

INNOVATION INSIGHT



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CORPORATE PROFILE

ENPAY is the Pace-Setter of Transformer Industry serving to its customers from its 4 Plants Worldwide. Having founded in 1978, ENPAY is a world-known producer of;

- Power and Distribution Transformer Cores
- Shunt Reactor Cores
- Wound Cores
- Flux Collectors
- Current Transformers
- Transformerboard and Laminatedboard
- HV Insulation Components

In 1989, the Company launched production of transformer components in its Kullar Plant in Turkey.

In mid-2005, ENPAY launched the second manufacturing plant in Slovakia. In 2009, ENPAY has made a breakthrough step and started to manufacture Transformerboard in his own premises in Kullar/Turkey starting from July 2009 with the new brand name of ENPAYBOARD®.

Right after this investment, in the second half of 2010, ENPAY started its third manufacturing plant in India and in 2017 fourth Plant of ENPAY has been launched in Bulgaria. All four Plants of ENPAY are serving in the same field, production of Transformer Components with a dedicated level of quality.

Strong know-how, continuous R&D activities and utilization of State of the Art Technology lays behind ENPAY's sustainable growth. The investments with state-of-the-art technological equipment, its determined steps toward institutionalization and its quality-oriented corporate culture and customer service are among the most important competitive advantages of ENPAY.

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.



QUALITY AND ENVIRONMENT 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.

All incoming materials are checked and further controls are carried out; manufacturing processes are monitored continuously.

Final checks are made on fully assembled cores, and test reports are included in the shipment. 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 facilities employ 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.

Having laboratories internationally accredited and equipped with cutting-edge technology, ENPAY serves its customers with a dedicated level of quality.

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.



OUR PRODUCTS

SLITTING LINES

Core production starts with slitting of master steel coils. ENPAY is able to slit all types of magnetic grade steels and magnetic materials in various slitting lines. Slit widths start from full coils 1,200 mm, down to 5 mm in any required band width. The slit material thickness is 0.022 mm (Amorphous and Nanocrystalline strips), 0.05 - 0.08 - 0.10 - 0.20 mm (thin electrical steel - Nickel-alloy strips), 0.18 - 0.23 mm (grain oriented laser treated sheets),

0.27 - 0.30 - 0.35 mm (HIB - grain oriented sheets), 0.50 - 0.65 mm (non-oriented cold rolled electrical steel sheets). The cutting quality is constantly controlled. Tungsten carbide slitter blades are used in order to achieve a minimum formation of burrs.



ELECTRICAL STEEL TESTS

TESTS OF MAGNETIC PROPERTIES OF ELECTRICAL STEEL SHEET

The tests are performed according to IEC 60404-2 "methods of measurement of the magnetic properties of electrical steel sheet and strip by means of EPSTEIN FRAME" and IEC 60404-3 "methods of measurement of the magnetic properties of electrical steel strip and sheet by means of a SINGLE SHEET TESTER."



ONLINE CONTINUOUS THICKNESS MEASURING

Material Thickness is measured by online and continuous measuring gauge during the Slitting process. Measuring Capability; Repeatability better 0,1 % and Resolution 1 μm .



SURFACE INSULATION RESISTANCE (FRANKLIN TEST)

Surface Insulation Resistance (FRANKLIN TEST) are controlled according to IEC60404-11 Mode A



ONLINE MEASURING SURFACE CONDITION (HOLE and SURFACE IMPURITY DETECTION)

Surface Condition are controlled according to IEC60404-8-7 / 6.4



ADHESION and BENDING TEST

Adhesion and Bending Test are controlled according to IEC60404-12 and IEC60404-8-7.

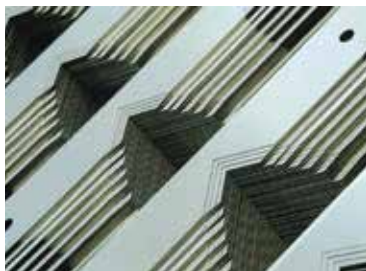
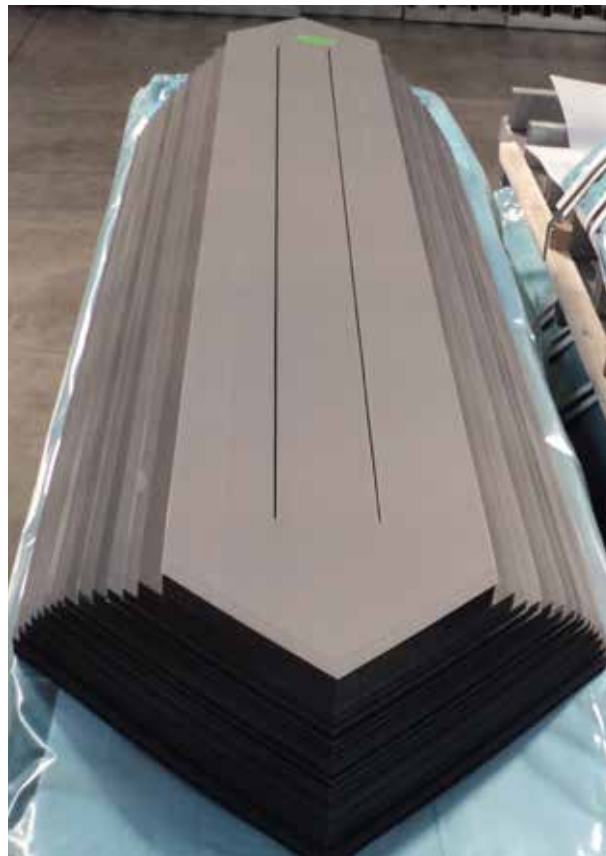


STEP-LAP CUTTING

ENPAY uses the newest, computerized version of GEORG Cut-to-Length Machines in order to produce step lap laminations. Advantages of cutting in step lap are:

- reduction in iron losses
- lower noise level
- time saving in assembly.

Several GEORG Step-Lap Cutting Machines are in operation. Cores with band with up to 1 meter can be produced.



STACKING AND ASSEMBLY FACILITIES

ENPAY has different sizes and types of stacking tables in order to produce complete flat stacked laminations, and Step-Lap transformer cores. All necessary insulation parts from transformer board or plywood for yoke clamping and winding supports are manufactured according to customer specifications and drawings if available. Reel frames are also produced for dry type transformers as per the customer requirements. The cores are glued and varnished according to the technical requirements (core gluing varnish for all transformers). The legs are bandaged if desired. The customer receives complete cores with

insulation parts. The sheets may also be delivered as cut-to-length laminations. The cores are built on modern core stacking tables. Stacking on guiding bolts and most accurate setting of the leg supports on center distance enables to keep the geometrical dimension on leads to an absolute minimization of the air gaps. The completely clamped core is then swung into vertical position 90° by means of a hydraulically operated table platform, resulting in a tension-free-up-tilting. A pre-measurement of the core losses guarantees the required no-load losses.



