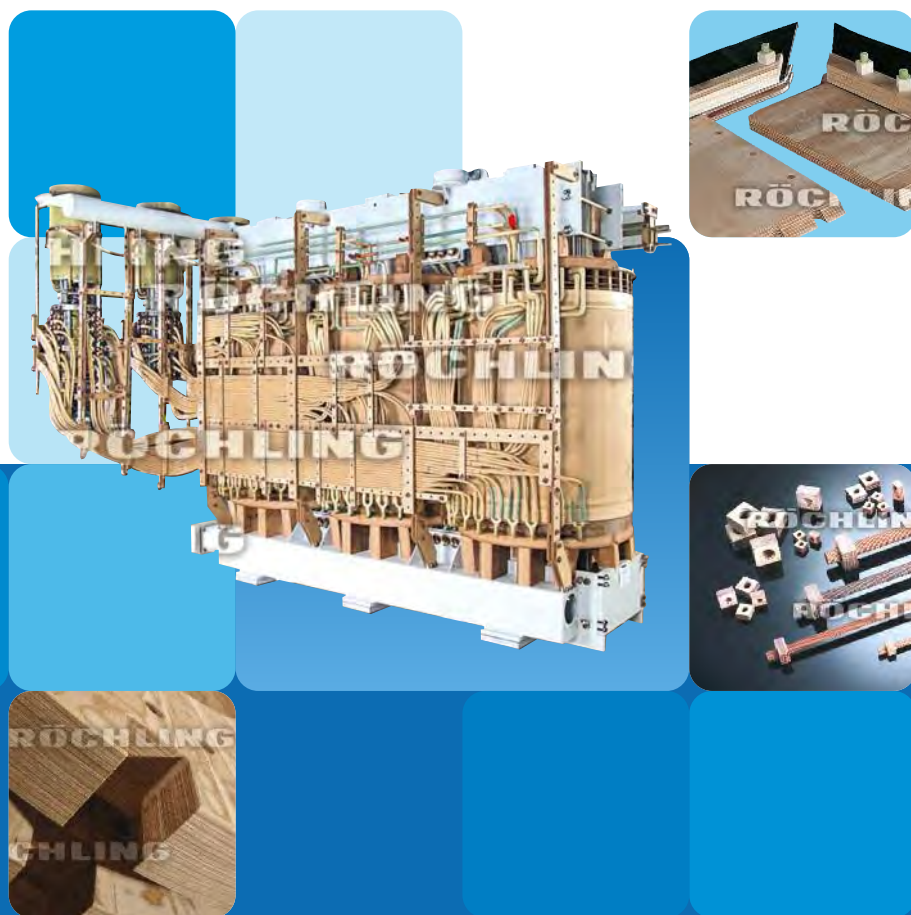




Lignostone® Transformerwood® **High-performance insulation components** **for oil filled power transformers**

浸油大功率变压器用的
高效绝缘组件



Lignostone®

Laminated densified wood
强化层压木

The experience of one century

百年经验



For almost one century Röchling Engineering Plastics KG has been manufacturing the insulation material Lignostone® Transformerwood® for use in oil filled transformers. This outstanding material enjoys an excellent reputation within the international transformer industry.

What is special about Lignostone® Transformerwood®?

Selected red beech veneers from highest quality are used

Of all known timbers the wood of the red beech (*Fagus sylvatica*) has the best electrical and mechanical characteristics with respect to the use as insulation material in oil-filled transformers. These trees only grow in Europe. The peeled veneers used for Lignostone® Transformerwood® are subject to stringent quality specifications and come from sustainable forest management.

Large dimensions up to 4,200 x 3,400 mm

Large sheets and tangentially layered rings allow the production of large-sized, one-piece components, such as pressure rings and beams, with high mechanical strength and exact specific weight.

Utilisation of modern hydraulic presses with very close press tolerances

Sheets with tight tolerances minimize the need for further processing. In many cases planing or sanding is not necessary.

Moisture content < 5 %

The lower moisture content reduces the drying time during the vapour phase and thus saves energy and costs. In addition, it reduces the risk of corrosion of metal parts of the active part of the transformer. You are buying wood, not water!

