

**INSULATION AND AGING PERFORMANCE OF LAMINATED PRESSBOARD  
VERSUS LAMINATED WOOD IN HV POWER TRANSFORMERS**

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## Introduction

The power network reliability depends strongly on safe function of transformer insulation parts. The quality of the insulation components have big impact on the design optimization. Therefore the overall insulation volume and active part dimension of transformer can be reduce. The best and most cost effective solid insulation is cellulose based pre-compressed pressboard. To use thick massive solid cellulose based insulation materials LAMINATED PRESSBOARDS in H.V. power transformers is unavoidable. In IEC 60763 defined all technical conditions and test requirements. There are alternative material LAMINATED WOOD acc.IEC 61061.Clamping rings, beams, blocks, plates made from laminated pressboard or as alternative laminated wood. But the aging test results shows that laminated wood products produce significantly more acids and sludge formation which contains high lignin and natural resin. Dielectric strength is also much lower.

This paper concentrated to compare the laminated pressboard with laminated wood. At specially presented electrical and mechanical strength and aging conditions in mineral oil.

**Laminated Board IEC 60 763**  
**Laminated Wood IEC 61 061**



Oil contamination,  
The open splits are not allowed.  
Free particles are contaminated to transformer oil.



**Laminated Board IEC 60 763**  
**Laminated Wood IEC 61 061**



The deep, open and black splits are not allowed on/in Laminated Wood. This problem isn't observed on/in the Laminated Board. The knots are very dangerous in terms of electrical and chemical tests.

## Laminated Board IEC 60 763 Laminated Wood IEC 61 061



### Laminated Board

- ❖ No air-filled void or gaps
- ❖ No particles and dust

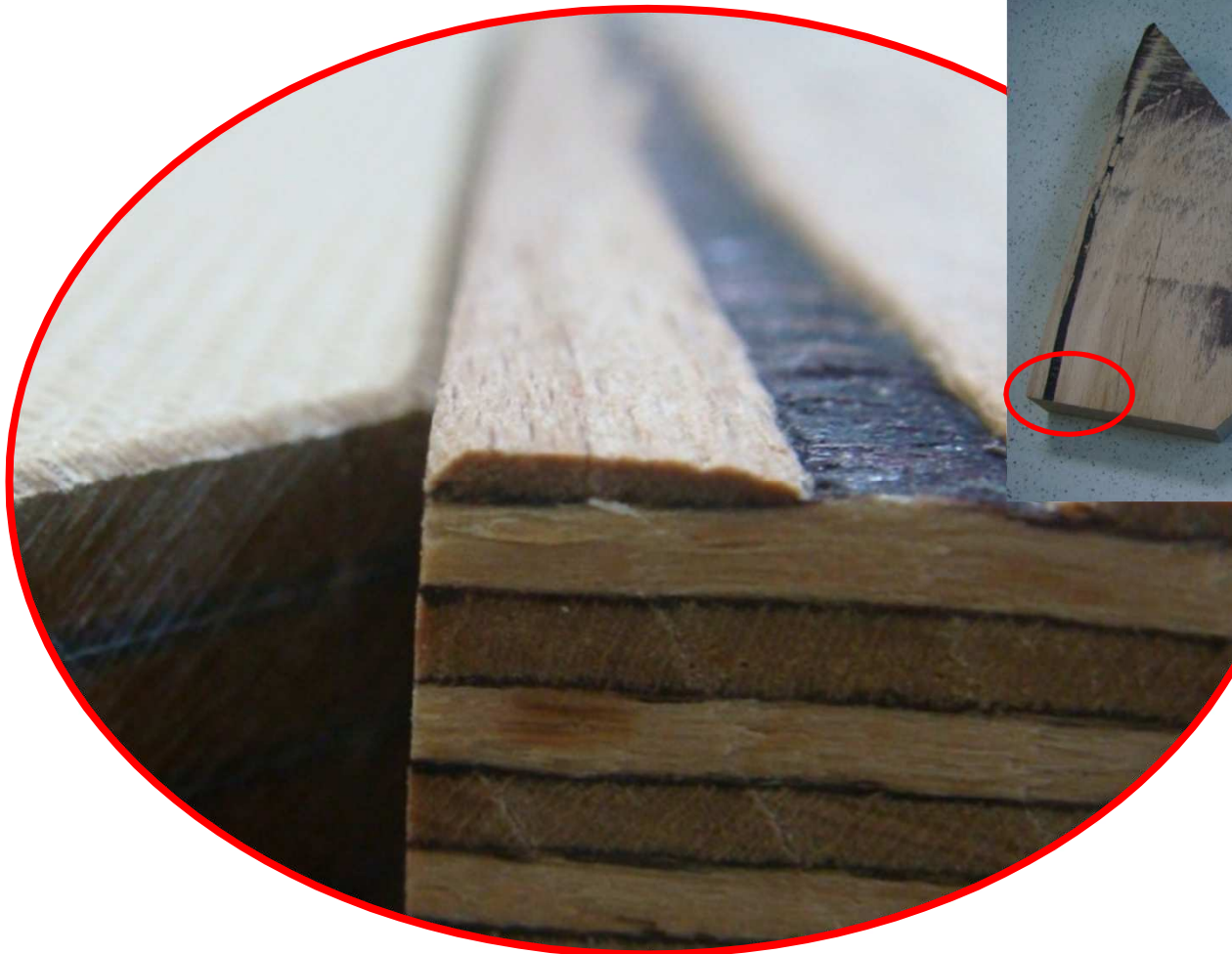
### Laminated Wood

- ❖ Air-filled void
- ❖ Much more particles and dust

A gap is not natural, due to the manufacturing process. (overlapping veneers) Transformer oil contact formaldehyde adhesive in the gap.