POWER TRANSFORMER CORES

Up to 1000 mm width for largest power transformers.

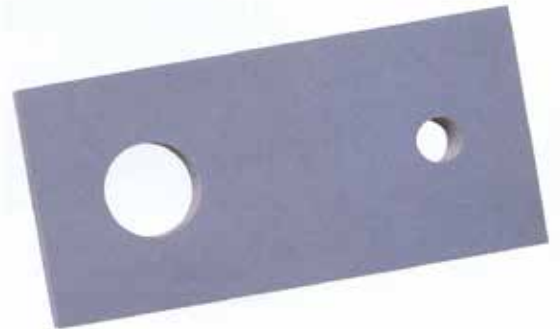
If the core weight is over 100 tons, the limbs and the yokes will be packed on separate palettes.

Ready stacked and fixed limbs can be produced according to customer's design in order to save cost for assemblies.

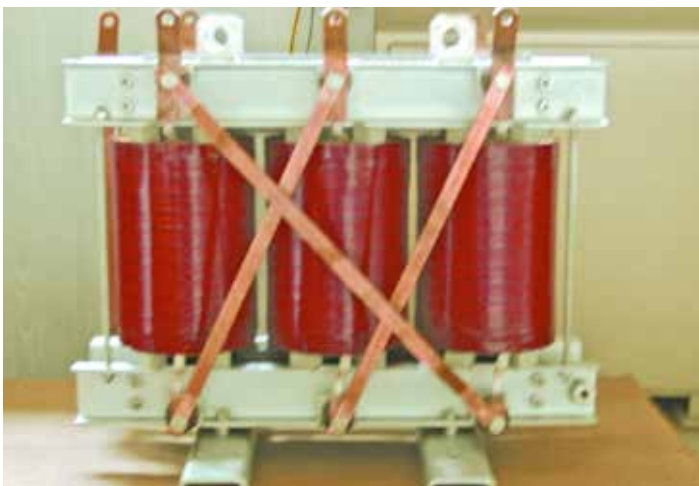


CUTTING WITH VARIOUS ANGLES

ENPAY has different cutting systems which can produce magnetic steel laminations with cuts of 90° or in other angles in order to manufacture cores for small transformers, chokes, shunt reactor as well as other magnetic cores.



CAST RESIN TRANSFORMER CORES



Step-Lap Cut cores are produced according to customers specifications. Cores are painted as customer requirements and Core assemblies are made with Galvanized Clamps.

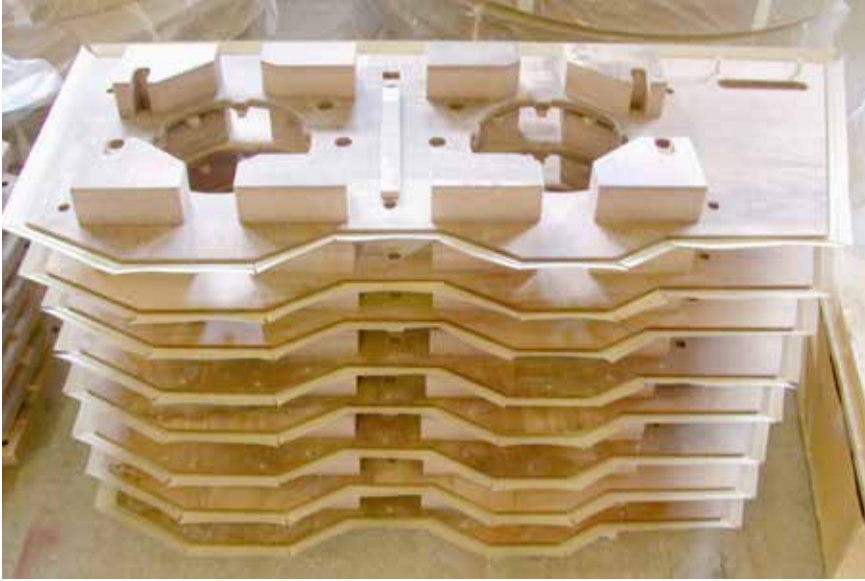


VOLTAGE TRANSFORMER CORES - FLAT STACKED

Cores for voltage transformers are manufactured from high quality Grain Oriented Silicon Steel in various dimensions as specified by the customers. Laminations are cut to length and assembled according to customer drawings.



MAGNETIC CORES AND INSULATION PACKAGES FOR TRACTION TRANSFORMERS



Similar to Flat Stacked Cores, Traction Transformer Cores are produced with metal or wooden clamping material according to customer design. Welding for metal parts for this products are in conformity with DIN EN 15085-2.

ZERTIFIKAT • CERTIFICATE • CERTIFICADO • CERTIFICAT



CERTIFICATE
Welding of railway vehicles and components according to
EN 15085-2

This is to certify that **Enpay Endüstriyel Pazarlama ve Yatırım A. S.**
Karadenizliler Mah.Fakulte Cad. No. 147/A
41140 Kullar Basiskele Kocaeli
TURKEY

is qualified to perform welding work within the range of certification of:
Certification level CL1 according to EN 15085-2

Field of application: - New construction of railway vehicles and their components
- external machine equipment parts
- machine room equipment (transformer casing)
- without design

Range of certification

Welding process according to DIN EN ISO 4063	Material group according to EN ISO 5817	Dimensions	Comments
131	21 22 1.1B 8 31	t = 1.5 - 6 mm t = 2.5 - 20 mm t = 3 - 12 mm t = 3 - 20 mm t = 3 - 24 mm	- PW, 22: t = 3 - 40 mm - BW PW, BW: t = 3 - 12 mm
135	1.1 1.2 1.1B, 3.1 8	t = 1 mm t = 1.5 - 40 mm t = 3 - 20 mm t = 3 - 24 mm	WIPOR Enpay VUP 65 PW, BW: t <= 20 mm ReH <= 690 Mpa -

(continuation: see reverse)

Responsible welding coordinator: Dipl.-Ing. Tahir Eryigit (IWE) born: 14.08.1967
Deputy with equal rights: Dipl.-Ing. Ömer Balta (IWE) born: 29.07.1984
Deputy: Zafer Cakir (Level C) born: 14.06.1976

Comments: see reverse

Certificate no.: TÜV SÜD 15085/CL11085/5/00
Valid: from 10.06.2016 to 10.06.2019
Issued on: 07.07.2016
Auditor: HOHENWARTER
General regulations (see reverse)