Fast oil absorption

Due to its continuous capillaries Lignostone® Transformerwood® can be dried very quickly and filled with oil air-free. This reduces the energy consumption and makes Lignostone® Transformerwood® resistant to high-voltage.

100% metal detected

During its manufacturing Lignostone® Transformerwood® is tested with modern metal detectors up to four times on potential dangerous metal inclusions. Each veneer is metal checked.

Own high-voltage and materials laboratory

Röchling has its own laboratories for performing mechanical and electrical testing (up to 200 kV under oil). Thus our products always meet international standards.

World-wide machining centres

Röchling has its own machining factories, warehouses with semi-finished products and qualified partner companies on the spot worldwide. This allows personal counselling, short routes and quick delivery times.

We are ISO 9001:2008 certified

Our Quality Management System has been certified since 1994 and thus ensures our continuously high product and service quality and process reliability.

R&D in cooperation with the University of Osnabrück

Unlike any other supplier in the world, we have sound, scientifically exact evidence regarding the electrical properties of our materials. We work closely with the High Voltage Laboratory of the Hochschule Osnabrück – University of applied sciences, where we obtain PD values of Lignostone® Transformerwood®.

劳士领工程塑料公司生产的高效绝缘材料 Lignostone® Transformerwood® 有将近一百年的悠久历史，产品广泛应用于浸油变压器。这种出类拔萃的高品质材料在国际变压器产业中享有极高的声誉。

Lignostone® Transformerwood® 有什么特点？

选用高品质的欧洲山毛榉（水青冈）单板

就作为绝缘材料在浸油变压器中的应用而言，在所有众所周知的木材中，欧洲山毛榉木（*Fagus sylvatica*）具有极高的电气稳定性和机械强度。Lignostone® Transformerwood® 旋切单板仅选用生长在欧洲的树种，达到了最严格的质量要求，来源于可持续的林业经济。

最大尺寸达 4,200 x 3,400 mm

大型板材和沿切线方向层压环可实现制备压环和横梁等大尺寸机械强度高和比重精确的单元组件。

应用层压公差最小的液压层压工艺

公差小的板材降低了在其他加工流程中的投入。在许多情况下可放弃刨平或磨削。

水份含量 < 5 %

水份含量比较小，缩短干燥时间，从而节省能源和降低成本。此外，变压器有源部件中的金属件腐蚀危险性下降。您买的是木材，不是水！

吸油快速

Lignostone® Transformerwood® 由于其有多孔毛细管，可非常快速脱水，加油时无空气混入。这就降低了能量消耗，使 Lignostone® Transformerwood® 具有耐高电压特性。

100% 检查金属杂质

Lignostone® Transformerwood® 在生产流程中运用最现代的金属探测仪检查可能混入的危险金属杂质达四次。每块投放的单板均进行检查。

公司自己的高压电和材料试验室

劳士领公司设有自己的试验室，进行机械和电气检测（在浸油中小于 200 kV）。因此，本公司的产品始终符合国际标准。

分布在世界各地的生产基地

劳士领公司建有自己的生产基地、半成品库房以及高素质的合作企业，遍及世界。这就实现了面对面咨询、近距离以及快速交货周期。

本公司已获得 ISO 9001:2008 认证

本公司的质量管理体系自 1994 年以来获得认证，保证本公司持之以恒的高品质和服务质量以及流程的可靠性。

产品研发与德国奥恩斯布吕克大学的合作

作为世界上唯一的供应商，本公司在我们所提供的材料的电气特性上具备健全的、科学严谨的知识体系。为此，本公司与德国奥恩斯布吕克大学高压电试验室密切合作，本公司产品送该试验室测定 Lignostone® Transformerwood® 的 PD 值。

Our standard range

本公司的产品范围



Sheets

Standard size:
2000x1000x10 to 120 mm
2000x1200x10 to 120 mm
2000x1300x10 to 120 mm
2000x1600x10 to 120 mm
2400x2000x10 to 120 mm
Other sizes on request.
Maximum size: 4200 x 3400 mm
Thickness up to 300 mm

