Secondary:
Simple 1,5mm² wiring
Only voltage meting

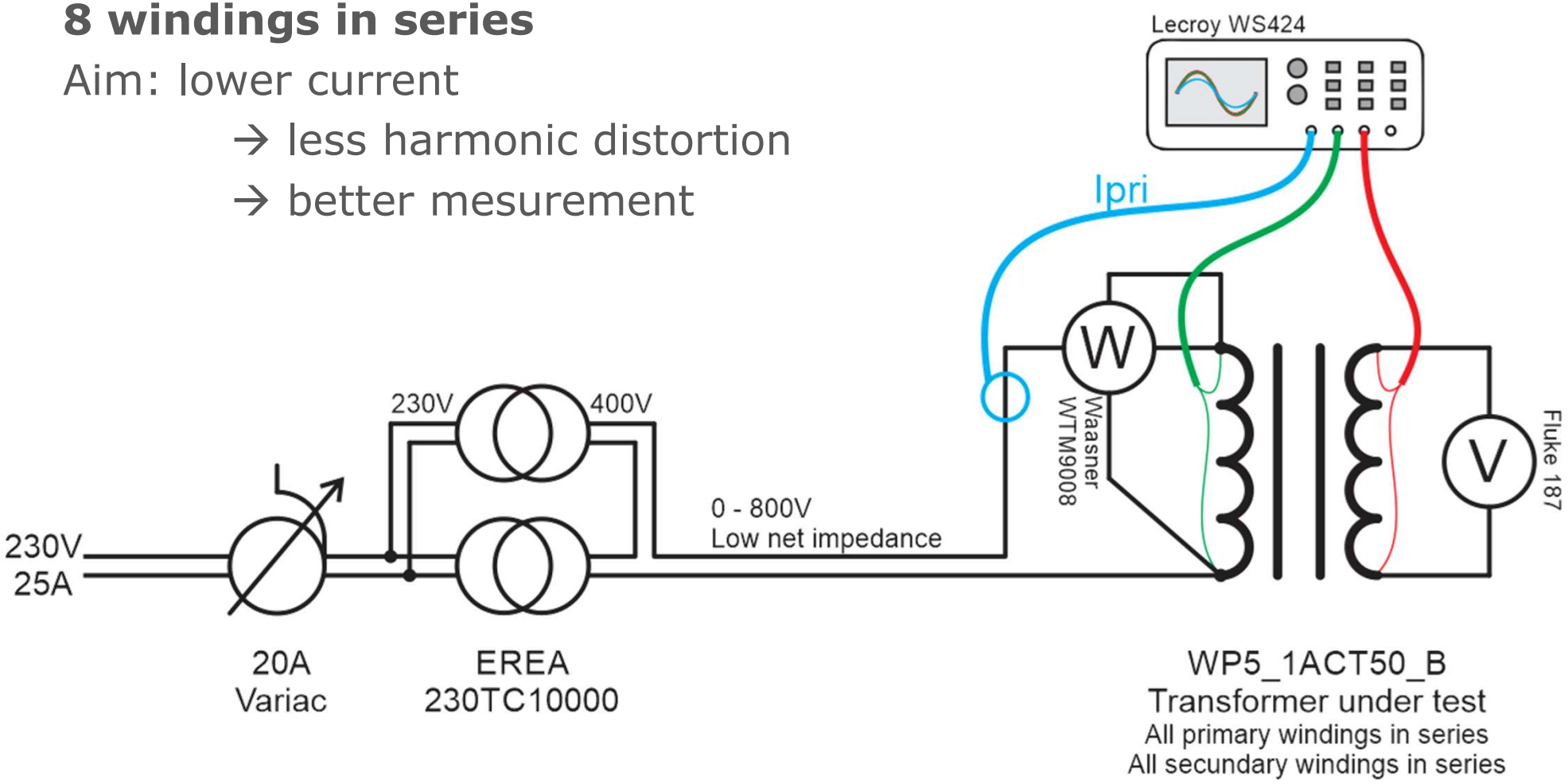
Measurement setup

8 windings in series

Aim: lower current

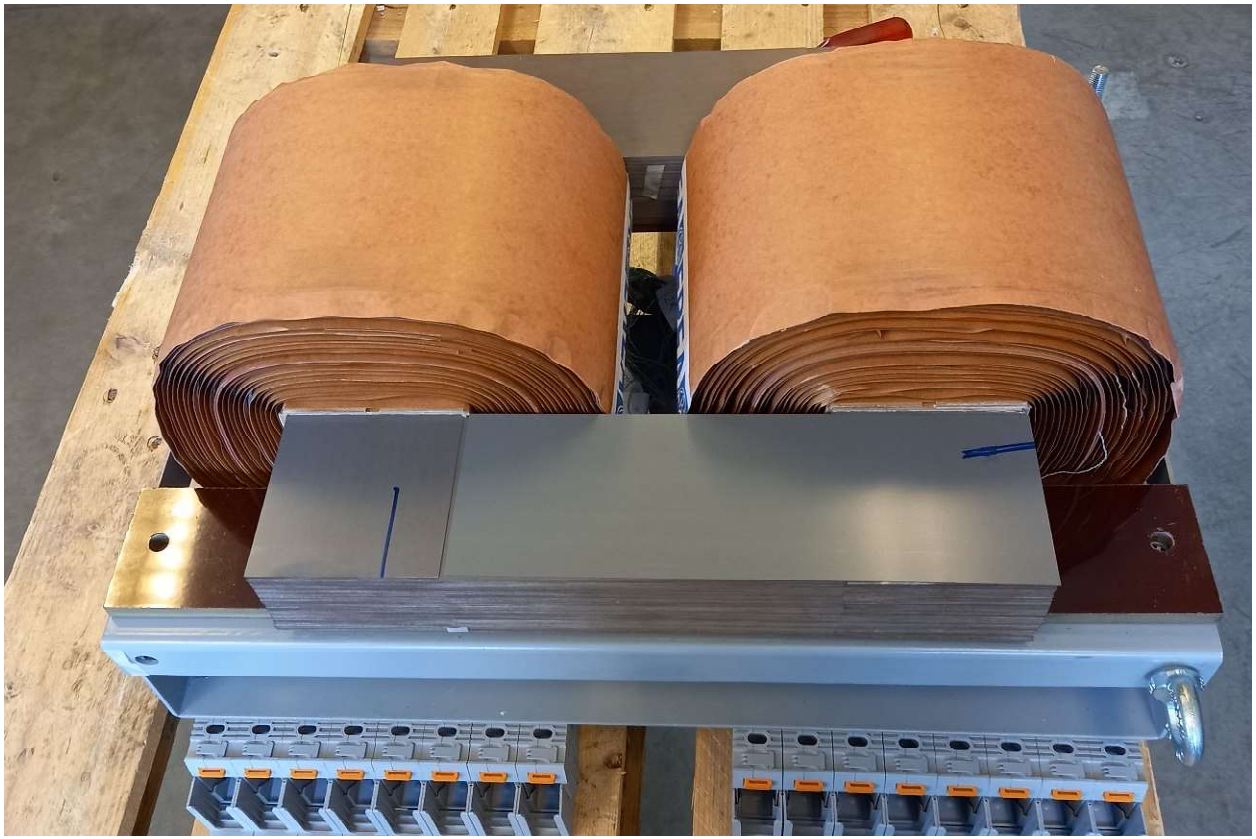
→ less harmonic distortion

→ better mesurement



Step 3: Disassembly

Step 4: Reassembly en re-measurement
