HIGH VOLTAGE INSULATION COMPONENTS
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Vadodara Plant-India
Kullar Plant-Turkey
Kőrny Plant-Slovakia
CORPORATE PROFILE

ENPAY: A GLOBAL BRAND, A ROOTED COMPANY

Established in 1978, ENPAY is a world-known producer of
• Transformerboard
• Transformer Components
• Magnetic Cores
• Flux Collectors
• Transformer Tanks
• High Voltage Insulation Components
• Transformer Windings

ENPAY is a reliable partner to its customers in solving complex technical problems with an excellent reputation and market track record. High qualified staff, a strong know-how, an enviable R&D base, and a comprehensive range of products are the most valuable assets of the Company.

The investments with up-to-date technological equipment, its determined steps toward institutionalization and its quality-oriented corporate culture and customer approach are among the most important competitive advantages of ENPAY.

ENPAY’s plants are located in Turkey and Slovakia. In 1989, the Company launched production of transformer components in its Izmit Plant. First manufactured products were exported to Germany. Since mid-2005, ENPAY launched a manufacturing plant in Slovakia. ENPAY TRANSFORMER COMPONENTS S.R.O. operates in the same field equivalent to the production in Turkey plant.

We are going to launch a manufacturing plant in India on June 2010.

The total closed production area of the plants has reached 72,000 m². ENPAY is ranked 142nd in the first 250 exporters in Turkey.

We thank you for your interest you have shown to ENPAY and its products.
ENPAY’S VISION

In order to reach the goal of becoming a company of worldwide reputation ENPAY ensures,
• customer satisfaction and preference
• profitable growth
• perpetuity
• shareholder’s satisfaction and pride fulfillment of social obligations.

Through continuous improvement of processes ENPAY focused on,
• total quality
• high productivity
• cost effectiveness
and by creating an environment which encourages team effort and where,
• each individual’s contribution is recognized and esteemed
• each individual enjoys his work and has urge to excel
• each individual gives his best to achieve the common vision.
ENPAY APPROACH TO QUALITY

Thanks to a wide activity range in ENPAY Group, overall quality levels can be achieved in the field of transformer insulation, complete active part - core and coil assembly and consulting for transformer production.

This is the main reason ENPAY became a traditional supplier for the transformer industry.

ENPAY has been awarded with the ISO 9001 Quality Management System Certificate from TÜV Süd.

All incoming materials are checked and further controls are carried out; manufacturing processes are frequently monitored. Final checks are made on fully assembled cores, and test reports are sent together with them to the customer. The type of packaging and labeling is chosen according to the transport means, the final destination and the customer specific requirements.

ENPAY Quality Control System

ENPAY is based on the criteria of satisfying the needs of the customers in quality and quantity for transformer components.

ENPAY investment planning is designed in such a way that will ensure service in the future. Effective production techniques creates also resources for R&D. The Company’s facilities have state of the art technology with modern production processes. ENPAY production of transformer components are fully compatible with the International Electrotechnical Standards and complies with customer demands.

We are aware that in the global market priority number one is quality, therefore we established the ENPAY Quality Control System in order to ensure that the quality of our products is kept steadily at a high level. In case the information in this catalogue is not sufficient, we would be glad to work with you in solving your individual problems. Our R&D activities are responding to the needs of the future. Being informed of your problems and comments will be of great help to us.

ENVIRONMENTAL PROTECTION: OUR UNIVERSAL RESPONSIBILITY

We are responsible for the society and environment at our industrial location. Active participation in environmental measures to protect the human being and nature is a major aspect of our company policy. It begins in development, runs through the entire production process and covers waste disposal problems.
HIGH VOLTAGE INSULATION COMPONENTS

CYLINDER

- Cylinders made of Transformerboard according to IEC 60641 (with or without oil impregnation).
- 100% Sulphate Wood Pulp.
- Insulation class A (105 °C), natural coloured.
- Cylinders of Transformerboard are stable, mechanically strong, electrically reliable and favourably priced.