1 of 2

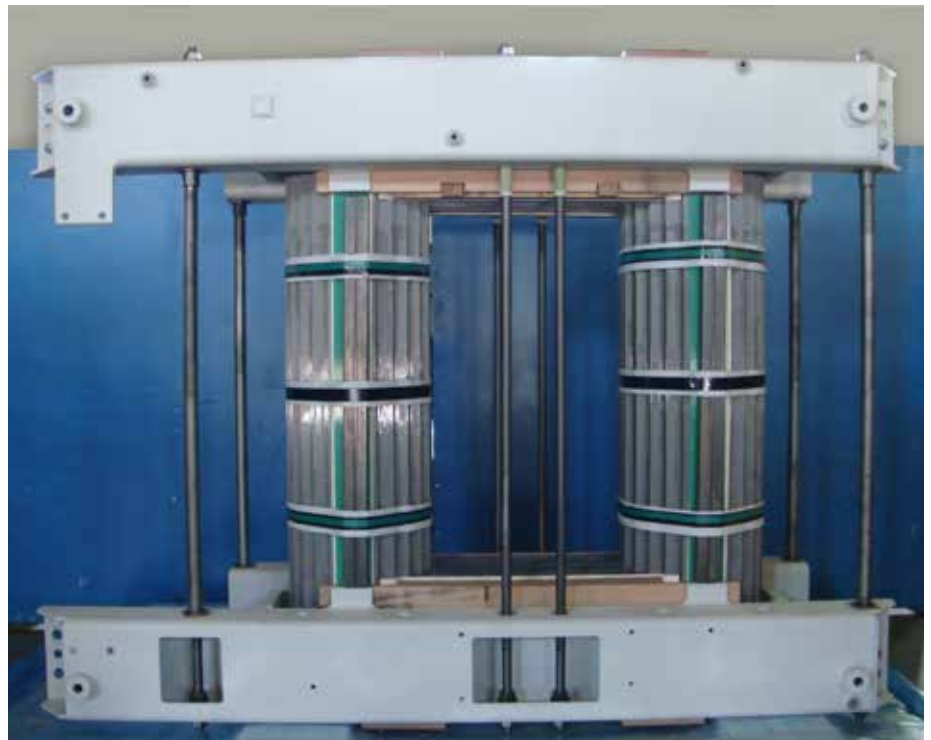
TÜV SÜD Industrie Service GmbH, Westendstr. 199, 80686 Munich, Germany

Certification Body
Material and Welding Technology

(Signature)

Lecca
head of certification body

ZERTIFIKAT • CERTIFICATE • CERTIFICADO • CERTIFICAT



RADIAL STACKED CORES FOR SHUNT REACTORS

up to 1200 kV - 400 MVAR

ENPAY produce special stacked cores for Medium and High voltage reactors from grain oriented magnetic steel according to customer design. These cores are produced with legs and yokes complete with its cooling channels and insulation accessories. Wound yokes are also in the production scope of ENPAY.

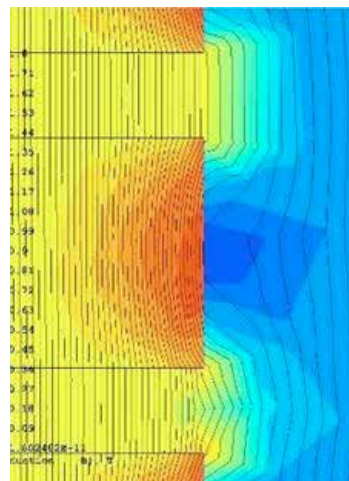
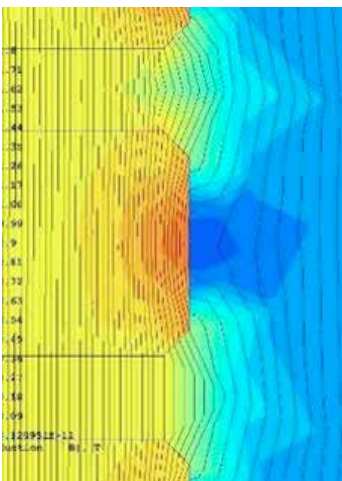
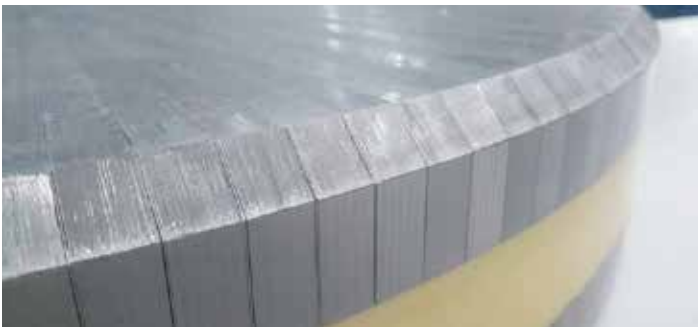
Ceramic spacers as per customer specifications are used to obtain radial distance between core elements. These ceramic spacers are tightly glued on both sides to the core elements with special adhesive under pressure. The total weight of the core may reach 100 tons.



SHUNT REACTOR CORES WITH BEVEL EDGE TECHNOLOGY

Advantages of Bevel Edge;

- Reduces average flux density
- Provides homogeneous flux distribution
- Lower losses
- Lower noise
- Prevents overheating



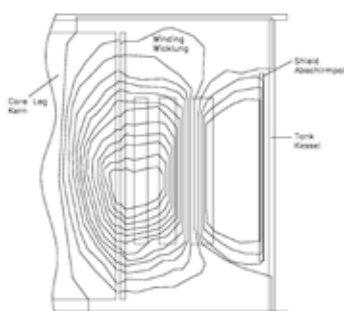
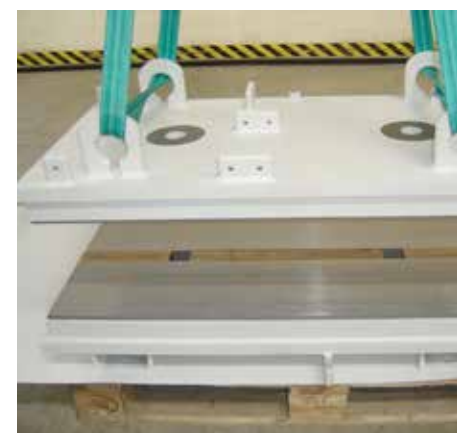
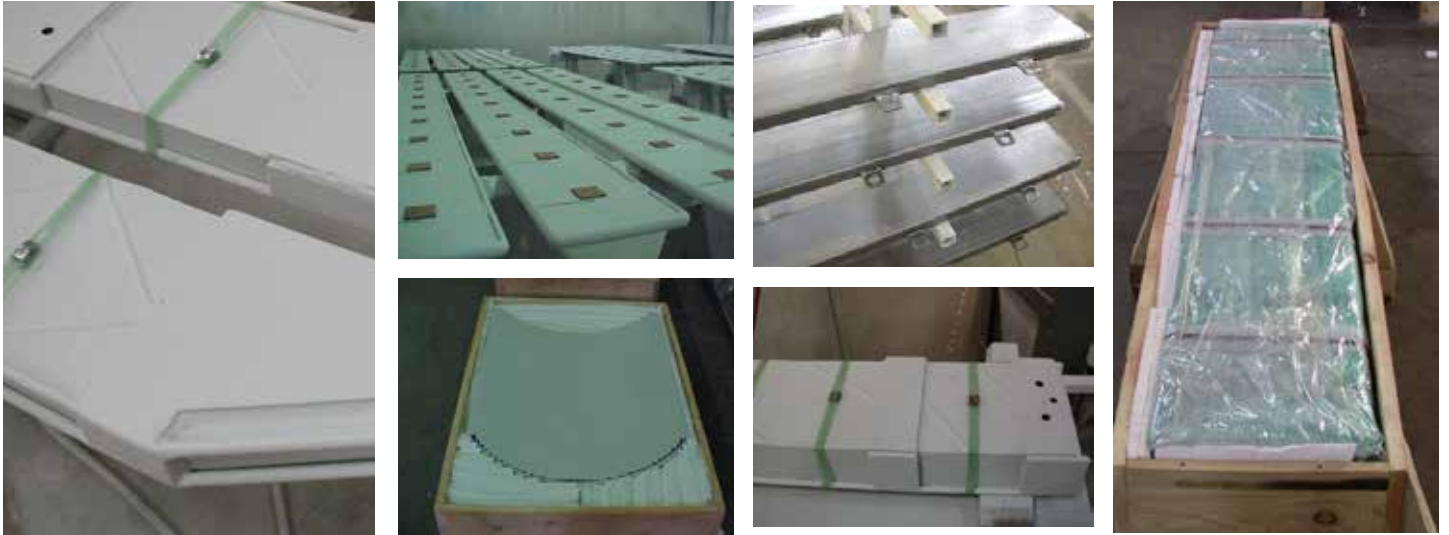
With Bevel Edge