(after laser treatment and eventually coating)



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Results of the laser treatment

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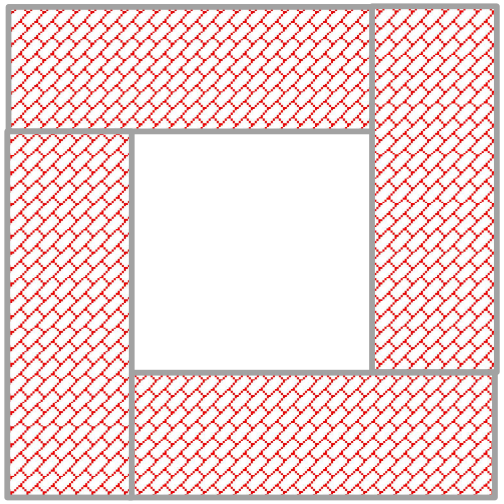
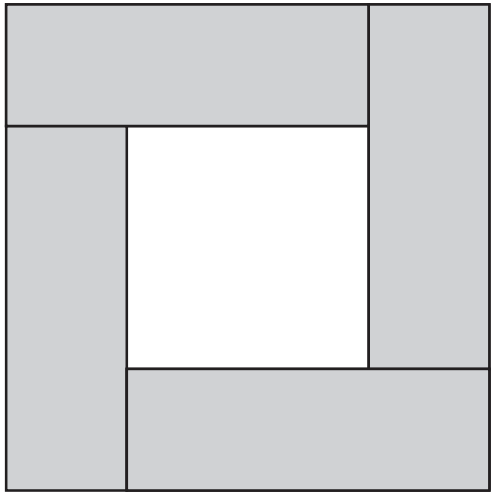
WP5_1ACT50_A – laser pattern