# Laminated Board IEC 60 763

## Laminated Wood IEC 61 061



- Transformer Oil
- Gap
- Relation
- Contamination &
- Finally Oil Degradation

Insulation materials to be used in liquid-immersed transformers must be compatible to the liquid



# Laminated Board IEC 60 763 Laminated Wood IEC 61 061

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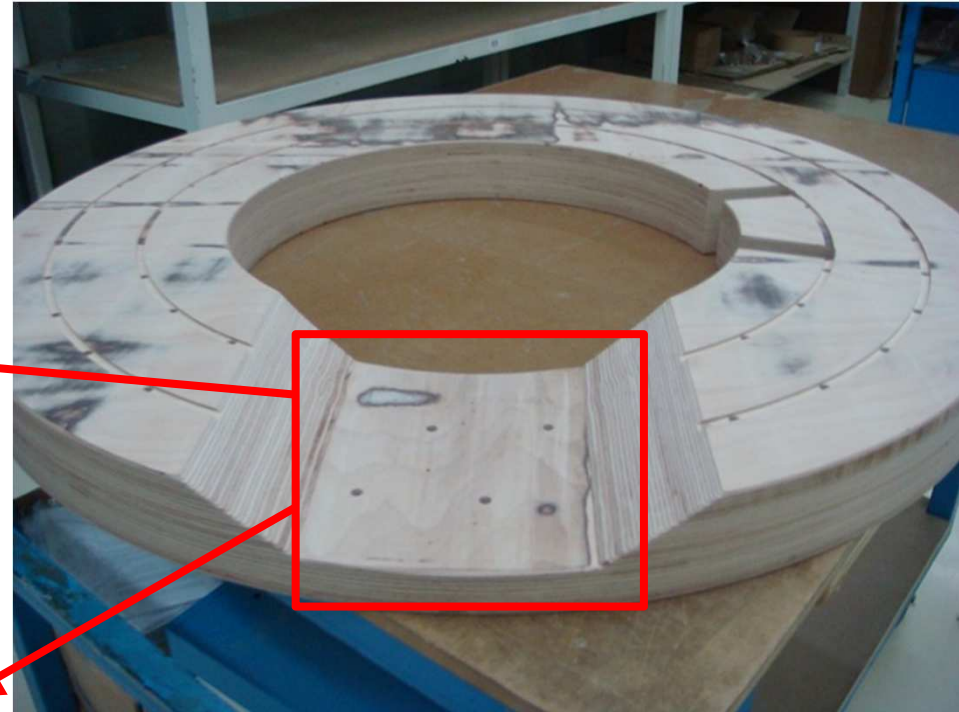
There are a lot of overlap positions. This production method causes mechanical and electrical problems in transformer.

After and During of Winding Installation





# Laminated Board IEC 60 763 Laminated Wood IEC 61 061



The moths comes from natural life and are very dangerous in terms of electrical and chemical life, must be take precautions against this problem