Without Bevel Edge

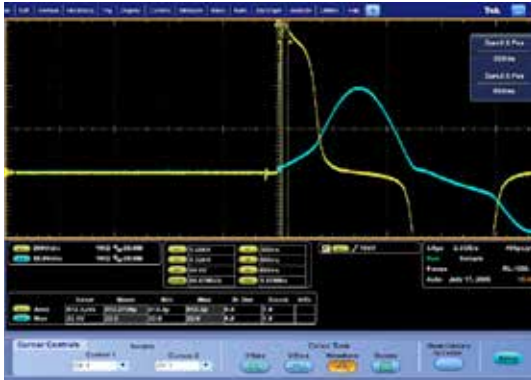
TANK SHIELDING

Flux collectors are parts of the Power Transformers which are designed to lower power losses in high power transformers. They act as shielding which reflect the electrical flux leakages coming from the bobbins that are wound to the cores, under high power.

ENPAY produces flux collectors with/without rubber in painted or bare form for power transformers in any size what your project needs.



HVDC TRANSMISSION C-CORE

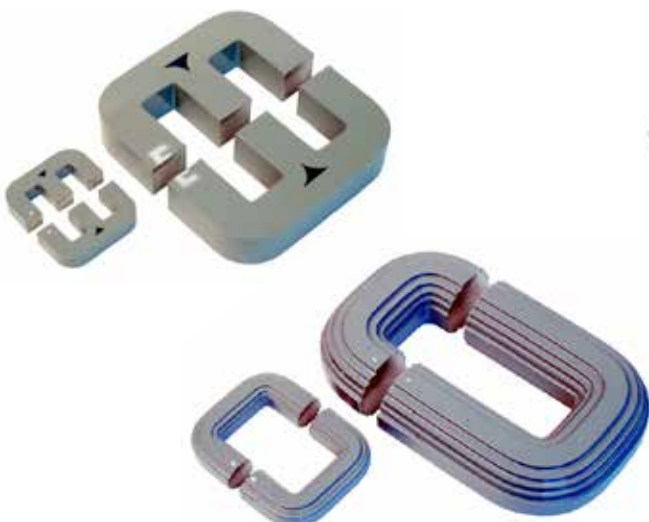


ENPAY manufactures also all type of C-Core for HVDC Transmission system. The specific characteristics of these cores are measured in High Voltage DC Laboratory.

WOUND CORES

ENPAY produces wound cores such as Toroidal Cores for power and instrument transformers, C and E shape cut cores for different applications in electrical and electronic devices as well as GFI cores for protection circuit breakers. Wound Cores are

produced in different shapes according to customer design. ENSI Wound Cores are produced from Grain Oriented Silicon steel and ENNI cores are produced from Nickel Iron Alloys.



ADVANCED MAGNETIC CORES

Soft magnetic materials are used in the production of nickel iron cores, nanocrystalline cores and amorphous cores.

Quality materials and production technology provides products with;

- Higher permeability
- Lower magnetization in higher inductions
- Low core losses especially at high frequencies
- Less losses on high temperatures

ENNI® cores are available with plastic end-caps, epoxy coating or impregnated forms.



Amorphous C-core



Nanocrystalline Toroid



Nickel C-core, Toroid,
Cut core & Rectangular

Comparison with usual materials	Nanocrystalline	Amorphous FE-base	ENNI® 80
Permeability (10 Khz)	20000 to 200000	>60000	20000
Losses (25 Khz; 0.2T; 100 °C)	3 W/kg	5 W/kg	14 W/kg
Saturation Induction	1.25T	1.59T	0.8T
Coercive Field	5-10 mA/cm	3 mA/cm	5-15 mA/cm
Curie Temperature	600 °C	410 °C	400 °C
Max. Operating Temperature	150 °C	130 °C	120 °C

ENNI®-NICKEL IRON CORES

Nickel alloys are used in the production of ENNI® Magnetic Cores production. High permeability nickel iron ribbon with thickness 0.2-0.1-0.08-0.06 mm are used in production of magnetic cores. ENNI® cores are supplied with end-caps, epoxy coated, impregnated.

Code	Material	Band Thickness (mm)	Permeability μ_4	Permeability μ_{max}	Saturation Induction (T)
ENNI 80	72-83% Ni	0.05-0.2	60000-240000	150000-350000	0.6-0.8
ENNI 55	54-68% Ni	0.05-0.2	40000-80000	100000-160000	1.2-1.5
ENNI 50	45-50% Ni	0.1-0.2	10000-12000	90000	1.5-1.6
ENNI 40	35-40% Ni	0.2-0.3	4000-9000	50000-75000	1.3-1.5

ENNANO®-NANOCRYSTALLINE CORES

Nanocrystalline cores have high permeability, good thermal stability and flat hysteresis loop. The cores are supplied with plastic cases (UL94-Vo) or epoxy coated.

Applications

The performance of nanocrystalline cores is effective for many applications.