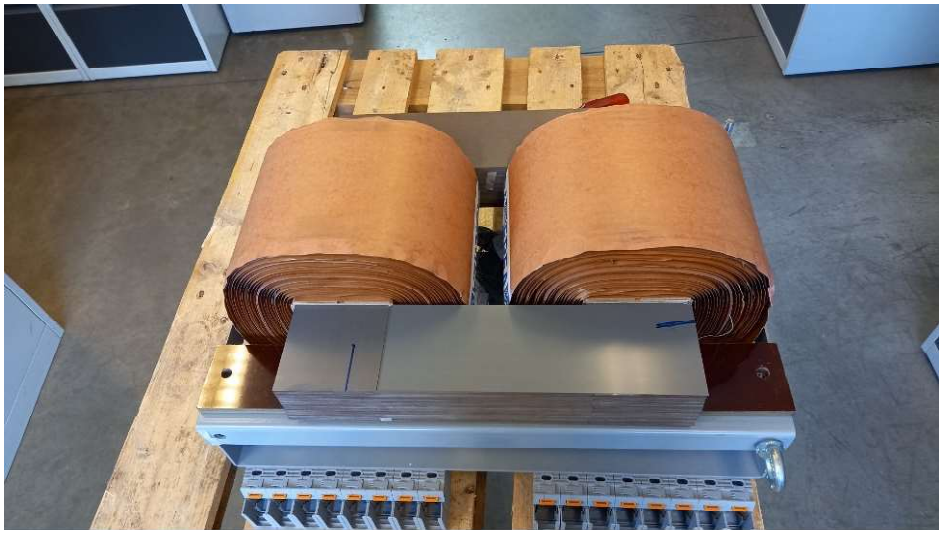
Recoated after laser treatment



Front



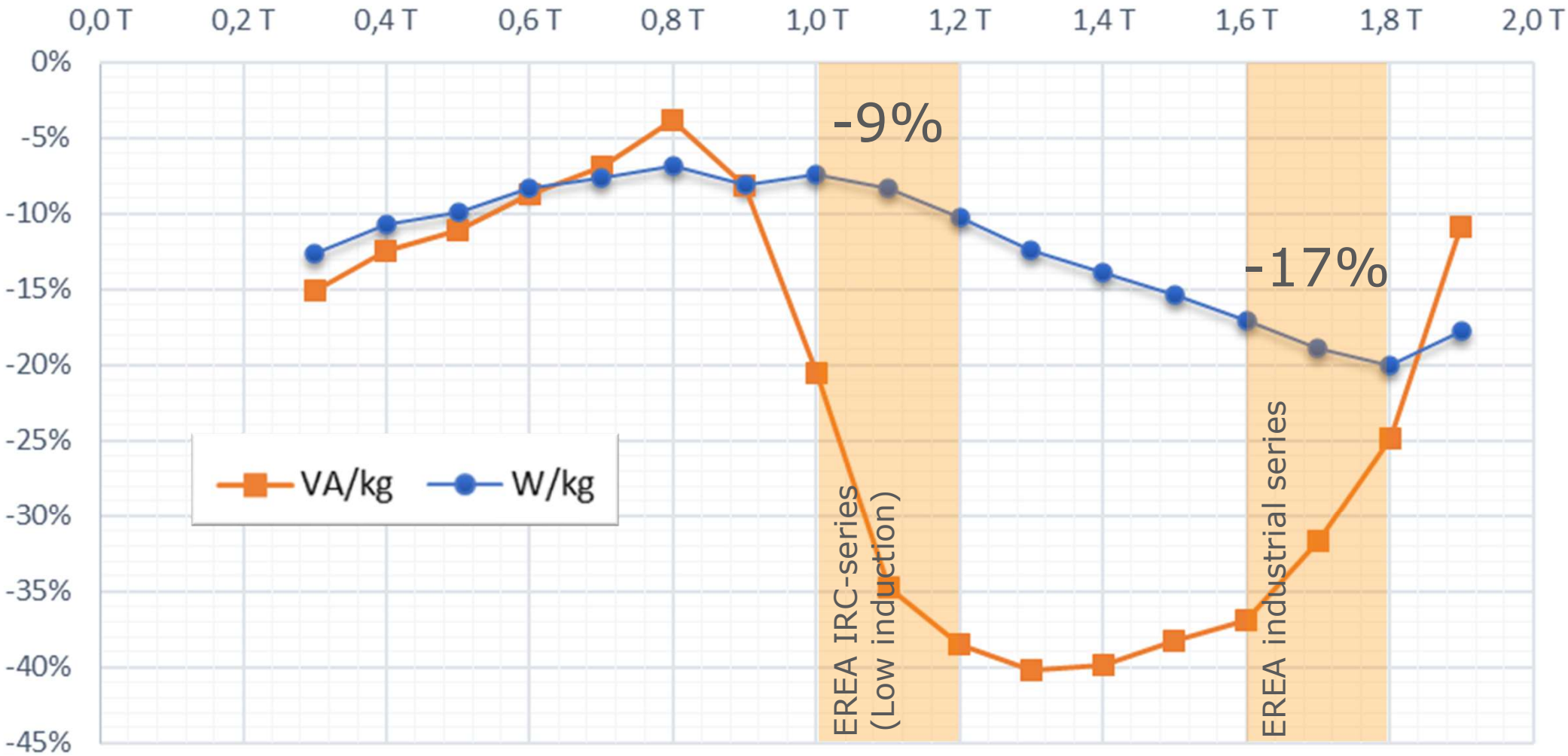
Rear



Untreated zone

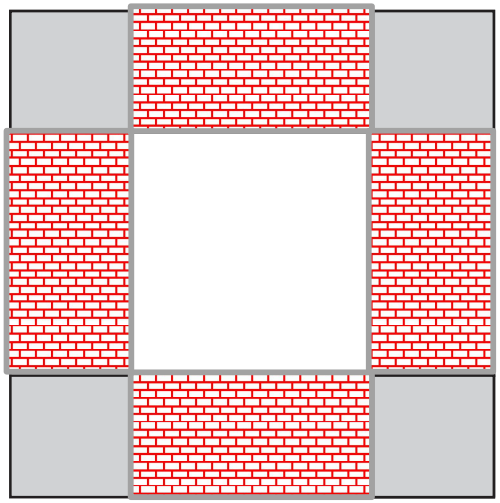
Treated zone (LASER CONFIGURATION 1)

WP5_1ACT50_A - results

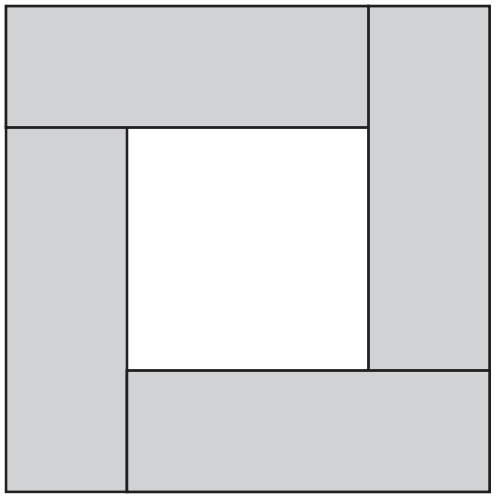


WP5_1ACT50_B – laser pattern (1st treatment)