板材

标准尺寸：
2000x1000x10 – 120 mm
2000x1200x10 – 120 mm
2000x1300x10 – 120 mm
2000x1600x10 – 120 mm
2400x2000x10 – 120 mm
其他尺寸的板材可按需供货。
最大尺寸：4200 x 3400 mm
厚度达 300 mm



Coil clamping rings

Single piece up to 3400 mm
in diameter with tangential or
crosswise lamination.
Thickness up to 300 mm

压环

整片压环直径达 3400 mm，迭
片结构为沿切线方向或十字交
叉。
厚度达 300 mm



Pressure beams

Single piece up to 5500 mm
in length fully machined.
Thickness up to 300 mm

夹件

最大长度达 5500 mm，整块机
加工成品。
厚度达 300 mm



Fasteners

M8 – M24 ex stock
Standard length: 1000 mm

连接件

M8 – M24 仓库交货
标准长度：1000 mm



Machined components

The fabrication of CNC machined
components as per drawings is
our strength. We utilize versatile
modern CNC, special and
automatic machines.

预制件

本公司的优势是按照客户提供的
图纸生产复杂的预制件，为此
我们采用多功能、现代的数控
机床和特种机床以及自动装
置加工生产。



Over the decades Lignostone® Transformerwood® has proved an indispensable construction and insulating material, particularly for power and distribution transformers and ideal for these applications.

Common components made of Lignostone® Transformerwood® are:

- Top and bottom coil clamping rings or multi-sectional pressure parts
- Platforms
- Pressure beams
- Lead and cleat support
- Step blocks
- Shield rings
- Potential rings
- Pressure blocks
- Fasteners

正是在大功率变压器和配电变压器的应用领域内，Lignostone® Transformerwood® 数十年来是一种不可获缺的结构型绝缘材料，最适宜于这一应用领域。

由 Lignostone® Transformerwood® 生产的典型部件如下：

- 上、下压环或扇形压件
- 托板
- 夹件
- 导引支撑
- 阶梯木块
- 电位环
- 梯度环
- 扇形压件
- 连接件



Multi-sectional pressure part
压环-扇形压件



Step blocks
阶梯木块



Tangential laminated coil clamping ring
沿切线方向层压环
(MX/2-E3, 1,300 kg, 2900 x 2590 x 100 mm)

Power transformer with
Lignostone® Transformerwood®
insulating parts
带 Lignostone® Transformerwood®
绝缘组件的
大功率变压器
(672 MVA / 525 kV)

Material description

材料说明

Lignostone® Transformerwood® is a laminated densified wood according to IEC 61061. It consists of red beech veneers, which are joined together with thermosetting synthetic resins under high pressure and heat.

Lignostone® Transformerwood® is characterized by the following properties:

- Good electrical insulation properties
- High mechanical strength at low specific density
- Easy and fast to dry
- Very good oil absorption

Lignostone® Transformerwood® 强化层压木执行 IEC 61061 标准。以精选的欧洲山毛榉（水青冈）单板为基本材料，以热固性合成树脂为粘结剂，经高压和高温压制而成。

Lignostone® Transformerwood® 具有以下特点：

- 电气绝缘性能好
- 在比重小条件下机械强度高
- 干燥性好且快速
- 吸油性非常好



II = crosswise
II = 十字交叉

I = parallel
I = 平行

X = tangential
X = 沿切线方向

Different laminations
不同的层压

Red beech peeled veneers (Fagus sylvatica)
山毛榉旋切单板 (Fagus sylvatica)



Key to identification

标记缩写字母

Key to identification 标记缩写字母			
	Key 缩写	Explanation 说明	
Degree of density 密度等级	L	Low density 低密	Specific gravity: 密度: 0,75-1,10 g/cm³
	M	Medium density 中密	Specific gravity: 密度: 1,10 – 1,30 g/cm³
	H	High density 高密	Specific gravity: 密度: 1,30 – 1,40 g/cm³
Lamination 迭片结构	I	parallel 平行	
	II	crosswise 十字交叉	
	X	tangential 沿切线方向	
Veneer thickness 单板厚度	2	≥ 2 mm	
Resin 树脂类型	E3	Resin for electrical applications 电气型树脂	
Veneer quality 单板质量	(SQ)	Standard quality 标准质量	Field strength E at onset of PD: 3,3 kV/mm¹⁾ 使用局部放电测量 (PD) 时的场强 E: Fullfills the requirements of IEC 61061 符合 IEC 61061 的要求
	(HQ)	High Quality 高品质	Field strength E at onset of PD: 4,7 kV/mm¹⁾ 使用局部放电测量 (PD) 时的场强 E: Surpasses the requirements of IEC 61061 超过 IEC 61061 的要求
	(TQ)	Top Quality 顶级品质	Field strength E at onset of PD: 5,1 kV/mm¹⁾ 使用局部放电测量 (PD) 时的场强 E: Surpasses by far the requirements of the IEC 61061 远远超过 IEC 61061 的要求