- Transformers (Power, Current, Drive)
- Common mode chokes (Filters)
- Current sensor

Advantage

- High Permeability cores with flat hysteresis loop.
- Less losses on high temperature and high frequency
- Suitable for many electric and electronic applications on SMPS transformers (up to 100kW), inverters filter, magamps, signal transformers.
- Less weight than the other soft magnetic materials.
- Produced with plastic case or epoxy coated that is suitable directly winding

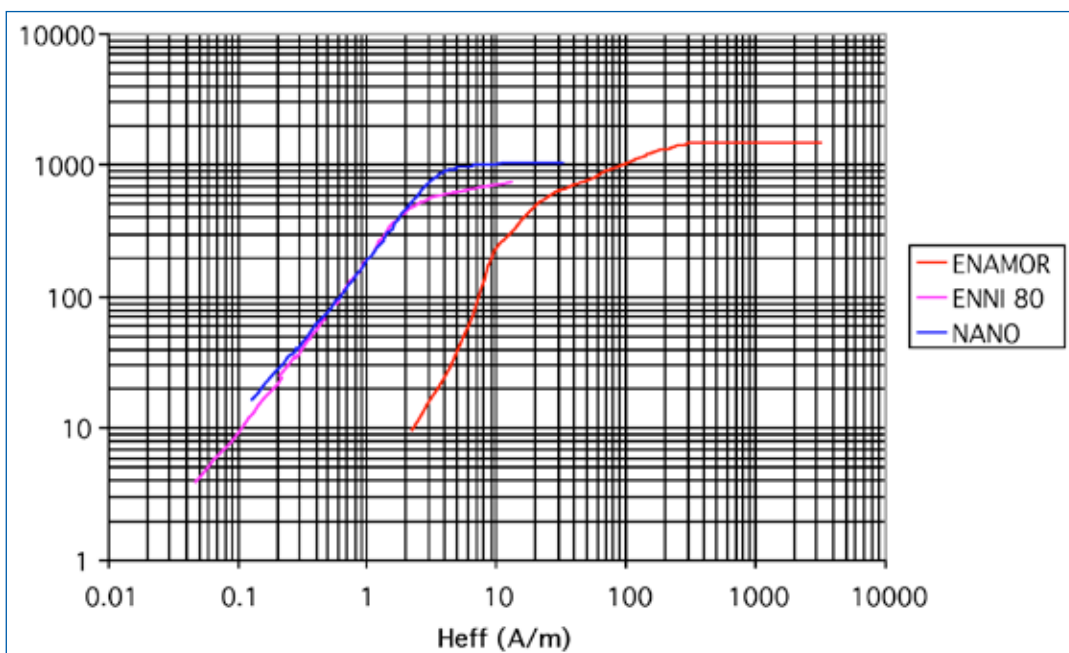
ENAMOR®-AMORPHOUS METAL CORES

Amorphous material is used for ENAMOR® core production.

High permeability, low core losses at high frequencies, high saturation induction are achieved by using amorphous materials.

ENAMOR® Cores have much better performance in power supplies when compared with the other materials. They are also used for high frequency transformers for inverters, high frequency welding power supply.

COMPARISON B(mT) & H(A/m) CURVE OF SOFT MAGNETIC ALLOYS



SATURABLE REACTOR CORES FOR RECTIFIER TRANSFORMERS



Continuous control of large magnitude A-C current by a small D-C current (rectifier transformer for electrolysis).

PRODUCTS AND R&D

ENPAY produces different types of magnetic cores for power transformers, instrument transformers and chokes, radially stacked shunt reactor cores with ceramic spacers, current suppression bobbins, cores and flux correctors. All types of cores are made according to customer's request. ENPAY engineers are

at your disposition for the development of special type transformer cores. The main target is the production by the customers of economical, low noise, low loss and highly efficient transformers.



TRANSFORMERBOARD

Enpay started up a state-of-the-art Transformerboard machine in 2009. Boards are characterized by high density, high purity, uniform thickness, dimensional stability, low compressibility, low shrinkage and high electrical strength.

Transformerboard produced, a hard and rigid one having high purity with excellent electrical and mechanical properties, is specifically engineered for the high voltage and extra high voltage transformer Industry. A number of online quality control systems exist, one of which is a X-Ray Metal Detector. Separate conditioning and testing facilities have been established for uninterrupted and rapid testing and evaluation of the raw materials and the product.

ENPAYBOARD® (ENPAY TRANSFORMERBOARD) has high dielectric strength and used as insulating material in different types of Power and Distribution Transformers, Capacitors, Switch Gears etc., in the form of winding cylinders, spacers, washers, keyway strips, etc.

ENPAY offers a comprehensive range of electrical products under the brand names E3 and E4. These two main product grades satisfy a wide range of insulation performance requirements for power and distribution transformers.



HIGH VOLTAGE INSULATION COMPONENTS

COMPLETE INSULATION PACKAGES (KITS)

- Cylinders made of Transformerboard according to IEC 60641
- Kits allows for less production costs and decreased manufacturing cycle time of power transformer production.
- Kits are produced according to customer request.



SNOUTS - CHIMNEY SECTORS - FLANGE TUBES

- Molded components made of Transformerboard according to IEC 60641.
- Tailor-made according to the customer specification.



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



STRIPS AND SPACERS

The products are exclusively made of Transformerboard according to IEC 60641.



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.

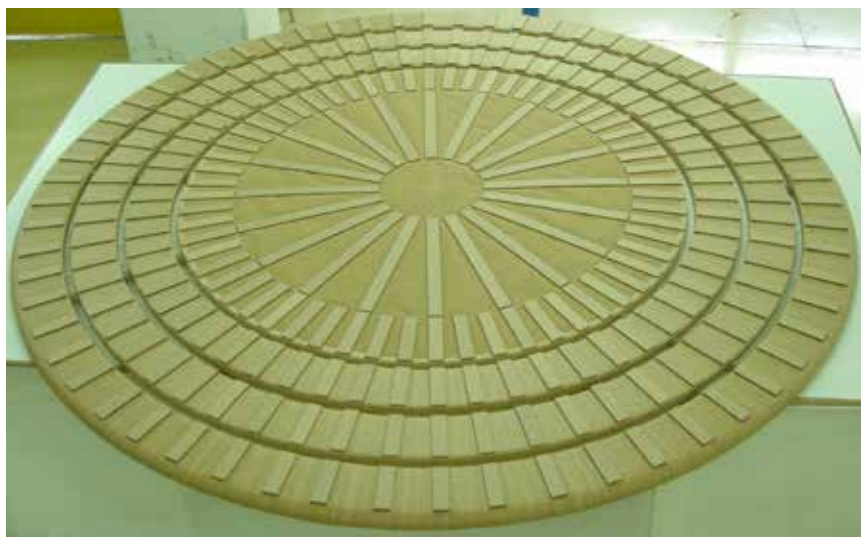
END (CLAMPING) RINGS

- 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.



SHIELD RINGS

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



Special Shield Rings are produced for High Voltage Power Transformers & HVDC.



SHIELD END RINGS

- The Rings are made of Laminated Wood according to IEC 61061 or Laminated Pressboard according to IEC 60763.
- Shield End Rings for High Voltage Power Transformers up to 850 kV.