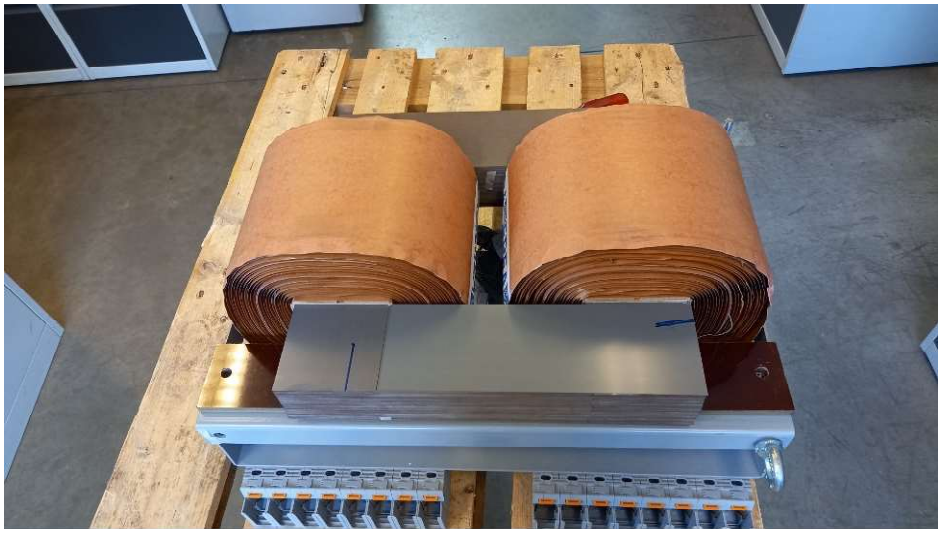
Not recoated after laser treatment



Front



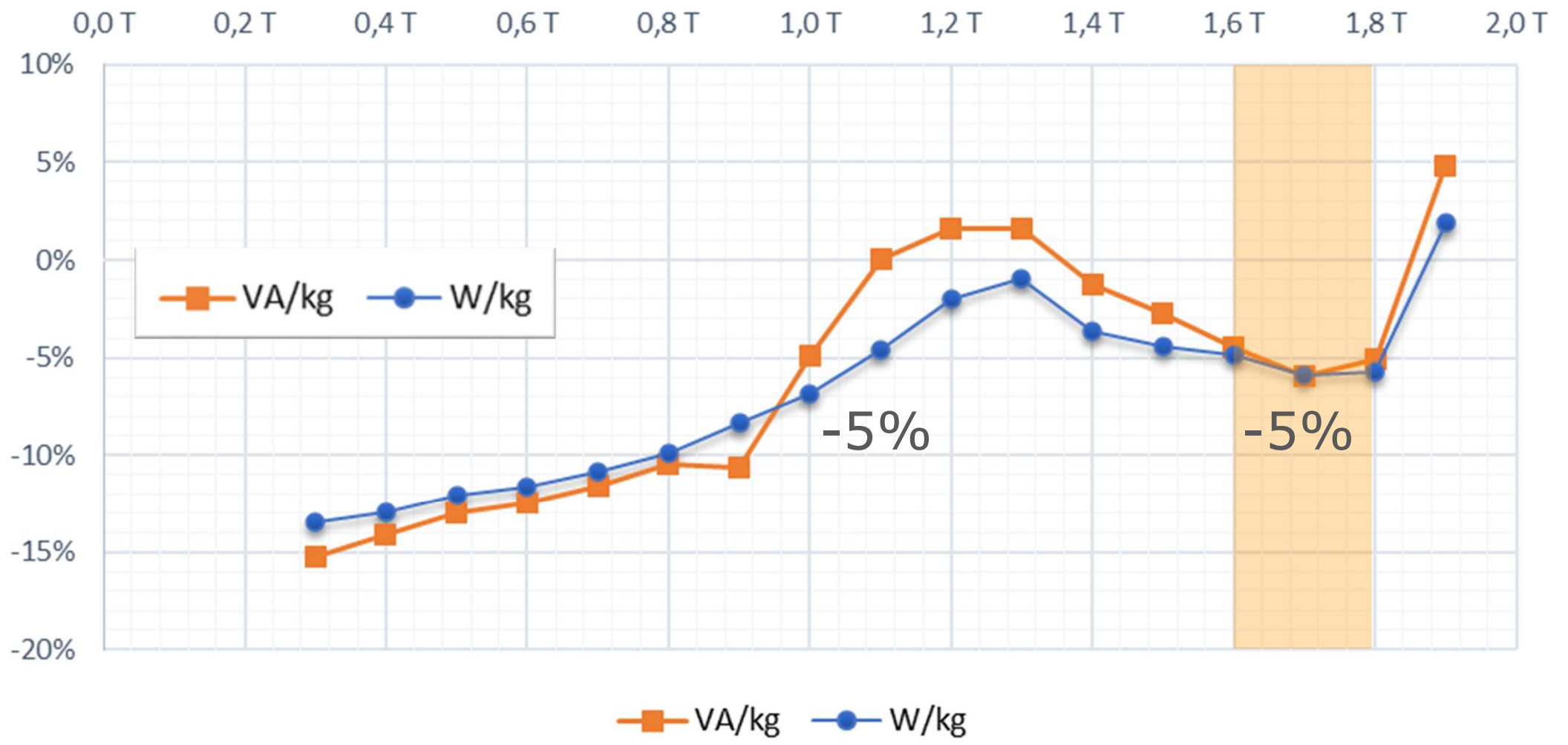
Rear



Untreated zone

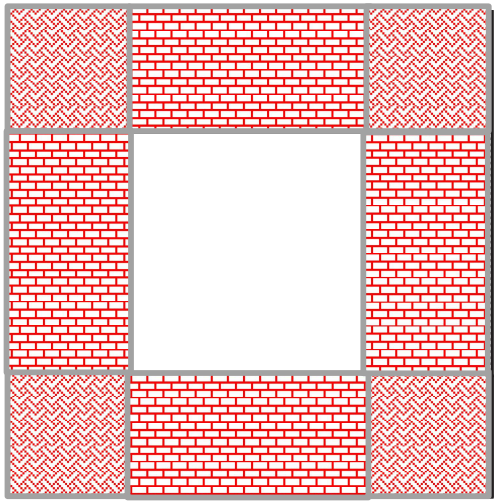
Treated zone (LASER CONFIGURATION 2)

WP5_1ACT50_B – results (1st treatment)

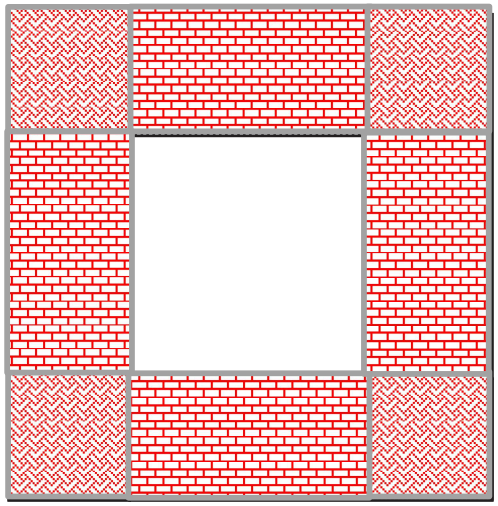


WP5_1ACT50_B – laser pattern (2nd treatment)