# Laminated Board IEC 60 763 Laminated Wood IEC 61 061

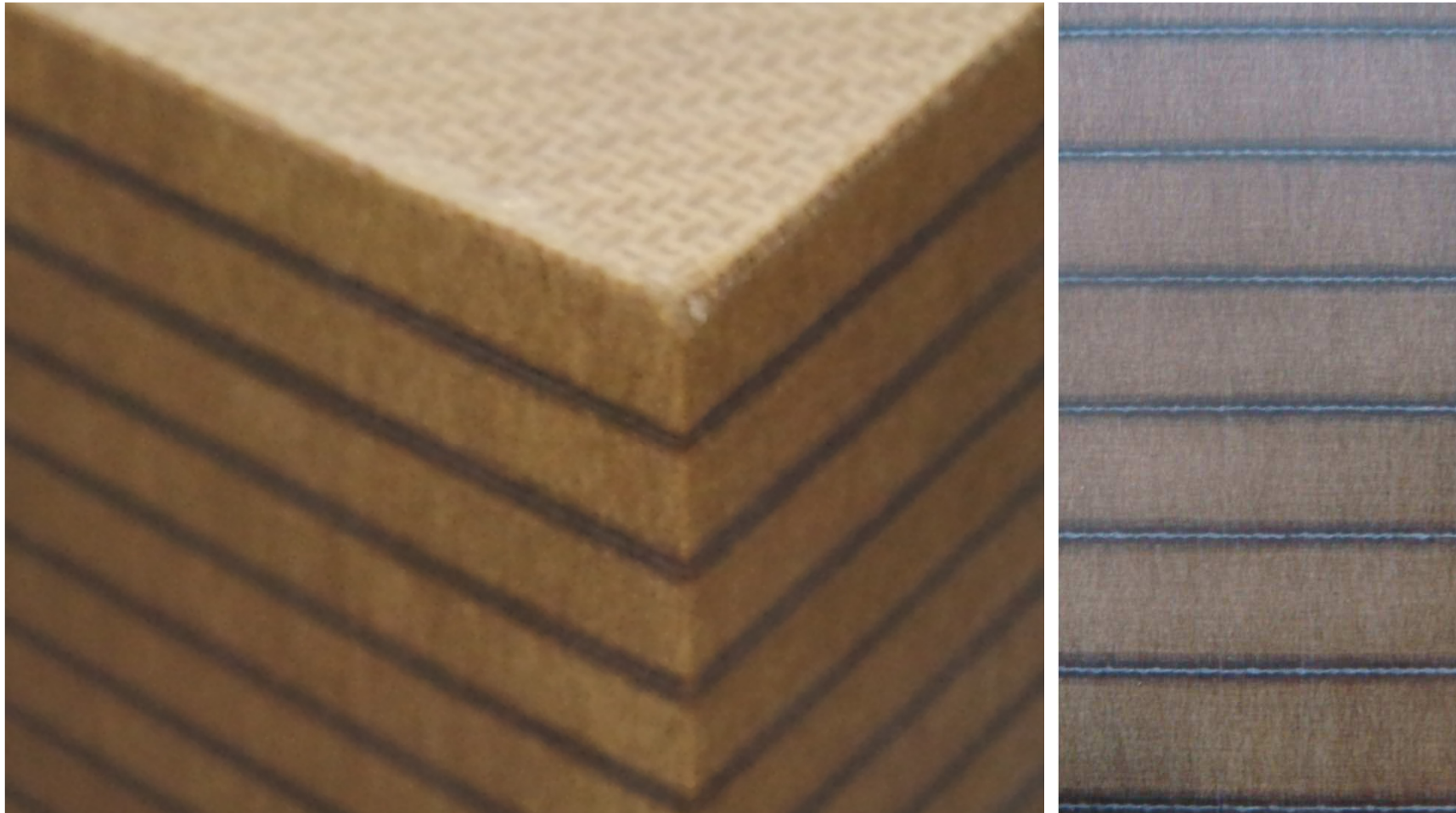


Flatness of Laminated Wood (IEC 61061-3-1 TYPE C2R) was controlled and 3,20 mm flatness in the middle of the disc was observed AFTER drying and oil impregnation processes.

**Difference In Flatness: 3,20 mm**

**Laminated Board IEC 60 763**  
**Laminated Wood IEC 61 061**

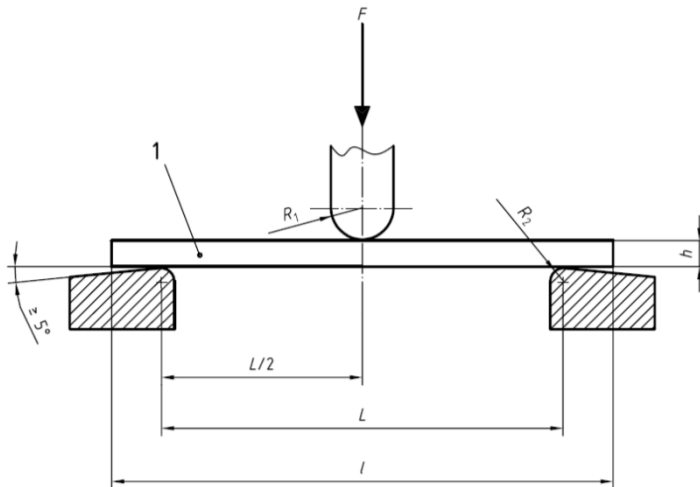
**Laminated Board**



Laminated Board materials doesn't have visual problems.



## Mechanical Property (IEC 60763-2 Clause 6.1)



Sample Dimension:  
Thickness (h) :15 mm  
Length (l): 300 mm  
Width (b): 20 mm  
Support Distance (L) : 240 mm



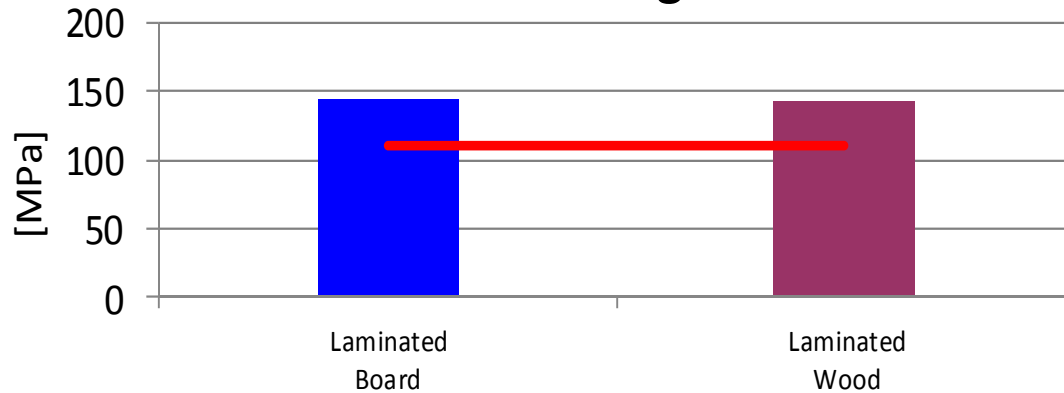
Calculation :

$$\sigma_f = \frac{1,5 \cdot F \cdot L}{bh^2}$$

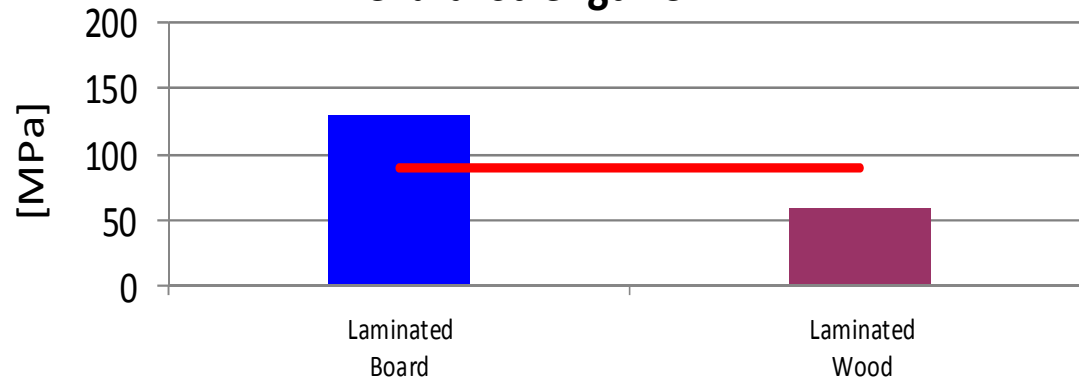
$F$  is the maximum load (in N);  
 $L$  is the distance between the supports (in mm);  
 $b$  is the width of the test specimen (in mm);  
 $h$  is the thickness of the test specimen (mm).