¹⁾ 1% probability Weibull distribution. The measuring sensitivity for all measurements of PD was < 2 pC
Weibull 分布概率 1%。对于所有 PD 测量的测量灵敏度 < 2 pC

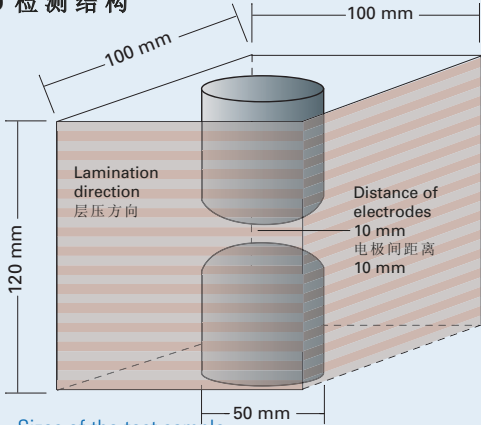
Example: LII/2 E3 (SQ) means:
Low density – crosswise lamination – veneer thickness ≥ 2mm – electric type – Standard quality

示例：LII/2 E3 (SQ) 含义：
低密 – 十字交叉层压 – 单板厚度 ≥ 2mm – 电极类型 – 标准质量

Partial discharge test (PD)

局部放电测量 (PD)

PD test set-up
PD 检测结构



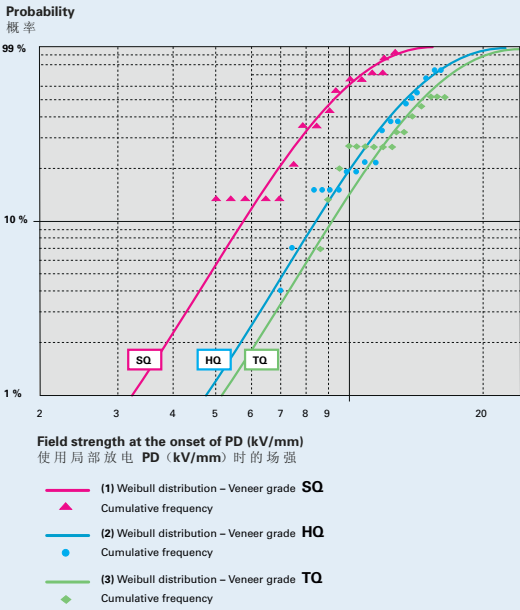
Sizes of the test sample
样品尺寸



Testing of PD under oil (Shell Diala D)
在浸油中执行 PD 检测 (Shell Diala D)

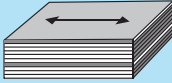
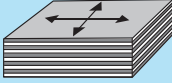
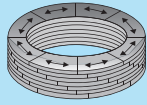
Test results

检测结果



(Source/资料来源：University of applied sciences – 德国奥斯纳布吕克大学)

Technical Data
技术参数

Designation 标识				Röchling	LI/2-E3 ²⁾⁴⁾ (SQ),(HQ),(TQ)	MI/2-E3 ³⁾⁴⁾ (SQ),(HQ),(TQ)	LI/2-E3 ³⁾ (SQ),(HQ),(TQ)	MII/2-E3 ³⁾ (SQ),(HQ),(TQ)	LX/2-E3 ²⁾³⁾⁵⁾⁶⁾ (HQ),(TQ)	MX/2-E3 ²⁾³⁾⁵⁾⁶⁾ (HQ),(TQ)
				IEC 61061	P1R	P4R	C2R	C4R	T2R	T4R
				DIN 7707	KP 20212	KP 20214	KP 20222	KP 20224	KP 20242	KP 20244
Standard 检测标准		Sample size 样品尺寸	Unit 单位	parallel packed 平行层压		cross packed 十字交叉层压		tangential packed 沿切线方向层压		
										