Impregnation system under vacuum
COMPLETE INSULATION PACKAGES (KITS)

• Kits allow for less production costs and decreased manufacturing cycle time of power transformer production.
• Kits are produced according to customer request.
HIGH VOLTAGE INSULATION COMPONENTS

SNOUT - CHIMNEY SECTORS - FLANGE TUBES

- Molded components made of Transformerboard according to IEC 60641.
- Tailor-made according to the customer specification.
- These products are used so as to isolate the terminal leads of transformer winding. They are final insulation components in the power transformers, regulates the electrostatic fields existing in the terminal leads and enable the transformer to work reliably.
- We are able to produce those products in various types as per the customer requirements right along with the attached drawings. After in time delivery, they can be used in the transformer production by the customers perfectly.
CAPS OR ANGLE RINGS

- Molded components made of Transformerboard according to IEC 60641
- 100% sulphate cellulose pulp and made of high quality Transformerboard. Soft calendered pressboard characterized by high purity and high oil absorption. Insulation Class A (105 °C) according to IEC 60085

Caps and angle rings is used for
- HV Coils edge insulations
- Regulating winding insulations

MACHINE MOLDED COMPONENTS

HAND MOLDED COMPONENTS

EDGE PROTECTIONS

- For high-voltage windings
- Made of Transformerboard according to IEC 60641 in form of Angle Ring or Cap Sectors

100% sulphate cellulose pulp and made of high quality Transformerboard. Soft calendered pressboard characterized by high purity and high oil absorption. Insulation Class A (105 °C) according to IEC 60085
HIGH VOLTAGE INSULATION COMPONENTS

STRIPS AND SPACERS

The products are exclusively made of Transformerboard according to IEC 60641 with fully authorised machines.

END (CLAMPING) RINGS

• Made of Transformerboard according to IEC 60641, manufactured in different technologies.
• Since it is glued with casein based glue, it has considerably high electrical strength.

• Minimised deformation at maximum permissible pressure load on vertical axis.
• The End-Rings and Clamping Rings are produced with additional tolerances for shrinkage.
SHIELD RINGS

- The Rings are made of Laminated Wood according to IEC 61061 or Laminated Pressboard according to IEC 60783.
- Special Shield Rings are produced for High Voltage Power Transformers & HVDC.
HIGH VOLTAGE INSULATION COMPONENTS

SHIELD END RINGS

• The Rings are made of Laminated Wood according to IEC 61081 or Laminated Pressboard according to IEC 60763.
• Shield End Rings for High Voltage Power Transformers up to 850 kV.

SHIELD CYLINDER

The Cylinders are made of Transformerboard according to IEC 60641.

• At high field strength; Shield cylinders are partial discharge free.
• In magnetic stray fields; Loss free.
PRESS RINGS

The Rings are made of Laminated Pressboard according to IEC 60763 or Laminated Wood according to IEC 61061 or Tangential Veneer Direction according to IEC 61061.

VARIOUS INSULATION COMPONENTS

Various insulation components made of Transformerboard according to IEC 60641.
Carrier Bands are made of thermally upgraded paper, Kraft Paper, Diamond Dotted Paper (DDP) or NOMEX® according to IEC 60641 & IEC 60554 (accept to NOMEX®).

<table>
<thead>
<tr>
<th>Ability (mm)</th>
<th>Tolerances (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strip width 20</td>
<td>+/ - 0.5</td>
</tr>
<tr>
<td>Distance between strips 50 or 65</td>
<td>+/ - 0.5</td>
</tr>
<tr>
<td>Band width 5&lt;8&lt;470</td>
<td>+ 0/-1.0</td>
</tr>
<tr>
<td>Total thickness 4,5,6,7,8,9</td>
<td>+/-0.2</td>
</tr>
<tr>
<td>Length by order</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ability (mm)</th>
<th>Tolerances (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strip width 13</td>
<td></td>
</tr>
<tr>
<td>Distance between strips 65</td>
<td>+/ - 0.5</td>
</tr>
<tr>
<td>Band width 5&lt;8&lt;470</td>
<td>+ 0/-1.0</td>
</tr>
<tr>
<td>Length by order</td>
<td></td>
</tr>
</tbody>
</table>
In today’s world, with the increasing demand for power it has become more essential to transmit higher and higher MW power from the generating station to the load centers. The transmission losses reduce with higher voltages. With availability of appropriate materials and better manufacturing practices, it is now possible to have transformers of voltage ratings of 1200 KV. This voltage range requires very advanced insulation materials and insulation design tools. One of the most important out of these is the lead exit at the 1200 KV end.

The geometries of the structures should be arranged to optimize the field stress distribution. For this optimization, it’s necessary to comprehend and compare the geometries which also provides us economical and safe solutions. ENPAY organizes the designs with regards to these conditions.

**750 kV / 400 kV LEAD EXIT**
Nominal Voltage: 750 kV - BIL: 1950 kV - SIL: 1550 kV

**1200 kV LEAD EXIT**
Nominal Voltage: 1200 kV/BIL: 2300 kV/SIL: 1675 kV

**50 kV / 400 kV LEAD EXIT**
Nominal Voltage: 400 kV/BIL: 1300 kV/SIL: 900 kV
HIGH VOLTAGE INSULATION COMPONENTS

FEM—FINITE ELEMENT METHOD

E Field Distribution

Electrostatic field line

FEM—Finite Element Method 2D & 3D Electromagnetic-Field Simulation.