**Mechanical Property (IEC 60763-2 Clause 6.1)**

**Flexural Strength MD**



**Flexural Strength CMD**



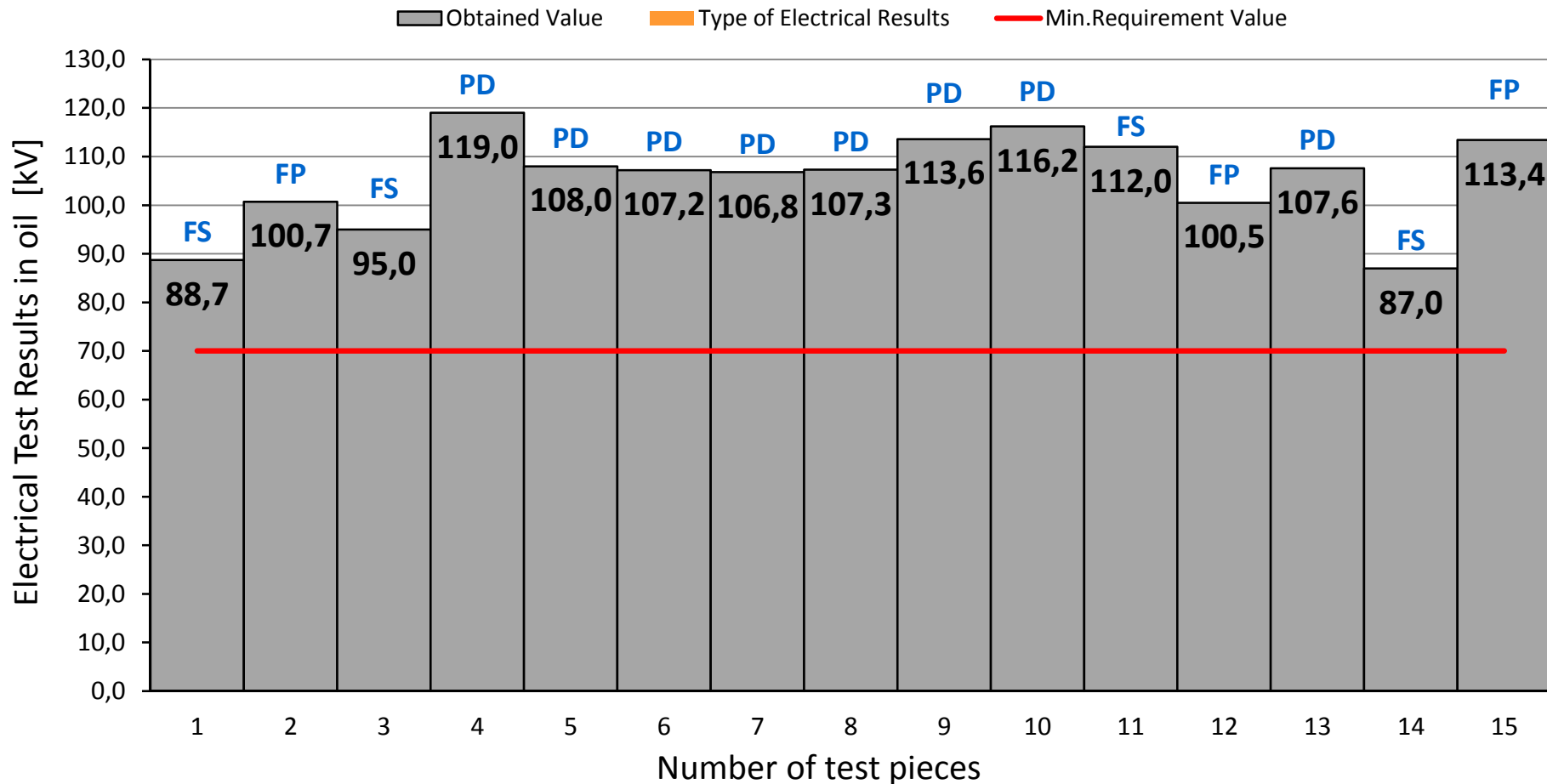
Material	Flexural Strength	
	MD [MPa]	CMD [MPa]
Laminated Board Polyester IEC 60763	144	<b>130</b>
Laminated Wood KP 20222 C2R IEC 61061	142	<b>59</b>