Specific gravity 密度				IEC 61061	—	g/cm³	0,85 IEC 61061: 0,7-0,9	1,25 IEC 61061: 1,2-1,3	0,95 IEC 61061: 0,9-1,1	1,25 IEC 61061: 1,2-1,3
Mechanical properties 机械特性	Flexural strength ¹⁾⁷⁾ 弯曲强度		DIN EN ISO 178	500x20x20 mm Support distance: 支撑距离 320 mm	MPa	140	200	110	130	130
	Modulus of elasticity in flexure ¹⁾⁷⁾ 弯曲弹性模量		DIN EN ISO 178	500x20x20 mm Support distance: 支撑距离 320 mm	GPa	11	16	9	11	11
	Compressive strength 抗压强度		DIN EN ISO 604	10x10x10 mm	MPa	100 55	120 90	200 70	230 90	120 80
Physical properties 物理特性	Oil absorption 吸油性		IEC 61061	—	%	30	7	25	7	25
	Moisture content 水份含量		IEC 61061	—	%	5	5	5	5	5
	Operating temperature limit 工作温度极限		DIN 7707	—	°C	105	100	105	100	105
Electrical properties 电气特性	Volumen resistivity 特定容积电阻		IEC 60093	—	Ω x cm	10 ¹²	10 ¹²	10 ¹²	10 ¹²	10 ¹²
	Electric strength 击穿强度	90 °C 	IEC 60243	—	kV/ 3 mm	SQ: 45 HQ: 50 TQ: 55	SQ: 45 HQ: 50 TQ: 55	SQ: 45 HQ: 50 TQ: 55	SQ: 45 HQ: 50 TQ: 55	HQ: 50 TQ: 55
	Electric strength 击穿强度	90 °C 	IEC 60243	—	kV/ 25 mm	SQ: 70 HQ: 80 TQ: 90	SQ: 70 HQ: 80 TQ: 90	SQ: 70 HQ: 80 TQ: 90	SQ: 70 HQ: 80 TQ: 90	HQ: 80 TQ: 90
	Dissipation factor 介电损耗因素	50 Hz 25 °C	IEC 60250	100x100x10 mm oil impreg- nated 浸油	tan δ	0,01	0,01	0,01	0,01	0,01
	Relative permittivity 相对介电常数		IEC 60250	100x100x10 mm oil impreg- nated 浸油	ε _r	3,7	4,1	3,7	4,1	3,7

Remarks

- 1) Direction A, the fibers of the outside veneers must run in the longitudinal direction of the specimen.
- 2) Mechanical values depend on the average ring diameter.
- 3) Corresponding reduction and safety factors are to be taken into account when dimensioning insulating components. For mechanical loads please consider the support span to thickness ratio. For the performance of the mechanical and electrical tests the specimens were treated according to IEC 61061-2 Item 3.
- 4) Parallel laminated types contain up to 20% transverse fibers.
- 5) Tangential laminated rings have up to 20% radial grain.
- 6) Tangential laminated rings we manufacture only in High-Quality (HQ) and Top-Quality (TQ).
- 7) Parallel laminated types must be present in the tension zone at least four longitudinal layers.

|| = parallel to the lamination

⊥ = perpendicular to the lamination

The data mentioned in this brochure are **average values** ascertained by current statistical returns and tests. The above data is provided purely for information and shall not be regarded as binding unless expressly agreed in a contract of sales.