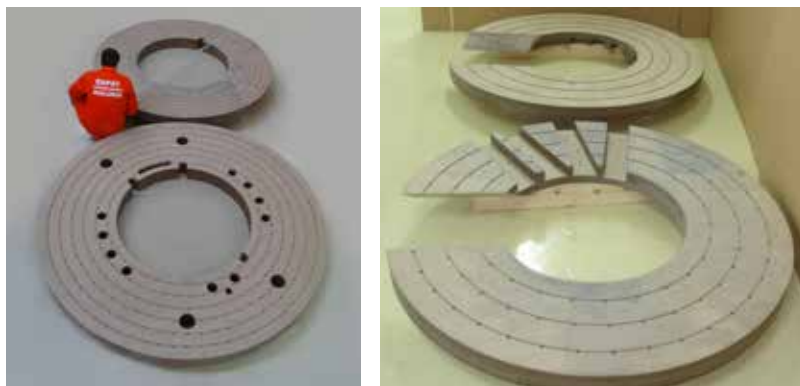
SHIELD CYLINDER

The Cylinders are made of Transformerboard according to IEC 60641.



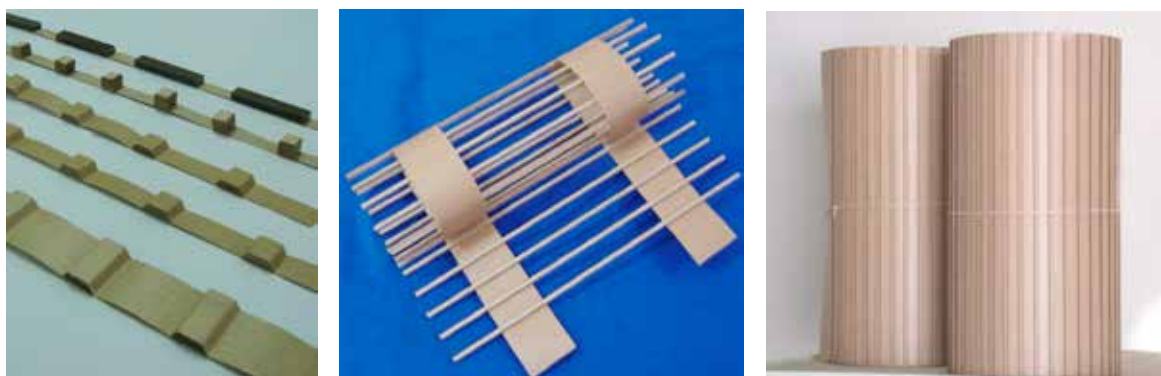
PRESS RINGS AND CLAMPING RINGS

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.



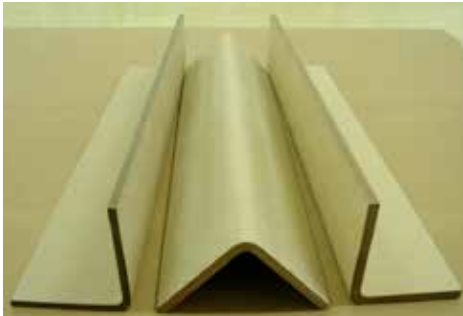
THERMOFLOWS - LADDERS - CLACKBANDS

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®).



VARIOUS INSULATION COMPONENTS

Various insulation components made of Transformerboard according to IEC 60641.



L - Corners



Components



Caps and Angle Rings



Rods and Nuts



Clamps



Fixing Parts

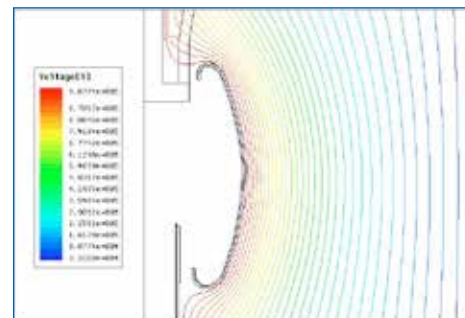
ELECTRODES

No Partial Discharges, excellent mechanical resistance.

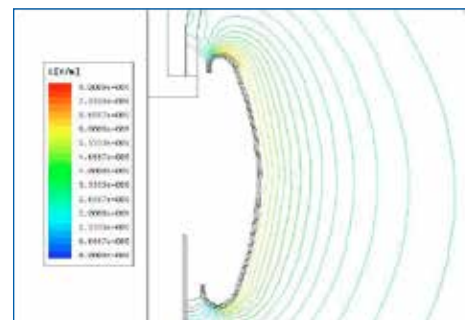


2D&3D ELECTROSTATIC-FIELD SIMULATION

Electrostatic-Field Simulation by using FEM(Finite Element Method)



E Field Distribution



Electrostatic field line

ENPAY EXIT INSULATION SYSTEM®

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.

400 kV Δ Connection

Nominal Voltage: 420 kV -
 BIL: 1425 kV - SIL: 1175 kV
 Tailor-made designs for special type applications are realized by us.

Special type connections allow to adjust full length at the different projects.



SMART SOLUTION



Test voltages AC (50/60 Hz, 1 minute)830.....kV
 BIL (1.2/50 6s)1950.....kV
 SIL (250/2500 6s)1550.....kV

800 kV

Nominal Voltage: 800 kV - BIL: 1950 kV - SIL: 1550 kV



1200 kV

Nominal Voltage: 1200 kV - BIL: 2250 kV - SIL: 1800 kV



400 kV

Nominal Voltage: 400 kV - BIL: 1425 kV - SIL: 1175 kV

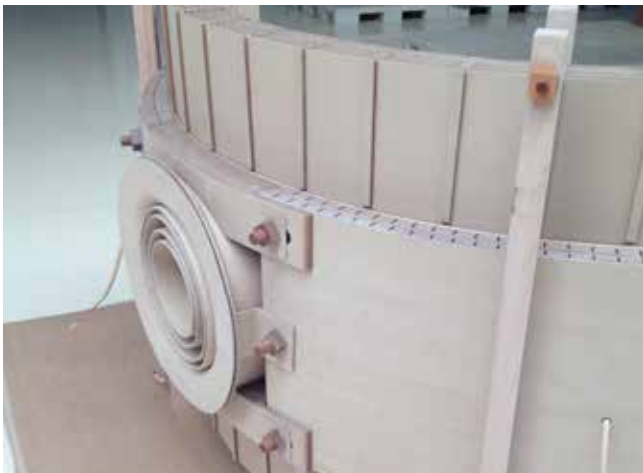


MIDDLE EXITS

When Regulating winding located outside of HV winding we should use middle exit app. to make system safe.

Middle Exit app. to make system safe. Connected to regulation winding and protect exit insulation system by making mounting process easier and shorter with convenient regulating winding support.