MD: Machine Direction

CMD: Cross Machine Direction

## Electrical Property of ENPAY LB – Casein (IEC 60270)

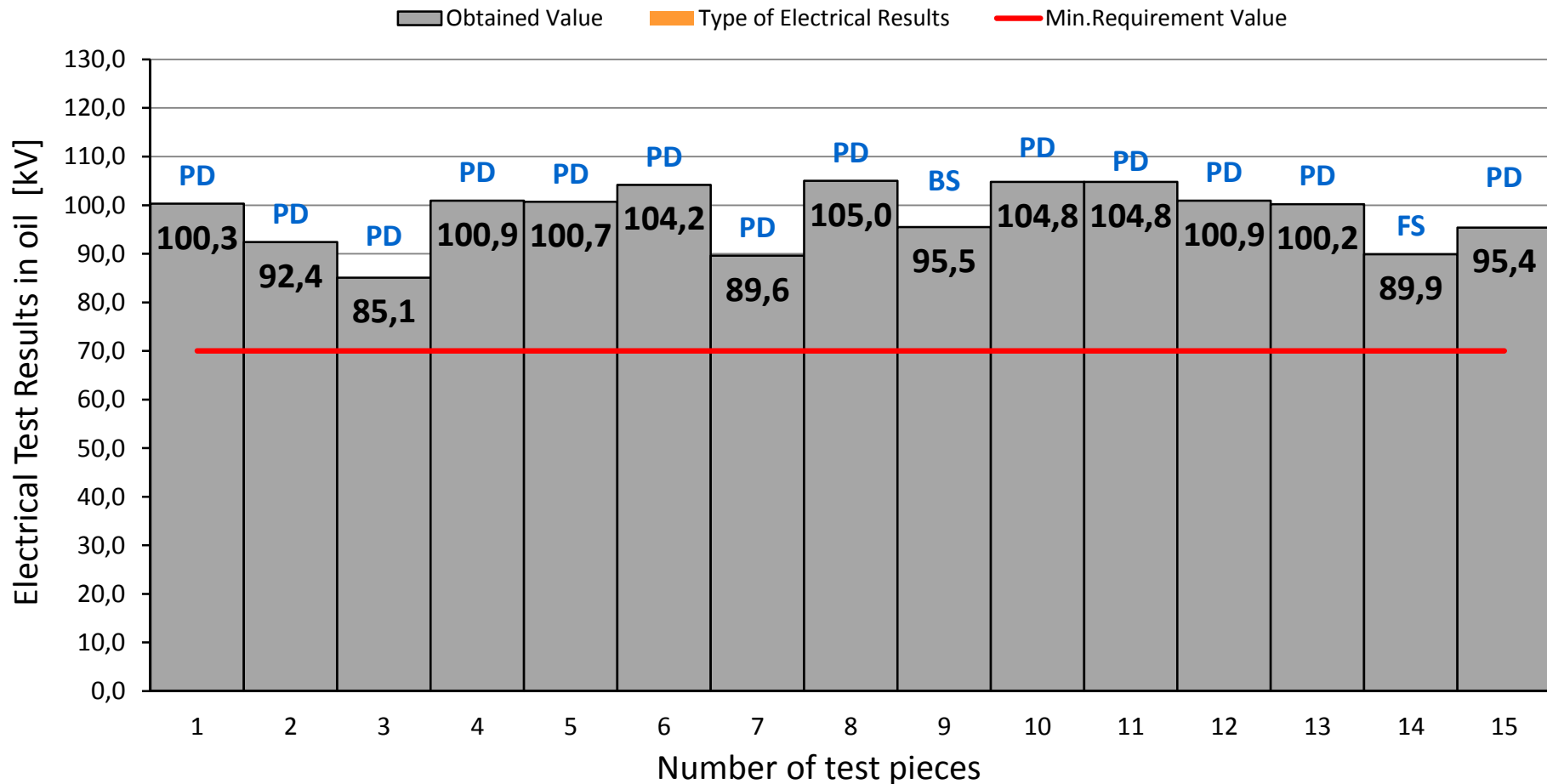
### Electrical Strength & PDIV of ENPAY Laminated Board Casein





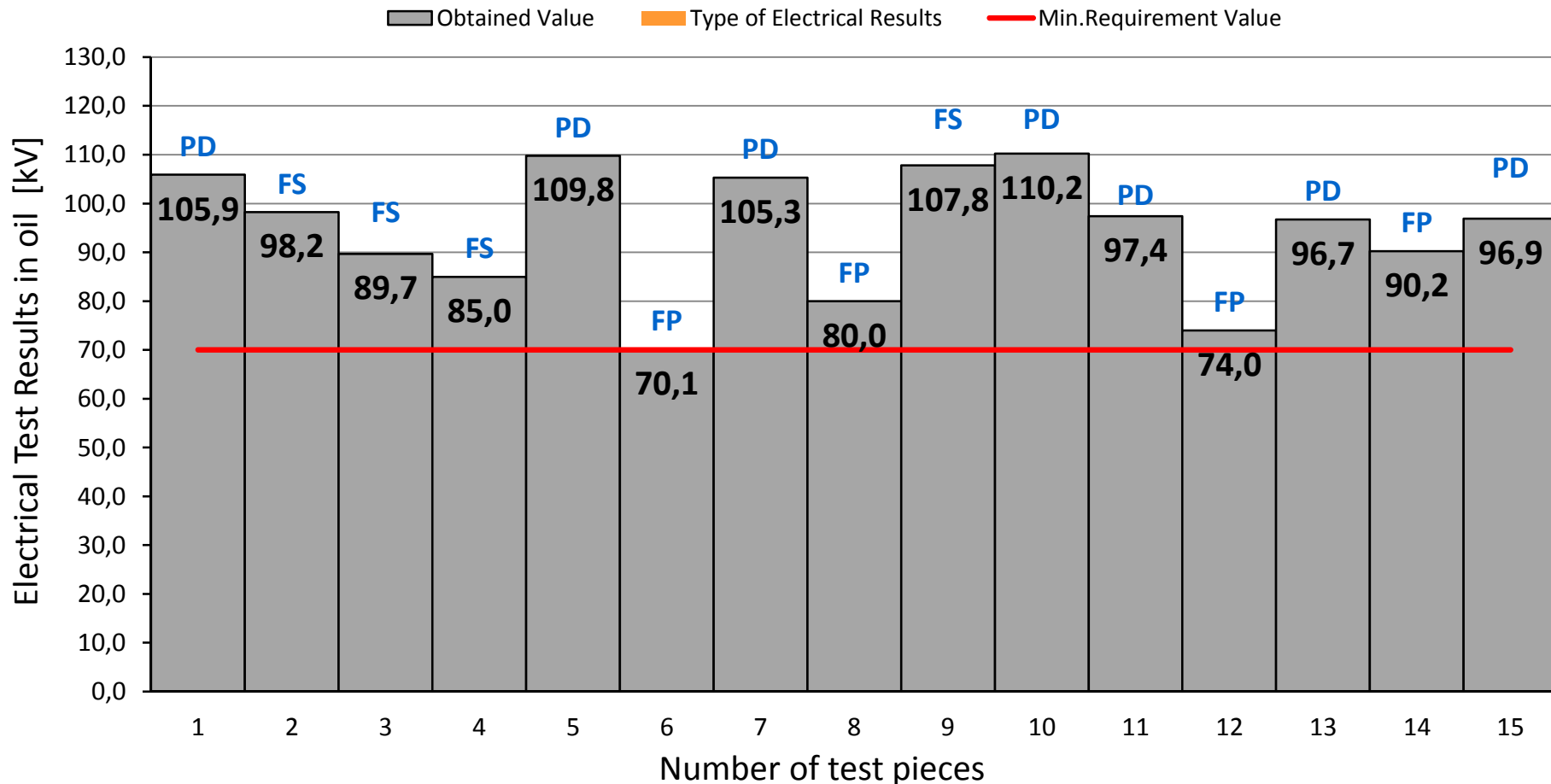
**Electrical Property of ENPAY LB – Polyester (IEC 60270)**