备注

- 1) 方向 A, 外单板纤维必须是沿样品纵向。
- 2) 机械强度测量值取决于中间环的直径。
- 3) 在绝缘组件尺寸上必须考虑到减量、稳定性等因素。在机械负荷下, 要注意支架与组件高度的距离。执行机械和电气检测时, 按照 IEC 61061-2 (第 3 点) 规定, 试样经预处理。
- 4) 平行层压品质的横向纤维比率达 20 %。
- 5) 沿切线方向层压环径向纤维比率达 20 %。
- 6) 我们生产切线方向的压环仅限于高品质 (HQ) 和顶级品质 (TO) 等级。
- 7) 平行层压方向的层压木在张力区内至少必须有 4 个纵向单层存在。

|| = 与层压平行

⊥ = 与层压垂直

上述参数值为平均值, 通过目前统计试验检测确定。上述数据仅是提供信息, 除非在销售合同中另有明确协议, 才具有约束力。

Fasteners 连接件

Lignostone® Transformerwood® Fasteners properties:

- Good electrical insulation properties
- High mechanical strength
- Resistant to transformer oils, weak acids and bases
- Corrosion resistant
- Non magnetic

Lignostone® Transformerwood® 连接件特点：

- 电气绝缘能力好
- 机械强度高
- 耐变压器上的油污、弱酸和碱液
- 耐腐蚀性
- 抗磁



Lead support
导引支撑



Threaded rods
and nuts
螺母和
螺旋杆



Square nuts 四角螺母

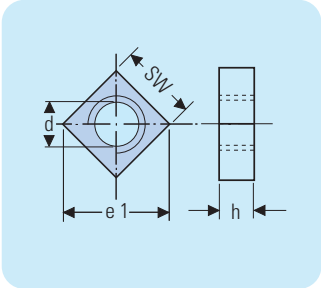
Lignostone® Transformerwood® square nuts are available in M8 – M24 with h = d and h = 2 d ex stock.

Lignostone® Transformerwood® 四角螺母（M8 – M24，h = d 和 h = 2 d）仓库交货。



Standard range square nuts 四角螺母的供货范围

Nominal diameter 额定直径	SW mm	e1 mm	H mm
M8	14	20	10
M10	19	27	10
M12	24	34	12
M16	32	45	16
M20	36	51	20
M24	46	65	24



On request we produce Lignostone® Transformerwood® nuts in addition to those listed metric sizes in inch thread sizes.

Special sizes can be produced on request.

根据客户需要，本公司除了按所列的公制螺纹尺寸生产以外，也按英制螺纹尺寸生产 Lignostone® Transformerwood® 螺母。

特殊尺寸可根据客户需要生产。

Threaded rods 螺杆

Standard nominal diameter:
M8 – M24 ex stock

Standard length: 1000 mm

Other sizes upon request.

标准尺寸：
M8 – M24 仓库交货

标准长度：1000 mm

其他尺寸可按需供货。



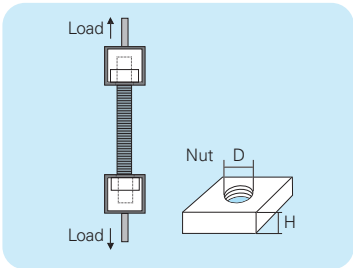
Fasteners

连接件

Tensile strength

抗拉强度

Nominal diameter 额定直径	Nut height 螺母高度 h = 1 d	Nut height 螺母高度 h = 2 d
M8	2700 N	4500 N
M10	3000 N	7000 N
M12	6000 N	12000 N
M16	12000 N	21000 N
M20	16000 N	28000 N
M24	20000 N	32000 N



Used test set up
Pulling speed: 5mm/min
Clamping length: 250 mm
使用的检测规程
拉伸速度：5mm/min
伸长长度：250 mm

Average values
平均值

Starting torque

拧紧扭矩

		Non lubricated thread 未润滑的螺纹		Oiled thread 已润滑的螺纹 (SAE 30)	
Nominal diameter 额定直径	Nut height 螺母高度	M _A (Nm)	F _V (N)	M _A (Nm)	F _V (N)
M8	h = 1 x d	2,0	1700	3,0	2500
	h = 2 x d	2,0	1700	3,0	2500
M10	h = 1 x d	5,2	2500	6,8	3200
	h = 2 x d	5,2	2500	7,0	3500
M12	h = 1 x d	8,5	3000	10,4	4100
	h = 2 x d	8,5	3700	13,8	5500
M16	h = 1 x d	25,0	6100	32,0	10100
	h = 2 x d	25,0	6100	32,0	10100
M20	h = 1 x d	33,0	9500	56,0	15300
	h = 2 x d	33,0	9500	56,0	15300
M24	h = 1 x d	40,0	12000	64,0	17500
	h = 2 x d	40,0	12000	64,0	17500

Average values for the starting torque M_A and the Pre-load F_V

拧紧扭矩 M_A 和预应力 F_V 的平均测量值

Round rods

圆棒

Lignostone® Transformerwood® rods are available in a diameter of 6–28 mm available with a standard length of 2,000 mm ex stock.