ELECTRODES

No Partial Discharges, excellent mechanical resistance.

14 ENPAY HIGH VOLTAGE INSULATION COMPONENTS
SLITTING MACHINES

Crepe paper, kraft paper, polyester foil and PSP rolls are slit up to 1 mm thickness into any width between 8 and 500 mm.

METAL CHECK

Continuous metal detectors are used in production. All the produced boards are passed through the metal detector. Metal detection is capable of detecting metal inclusions down to a minimum of 0.8 mm.

5 AXIS CNC

The machines are able to work on large dimension insulation components in any geometries, clamping rings for big power transformers, yoke clamping parts for traction transformer cores.

Working space: 3200x3200x700 mm
Handling Precision: +/- 0.2 mm
Positioning Precision: +/- 0.030 mm
High Voltage Insulation Components

Elbc and Elbp Laminated Board

The application areas of Laminated Board are press rings, end rings, shield rings, beams, support strips, fixing parts of power, distribution and special transformers. Laminated boards are usually processed into components for the mechanical support of windings, lead exits and lead ends.

Laminated boards are produced from the boards with different thicknesses. The densities of laminated boards vary between 1,20 and 1,25 g/cm³. These boards are A class (105°C) insulation materials and they are in pure cellulose color.

Elbc - Enpay Laminated Board with Casein
Elbp - Enpay Laminated Board with Polyester

The ELBC boards are produced according to IEC 60763-3-1 TYPE LB 3.1.1 standard.
The ELBP boards are produced according to IEC 60763-3-1 TYPE LB 3.1.2 standard.

ELBC water based casein glue with a good transformer oil permeability is used in the production of Laminated Boards. ELBP has the highest mechanical strength and polyester glue resin is used inside. Boards are glued to each other by strong pressing method. We recommend polyester glue for thicknesses >40 mm.

The thickness of laminated boards begins from 9 mm up to 150 mm. They can be produced in the maximum dimension of 4000x3000 mm or less as per the below table. For the thickness >150 mm and for other dimension requirements, please contact with ENPAY.

<table>
<thead>
<tr>
<th>Elbc - Elbp Sheet Sizes and Tolerances</th>
<th>Elbc - Elbp Thickness Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Sheet Sizes (mm) Tolerances (mm)</td>
<td>Thickness (mm) Tolerances (mm)</td>
</tr>
<tr>
<td>4000X3000 ± 50</td>
<td>9 - 20 ± 5.0</td>
</tr>
<tr>
<td>4000X1500 ± 50</td>
<td>21 - 50 ± 4.0</td>
</tr>
<tr>
<td>3000X3000 ± 50</td>
<td>51 - 100 ± 4.0</td>
</tr>
<tr>
<td>3000X2000 ± 50</td>
<td>101 - 150 ± 4.0</td>
</tr>
<tr>
<td>3000X1500 ± 50</td>
<td>&gt;150 ± 4.0</td>
</tr>
<tr>
<td>1500X1000 ± 50</td>
<td></td>
</tr>
<tr>
<td>1500X750 ± 50</td>
<td></td>
</tr>
</tbody>
</table>
Technical Data Sheet

ELBC - Enpay Laminated Board with Casein
ELBP - Enpay Laminated Board with Polyester

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>max./min. range</th>
<th>ELBC</th>
<th>ELBP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness ≤ 12 mm</td>
<td>mm</td>
<td>range 9 - 40</td>
<td>9 - 100</td>
<td></td>
</tr>
<tr>
<td>Thickness ≤ 12 mm</td>
<td>%</td>
<td>max. 5.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Thickness ≥ 12 mm</td>
<td>%</td>
<td>max. 4.0</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>g/cm³</td>
<td>range 1.15 - 1.30</td>
<td>1.20 - 1.30</td>
<td></td>
</tr>
<tr>
<td>Compressibility C</td>
<td>%</td>
<td>max. 3.5</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Reversible part of Compressibility Crev</td>
<td>%</td>
<td>min. 65</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Shrinkage MD</td>
<td>%</td>
<td>max. 0.5</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Shrinkage CMD</td>
<td>%</td>
<td>max. 0.7</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Moisture Content</td>
<td>%</td>
<td>max. 0.6</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Conductivity of Aqueous Extract</td>
<td>mS/m</td>
<td>range 6.0 - 10.0</td>
<td>5.0 - 6.0</td>
<td></td>
</tr>
<tr>
<td>pH of Aqueous Extract</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil Absorption</td>
<td>%</td>
<td>min. 7.0</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Electrical Strength in Oil Paralel to layers</td>
<td>kV/mm</td>
<td>min. 8.0</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>MD</td>
<td>min. 1.15</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>CMD</td>
<td>min. 100</td>
<td>110</td>
<td></td>
</tr>
</tbody>
</table>