**Electrical Strength & PDIV of ENPAY Laminated Board Polyester**

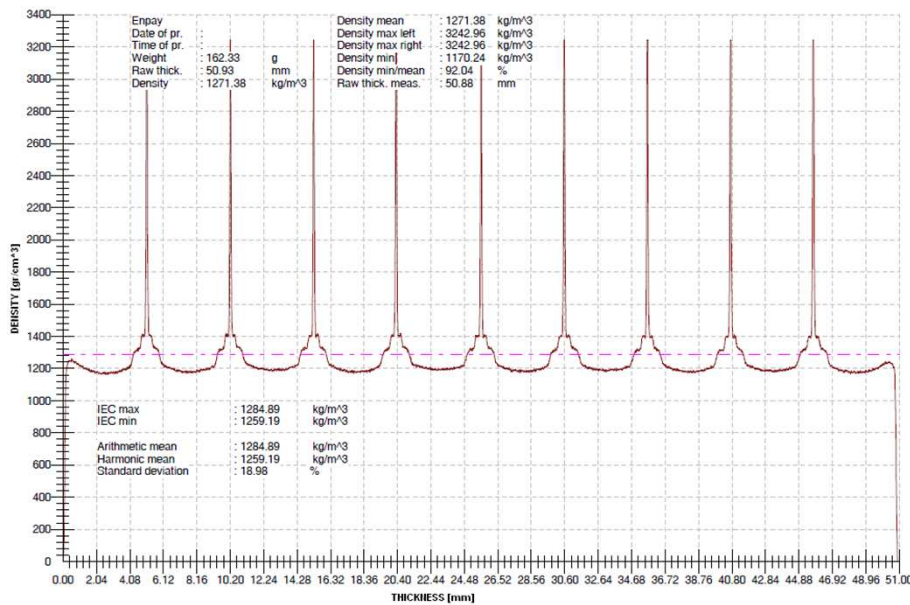


## Electrical Property of Laminated Wood – C2R (KP 20222)

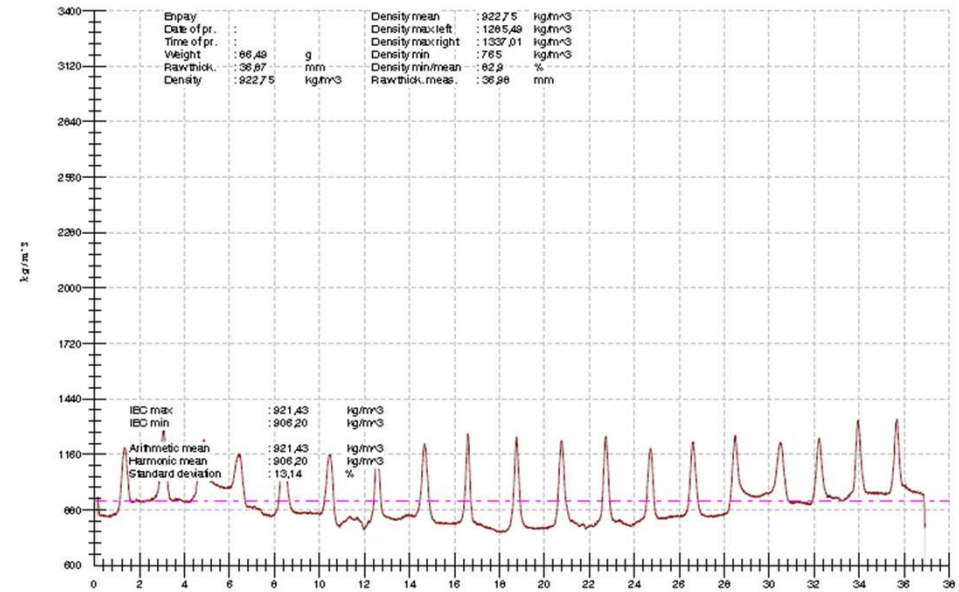
### Electrical Strength & PDIV of Laminated Wood Type C2R (KP 20222)