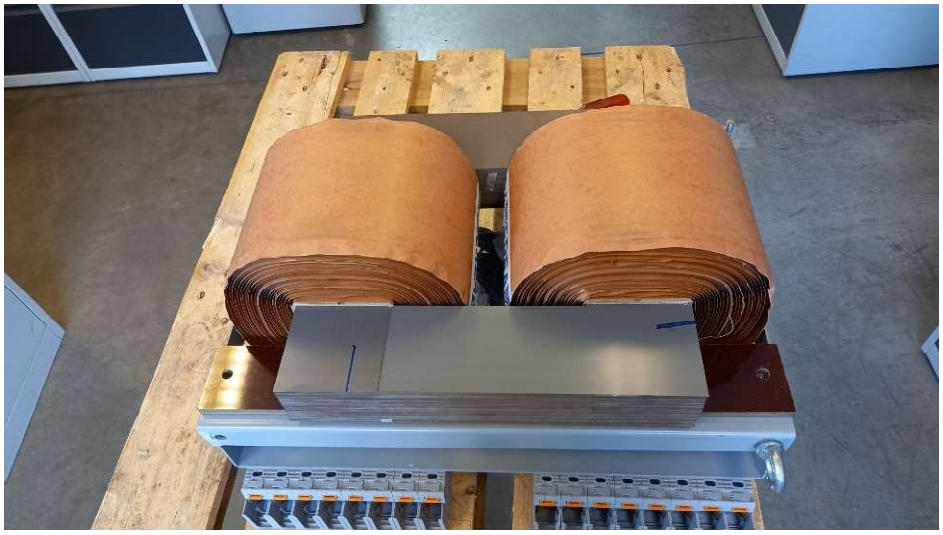
Not recoated after laser treatment



Front



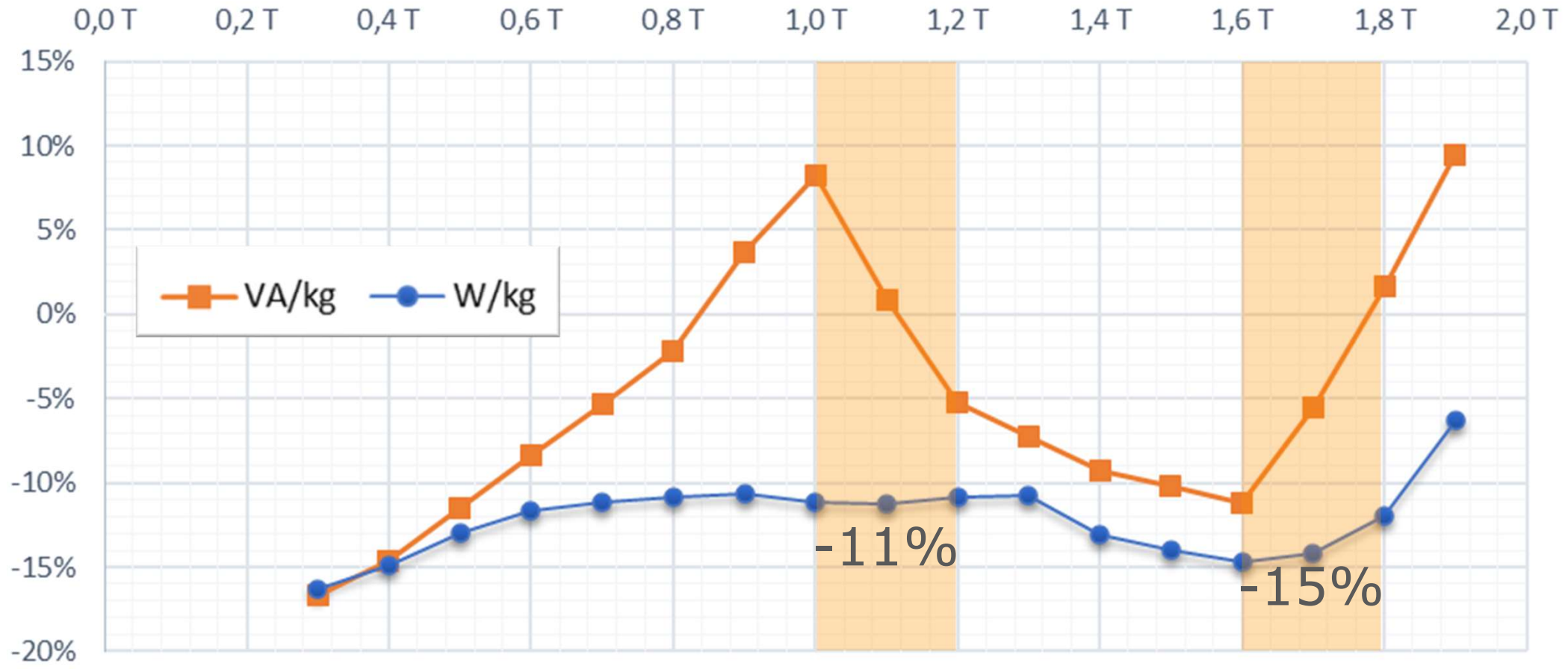
Rear



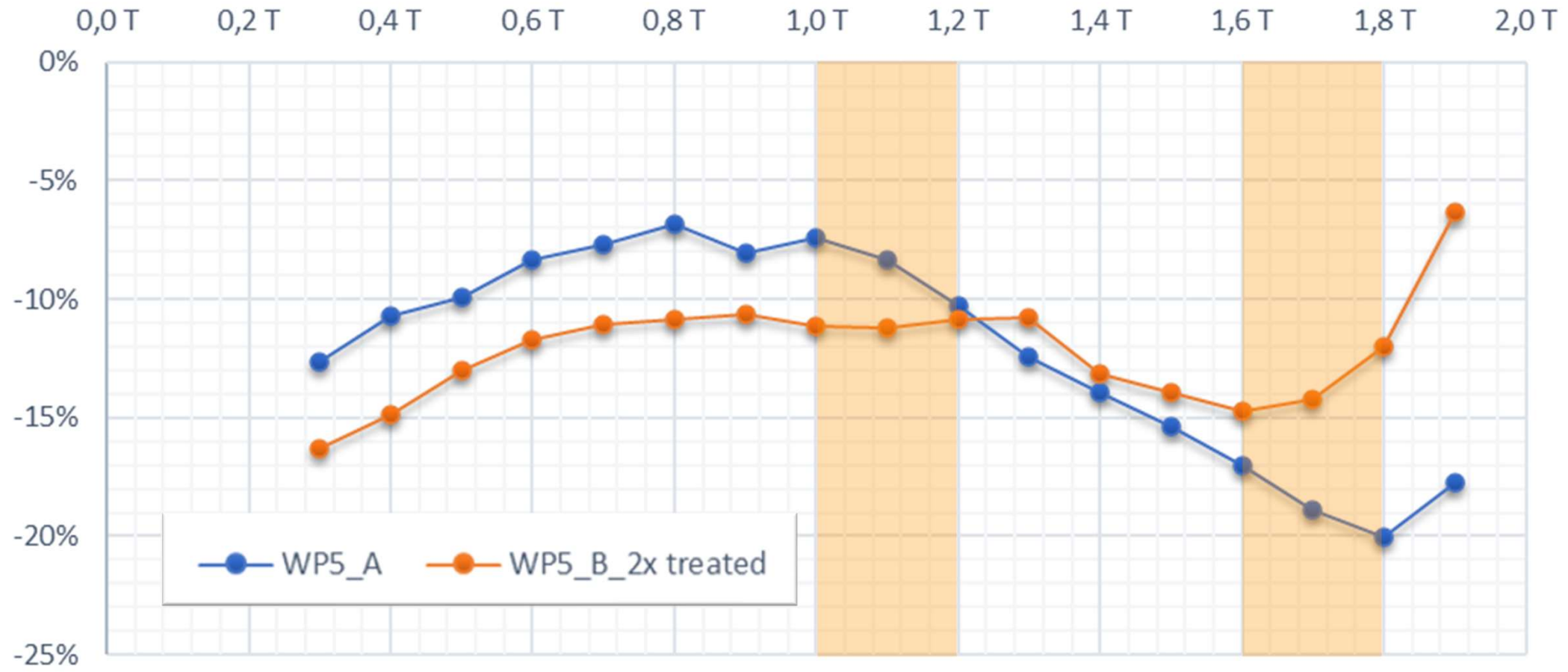
Treated zone (LASER CONFIGURATION 2)

Treated zone (LASER CONFIGURATION 3)

WP5_1ACT50_B – results (2nd treatment)



Comparison WP5_A vs WP5_B



Conclusion

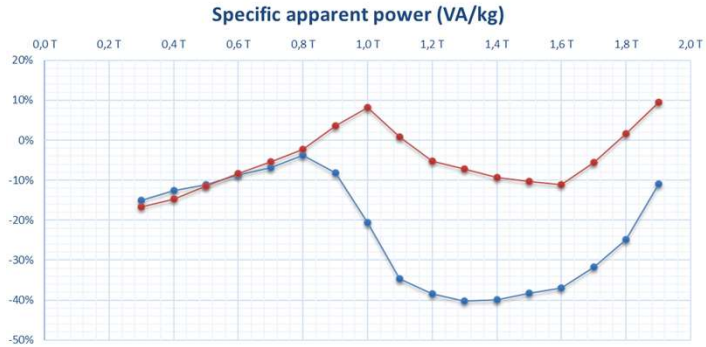
Specific active losses (W/kg)

- 1T-range → 8-11% improvement
- 1,6T-range → 15-19% improvement

Most important parameter for ROI

Specific apparent power (VA/kg)

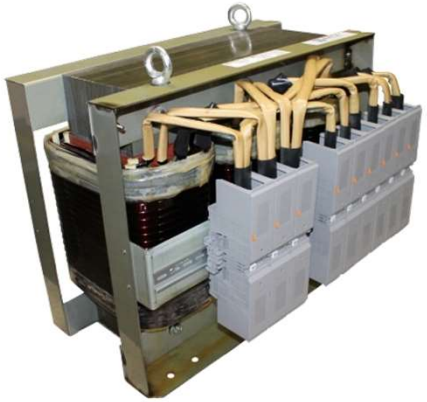
Large variation depending on coating



VA/kg has almost no impact on ROI

→ Results WP5 similar to WP4

Conclusion (feasiblity payback period)



Example:

SPT100000 – 100kVA 3-phase transformer

P_0 = 400 W → saving after laser (-15%) : ΔP_0 = 60W

Maximum additional cost for 3-year payback period (24/7 operation)

2021: € 250 margin for laser treatment (25% of cost untreated core)

2022: € 350 margin for laser treatment (35% of cost untreated core)

2023: ???

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Thank you for your attention!

ESSIAL FINAL PROJECT INFODAY

Monday, 11 July 2022 – UniLaSalle, Amiens (France)