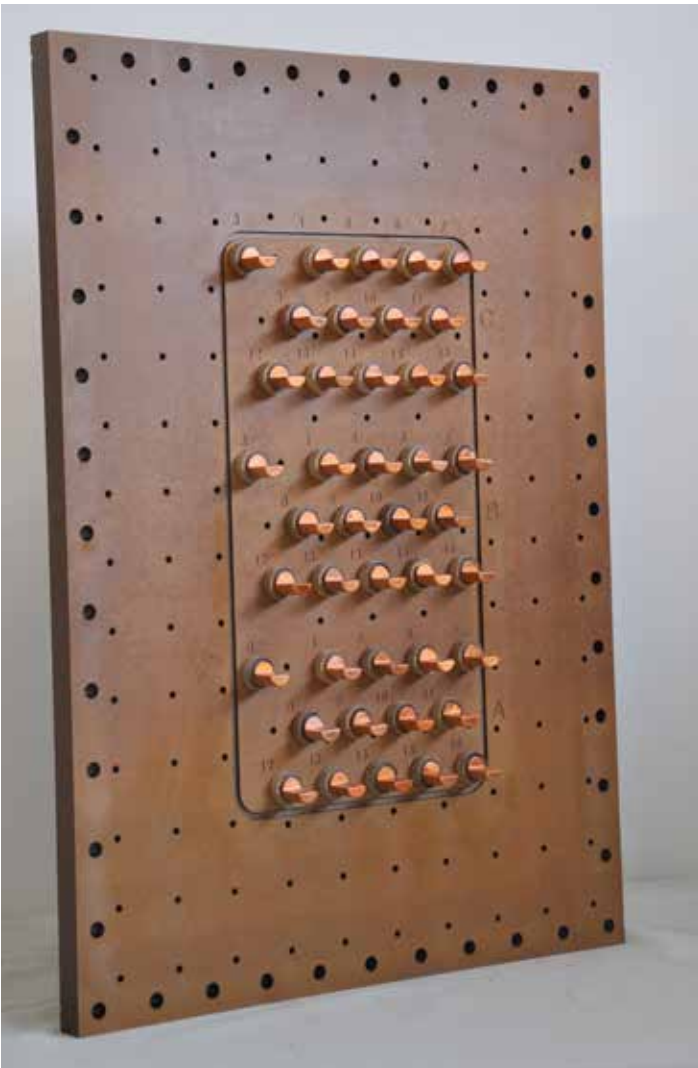
The transformer, 400 kV Middle Exit System was installed to connection between tap winding to Exit Insulation System, have been approved in accordance with IEC 60076-3.



BARRIERBOARD APPLICATION

Barrierboard is used in order to physically separate the tap changer from the tank which reduces the impact of a possible tap changer failure on other components of transformer. A barrierboard is made of ENPAYBOARD® with adequate mechanical and electrical properties and meets the requirement up to the highest level of voltage between the contacts. In case of maintenance required on a tap changer, thanks to Barrierboards, it is not necessary to take the whole oil out of the transformer. Other importance for large power transformers with dimensional limitations during transportation.

Barrierboards are designed according to customer specification considering all mechanical and electrical requirements for your transformer. A series of tests has been performed by us to verify and improve the electrical withstand strength of Barrierboards, i.e. between the through lead conductor terminal studs and ground and to improve pressure withstand. Barrierboards are dried and stabilized with oil before delivery. Hydraulic pressure tests are performed upon customer request on simulators parts. A hydraulic test with increased oil pressure more than 1.5 bar during determined time.



ELBC AND ELBP LAMINATED PRESSBOARD

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

Laminated Pressboards are produced from the boards with different thicknesses. The densities of laminated pressboards 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 Poliester

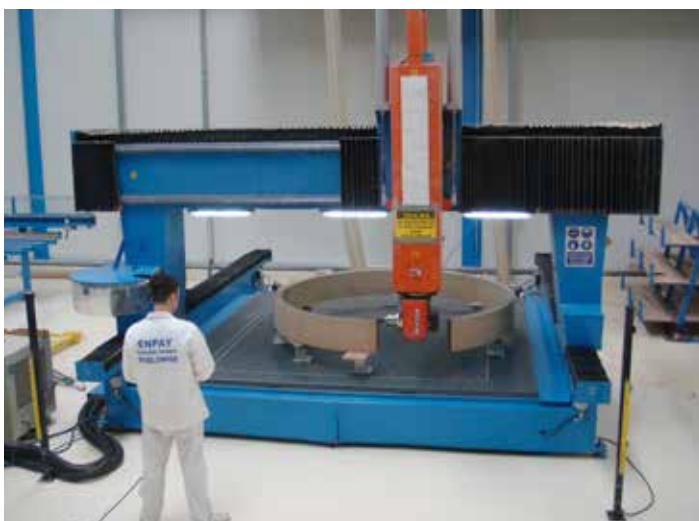
The ELBC boards are produced according to IEC 60763-3-1 TYPE LB3.1A.1 standard.

The ELBP boards are produced according to IEC 60763-3-1 TYPE LB3.1A.2 standard.

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

INSULATION LABORATORY

ENPAY laboratories are internationally accredited according to ISO/IEC 17025.



Test
TS EN ISO/IEC 17025
AB-0546-T

In ENPAY laboratories physical, chemical, cellulose, pulp, paper, insulation liquid and electrical tests are performed. These tests are performed according to the standards of the insulation materials. ENPAY laboratories are capable of performing these types of raw material tests below:

- Pressboard, Presspaper - IEC 60641
- Laminated Pressboard - IEC 60763
- Laminated Wood - IEC 61061
- Crep Paper - IEC 60554
- Kraft Paper - IEC 60554
- Insulation Liquid - IEC 60296
- Industrial Rigid Laminated Sheets – IEC 60893
- Industrial Rigid Round Laminated Tubes and Rods – IEC 61212

The tests and measurements are performed on not only 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%

Mechanical Tests

Universal Testing Machine with 50 kN with Environmental Chamber (up to +350°C) and 5 kN capacity are used in order to perform mechanical tests.

The tests below are performed both on the raw materials and finished products according to IEC standards:

- Tensile Strength
- Elongation
- Flexural Strength
- Modulus of Elasticity
- Internal Ply Strength
- Compressibility
- Plybond Resistance
- Thickness
- Apparent Density
- Shrinkage



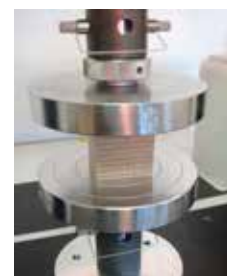
Universal Test Machine (50 kN)
Environmental Chamber
Test Temperature:
Between Ambient Temperature & +350°C



Tensile Strength



Flexural Strength



Compressibility

Chemical Tests

In addition to measurement equipments, various chemicals and other special devices are also used.

All these necessary devices and chemicals are accessible in ENPAY laboratories.