### Density Analyse with X-Ray Method

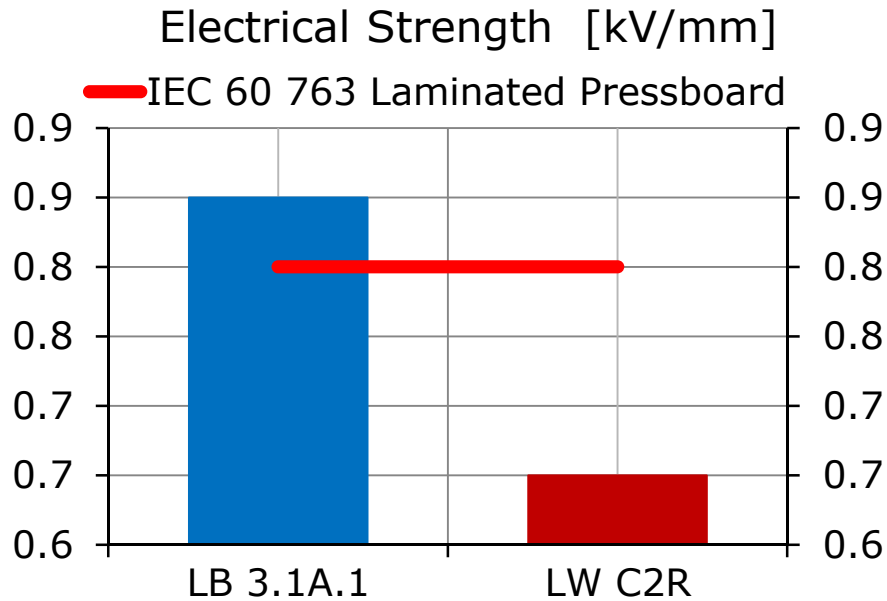


ENPAY Laminated Board (ELBP)



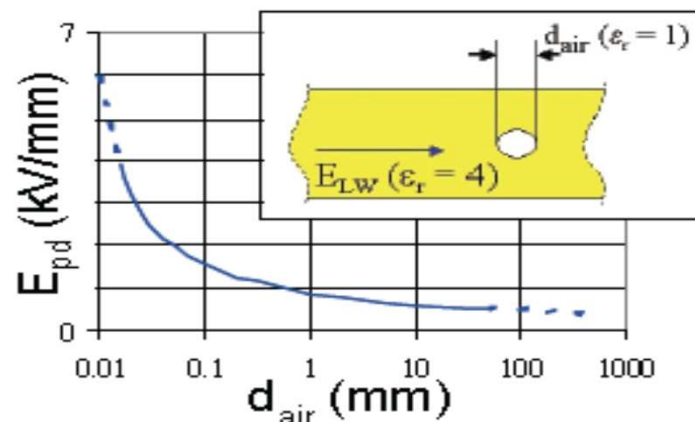
Laminated Wood – C2R





### Laminated Pressboard

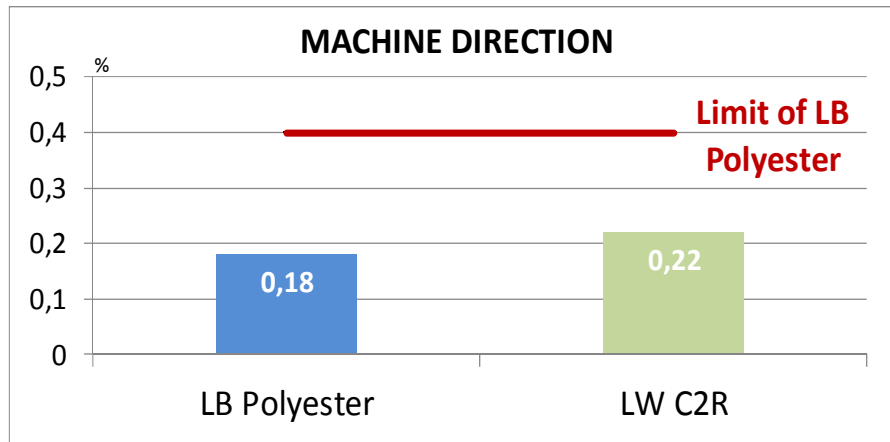
- Higher partial discharge inception voltage (PDIV)
- Better drying and oil impregnation feature
- Better aging behavior



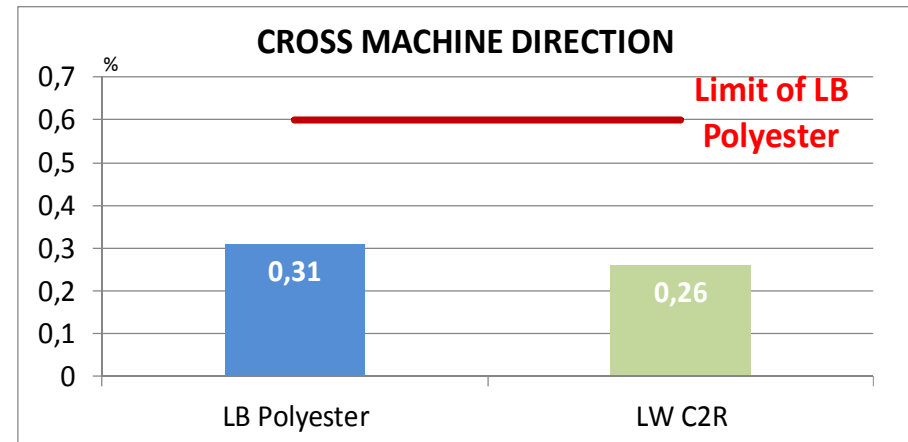
### Laminated Wood

PD-inception field strength of oil impregnated Laminated Wood as a function of the size of an air-filled void.