Special sizes can be produced upon request.

Lignostone® Transformerwood® 圆棒（直径 6–28 mm，标准长度 2000 mm）仓库交货。

特殊尺寸可根据客户要求生产。



Insulating components for traction transformers 铁路电力机车变压器用的绝缘部件

A reliable power supply is vital for locomotives. We are a system supplier offering fully assembled components for traction transformers. These parts provide an extremely high level of electrical insulation combined with very good mechanical strength. They are successfully used since decades in mineral oil and synthetic ester e.g. Midel® 7131.

机车能源供应非常重要。本公司为系统供应商，为电力机车变压器提供全套安装好的部件。它们在机械强度高条件下满足高绝缘性能。自数十年以来，在矿物油和合成酯（例如：Midel® 7131）中，得到成功的应用。

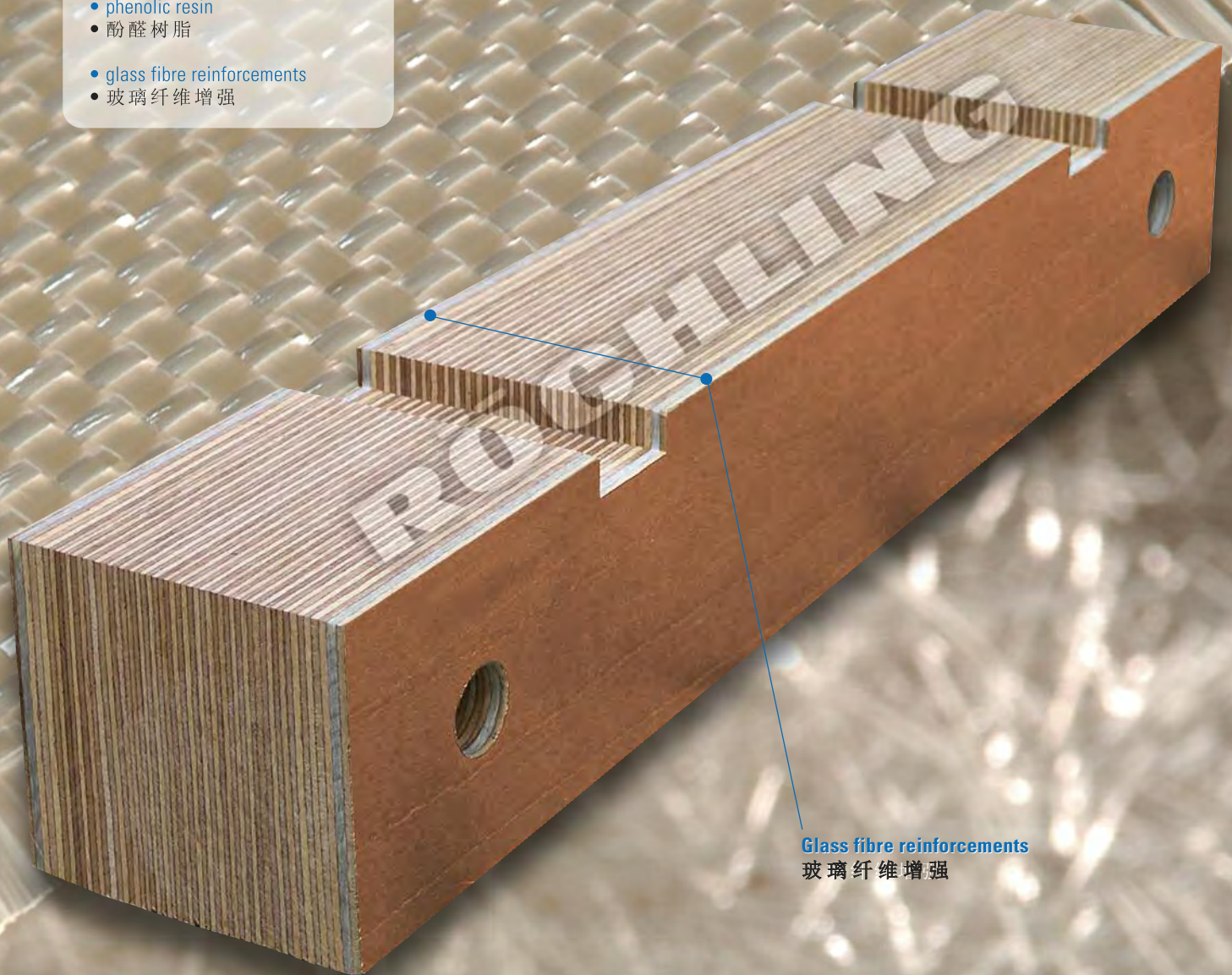
Insulating components with Durostone® Fasteners
带 Durostone® 连接件的绝缘部件