The measurements are made in ENPAY Laboratory and the results are compatible with IEC 60763 standards.
In ENPAY laboratory, physical, chemical, cellulose, pulp, paper and electrical tests are performed. These tests are performed according to the standards of the insulation materials. The types of raw materials tested in ENPAY test laboratory include:

- Pressboard, Presspaper - IEC 60641
- Laminated Board - IEC 60763
- Laminated Wood - IEC 61061
- Crep Paper - IEC 60554
- Kraft Paper - IEC 60554

The test and measurements are performed not only to raw materials but also components made of these materials.

**Conditions of Transformerboard Laboratory**
- Covered Area: About 200 m²
- Temperature: 23±2°C
- Relative Humidity: 50±5%

**Cellulose, Pulp and Paper Tests**
ENBOARD quality control department keeps the quality of the cellulose under control by conducting all necessary incoming goods quality control tests. One of the most significant control test type is Fiber Quality Analysis. It is a fact that the result of this analysis may affect the quality.

**ENPAY Laboratory contains all types of devices to achieve and maintain the outstanding quality of ENBOARD;**
- Rapid Köthen Sheet Machine Automatic - producing the sample of the ENBOARD in the laboratory environment allowing for physical and chemical tests to be carried out
- Bauer McNett Fiber Classifier System
- Somerville Shive Content Analyzer
- Schopper Riegler Freeness Tester (Auto & Man)
- PFI Mill - providing the result of Schopper - Riegler - SR tests within the range of required values
- Equalizer - Distributor - Disintegrator - providing homogenous cellulose mixture
- Speed Dryer
- Sample Cutter

The data provided by these tests are used in the fully-automatic manufacturing processes for the production of ENBOARD to be used in Ultra High Voltage Transformers with excellent performance.
**Mechanical Tests**

Universal Testing Machine with 50 kN and 5 kN capacity are used in order to perform mechanical tests. Thanks to the computer connection of Universal Testing Machine, all tests are supported by computer control. Universal Testing Machine utilizes also changeable fixtures because of which tests can be customized to the type of test and material. Tensile strength, elongation, compressibility, flexure strength, plybond tests are performed both on the raw material and on the finished product according to IEC standards.

Establishing the Raw Density with the Laboratory Density and Density Profile Measuring System.

Important information on the current measurement, including:
- average raw density
- maximum raw density of the top layer
- maximum raw density of bottom layer
- actual position of sanding surface

are shown in numerical form on the screen after the measuring process.

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**Chemical Tests**

In addition to measurement equipments, different chemicals and other special devices are also used. This process takes place in order to prepare the samples and perform the tests on these samples according to IEC standards.

Some of these are listed below:
- Drying ovens with air or vacuum
- Climatic test cabin
- Shaker
- Balloon heater
- Water bath
- Balances
- Various chemicals

All of these devices and necessary chemical materials can be found in ENPAY laboratories. With the help of these measurement equipments, various devices and chemicals, conductivity and pH meter, moisture content, degree of polymerization, water determination according to Karl Fischer, viscosity measurement according to Brookfield, ash content and determination of metallic particles are measured.
HIGH VOLTAGE INSULATION COMPONENTS

HIGH VOLTAGE TEST LABORATORY

- Test transformer - 200 kV, 0.2A, 40 kVA
- Test Transformer - 100 kV, 0.1A, 10 kVA
- AC Measuring System - 200 kV, 100 kV
- HV voltage measuring divider - 200 kV, 0.15 nF
- Coupling Capacitor 100 kV, 1 nF, 100 kV, 0.3 nF
- Breakdown Test Set for Transformer Oil
- Low voltage part built into the measuring impedance
- Versatile Partial Discharge Measuring System
- Measuring impedances for PD measurement
- Peak Voltmeter

X-RAY INSPECTION SYSTEM

- Accurate X-RAY system for control of particle and air pocket.
  - High Resolution X-RAY tube
  - Precision Manipulator
  - Larger inspection objects

- Tan δ and C Meter for Electrical Insulation Materials
  - Independent, real time image processing
  - Realistic 3D volume model with measurement in all spatial directions
  - Excellent image quality through high-contrast resolution with flat-panel detectors or other image chains
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