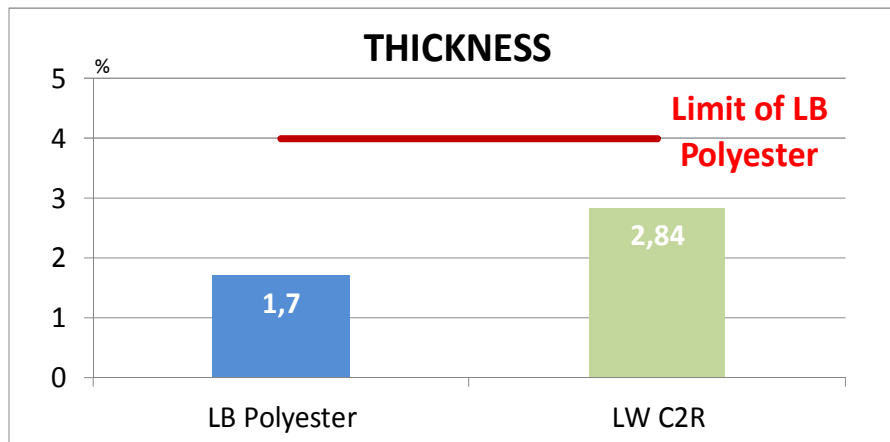
### Shrinkage Machine Direction



### Shrinkage Cross Machine Direction



### Shrinkage Thickness



Thickness of Laminated Board Polyester is more less shrinking than Laminated Wood materials.

**Laminated Board IEC 60 763**  
**Laminated Wood IEC 61 061**

If main ring laminated wood  
Slacken due to shrinkage





# Laminated Board IEC 60 763

## Laminated Wood IEC 61 061



### Comparison Table

#### Laminated Wood "Tangential" and Laminated Board "Polyester"

Properties	Unit	IEC 61061-3-2	IEC 61061-3-3	Manufacturer Values		IEC 60763-3-1	ENPAY
		TYPE T2R	TYPE T4R	TYPE T2R	TYPE T4R	LB3.1A2	ELBP
Density	g/cm <sup>3</sup>	0,9 - 1,1	1,2 - 1,3	0,9 - 1,1	1,2 - 1,3	1,15 - 1,35	1,3
Flexural Strength	N/mm <sup>2</sup>	90 - 100	125 - 140	<b>140</b>	<b>190</b>	110-90	<b>130 - 140</b>
Modulus of Elasticity in Flexure	GPa	10	13	12	16	[---]	8 - 11
Tensile Strength	N/mm <sup>2</sup>	[---]	[---]	120	140	[---]	130 - 150
Breakdown Voltage	kV/25 mm	50	50	<b>80</b>	<b>80</b>	[---]	<b>140 - 150</b>
Electrical Strength	kV/mm	10	10	[---]	[---]	[---]	35 - 40

**Laminated Pressboard with Polyester is the best one for electrical strength among insulation mat..**

## CONCLUSION

- Due to the nature of manufacture it is found that laminated wood is not suggestable in place of laminated pressboard regarding to important properties such as Acidity, Dielectric Dissipation Factor, Resistivity, Interfacial Tension and Breakdown Voltage
- Laminated wood has lower behavior dielectrically and in a view of aging due to lignin and resin content, type and amount of adhesive, stacking of the solid layers.
- Laminated board exhibits higher partial discharge inception voltage, better drying and oil impregnation feature, less shrinking in thickness, better aging behavior.
- Insulation materials must withstand the operating temperatures and compatible to the liquid during the life time of transformer. Laminated board has more advantages compare with laminated wood.

## BIBLIOGRAPHY

1. S. Yurekten, F. Erenler, E. Ozturk, Insulation Components for HV Transformers TRAVEK 2011 (21-22.06.2011/ Moscow) Presented by Selim Yurekten
2. IEC 60 763 - Laminated pressboard for electrical purposes  
IEC 61 061 - Non-impregnated densified laminated wood for electrical purposes
3. H. P. Gasser, C. Krause, T. A. Prevost, The aging characteristics of laminated pressboard, and laminated wood in oil cooled power transformers, IEEE2006, international symposium on electrical insulation
4. S. Yurekten, F. Erenler, E. Ozturk, Modern Trends in Application of Insulation Systems for Power Transformers, 11<sup>th</sup> International Conference TRAFOSEM 2011, on 'Current & Futuristic Prospects of Transformers Technology on Global Horizon and Challenges for Indian Power Sector' India , New Delhi, 21-22 November 2011
5. F. Erenler, S. Yurekten, G. Newesely, Compatibility Test of Pressboard with Transformer Oil , CIGRE- 2nd International Colloquium Transformer Research and Asset Management, (16-18 May 2012 ) , Dubrovnik, Presented by Faruk Erenler
6. S. Yurekten, F. Erenler, The Quality Aspects of Solid Insulation in Power Transformers and Reactors, 5th International Conference on "Large Power Transformers Modern Trends In Application, Installation, Operations & Maintenance " on 24-25 January 2013 at Habitat Center, New Delhi, India

# REFERENCE LIST **ENPAY** Transformer Components



Instrument Transformers



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