Traction transformer of the Velaro Rus, Siemens
Velaro Rus (西门子) 提供的电力机车变压器

Lignostone® Hybrid
Lignostone® 混合材料

- red beech veneers
• 山毛榉单板
- phenolic resin
• 酚醛树脂
- glass fibre reinforcements
• 玻璃纤维增强



Glass fibre reinforcements
玻璃纤维增强



Lignostone® Transformerwood® Hybrid Lignostone® Transformerwood® 混合材料

The innovation of a classic

One big advantage of Lignostone® Transformerwood®, over laminated pressboard, is the higher mechanical strength. Röchling improved this by **up to 40 %** by adding two FRP-layers.

Typical transformers, where Lignostone® Transformerwood® Hybrid is used, are for example:

- Oil-filled power transformers
- Oil-filled distribution transformers
- Traction transformers
- Furnace transformers
- Special transformers

Benefits by using Lignostone® Transformerwood® Hybrid:

- Higher mechanical strength without changing dimensions
- Possibility of design optimization in associated with high cost savings by dimension reductions
- Reduction of size and weight

We produce all Lignostone® Transformerwood® grades also as Lignostone® Transformerwood® Hybrid including tangential layered hybrid rings.

Please ask for our technical data sheets including PD values.

百年老字号的创新

Lignostone® Transformerwood® 的最大优点是：其机械强度比胶合层压板明显提高。劳士领公司成功地通过插入两层玻璃纤维增强层，使机械强度再次升高了 **40 %**。

典型的变压器应用了 Lignostone® Transformerwood® 混合材料，有以下例证：

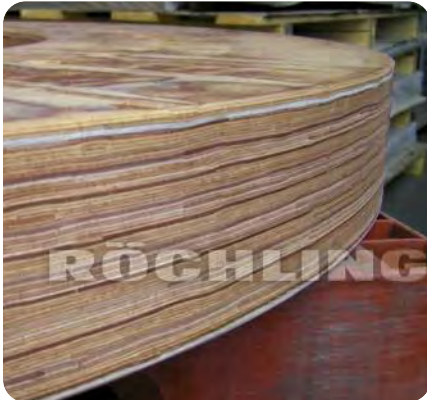
- 浸油大功率变压器
- 浸油配电变压器
- 铁路电力机车变压器
- 高炉变压器
- 特种变压器

Lignostone® Transformerwood® 混合材料应用优点：

- 在尺寸相同的条件下机械强度提高
- 设计优化的可能性，从而通过减小尺寸降低高成本（变压器更紧凑）
- 尺寸和重量降低

也作为 Lignostone® Transformerwood® 混合材料，包括沿切线方向层压混合材料环在内，本公司生产所有的 Lignostone® Transformerwood® 高品质材料。

请索取本公司的技术数据资料页，包括在 PD 值内。



Power transformer with
pressure rings
Lignostone® Transformerwood®
MX 2-E3 Hybrid

带压环的大功率变
压器采用 Lignostone®
Transformerwood® MX 2-E3
混合材料

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