- Moisture Content (Drying Method)
- Determination of Water of Solid and Liquid Test Samples (Karl Fischer)
- Ash Content
- Conductivity of Aqueous Extract
- Ph of Aqueous Extract
- Degree of Polymerization of Cellulose
- Oil Absorption
- Contamination of Liquid Dielectrics
- Metallic Particules

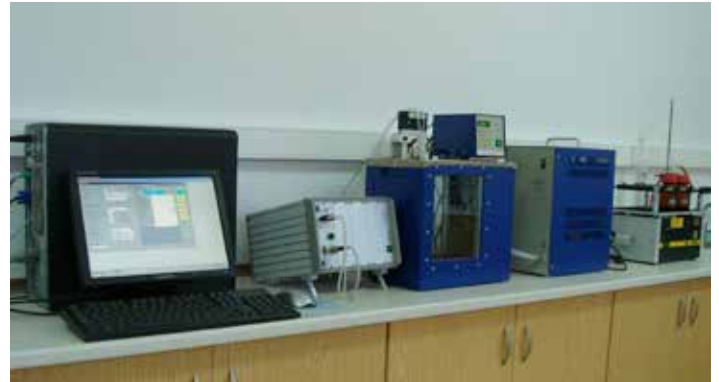
Cellulose, Pulp and Paper Tests

ENPAYBOARD® quality control department keeps the quality of the cellulose under control by conducting all necessary incoming goods quality control tests.

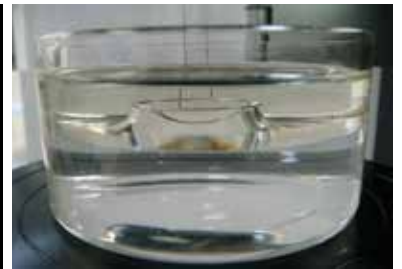
Transformer Liquid Insulation Tests

The tests below are performed on mineral oil complying with IEC 60296.

- Solid and Liquid Insulation Interaction Tests
- Water Content Coulometric Karl Fischer Titration - IEC 60814
- Breakdown Voltage - IEC 60156
- Permittivity - IEC 60247
- Dielectric Dissipation Factor ($\tan \delta$) - IEC 60247
- D.C. Resistivity - IEC 60247
- Acidity - IEC 62021-1
- Sludge Formation - IEC 61125 (Clause – 1.9.1)
- Interfacial Tension of Oil Against Water by the Ring Method - ASTM D971



Degree of Polymerization



Interfacial Tension

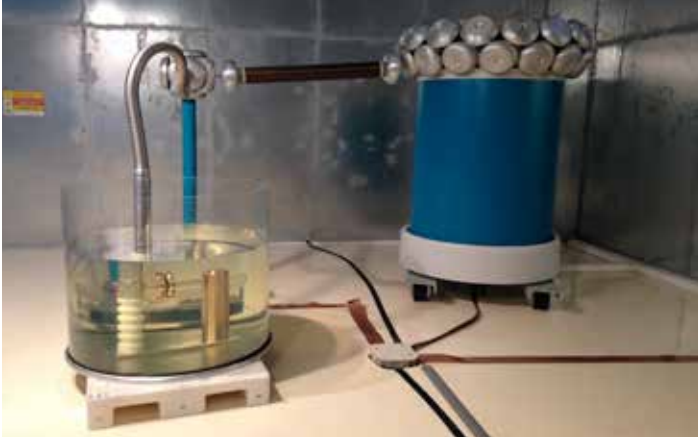


Water Determination (Karl Fischer)

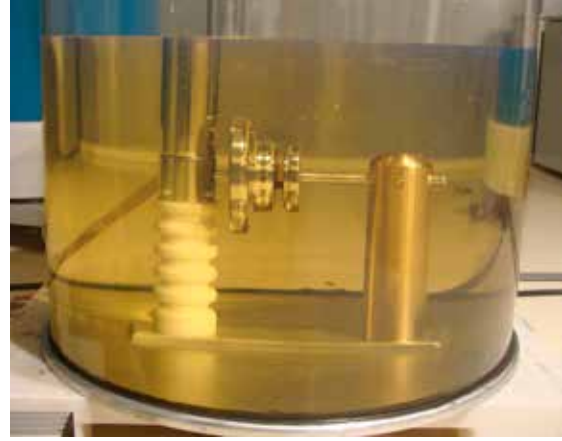


Solid and Liquid Insulation Interaction Tests Area

HIGH VOLTAGE TEST LABORATORY



High Voltage Test System up to 200 kV



Test Electrodes



In ENPAY High Voltage Test Laboratory, electrical tests in the right-hand column are performed on the samples conditioned in compliance with IEC standards related with the material type.

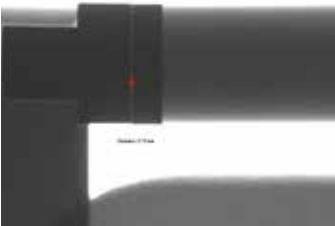
- Electrical Strength (up to 200 kV) - IEC 60641 – IEC 60763 – IEC 61061
- Partial Discharge (in Fully Screened Laboratory) – IEC 60270
- Permittivity – IEC 60250
- Dielectric Dissipation Factor (Tangent Delta) – IEC 60250
- Volume Resistivity – IEC 60093
- Surface Resistivity – IEC 60093
- Resistance – IEC 60167
- Equipment for Oil Treatment
- Equipment for Drying and Oil Impregnation of Test Samples

X-RAY INSPECTION SYSTEM

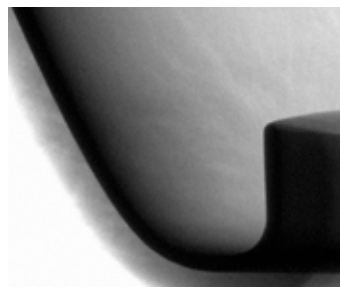
- Independent, real time image processing
- Realistic 3D volume model with measurement in all spatial directions
- Excellent image quality through high-contrast resolution with flat-panel detectors or other image chains

Accurate X-RAY system for control of metal particle and air pocket.

- High Resolution X-RAY tube
- Precision Manipulator
- Larger inspection objects



X-RAY Image



X-RAY Image



TRANSFORMER WINDINGS



- Maximum outer diameter:** 1200 mm
- Maximum height:** 380 mm
(over the 50 turns)
500 mm
(up to the 50 turns)
- Maximum weight:** 200 kg
(over the 50 turns)
500 kg
(up to the 50 turns)



BUSHING TYPE CURRENT TRANSFORMERS

ENPAY Bushing Type Current Transformers are designed and manufactured according to ENPAY's own design also in compliance with the customer specifications. These transformers are provided with suitable outer insulation of crepe paper or woven polyester tape or NOMEX allowing their usage in High and Medium Voltage Power Transformers. Internal insulation is made conforming their

use in liquid such as transformer oil, silicon oil etc. BT current transformers can easily be designed in different dimensions up to 1200 mm outer diameter, 500 mm height and 500 kg weight connections are made up with the latest technology allowing the lowest possible contact resistance together with the highest mechanical strength.

NON-ASSEMBLED BCT

Various insulation methods are used to comply customer requirements depending on the location of the BCT in power transformers. The main insulation materials used are cellulose based and polyester based materials. Cellulose based materials are preferred in case BCT will be used near active part of power transformer since the insulation of BCT should immerse the

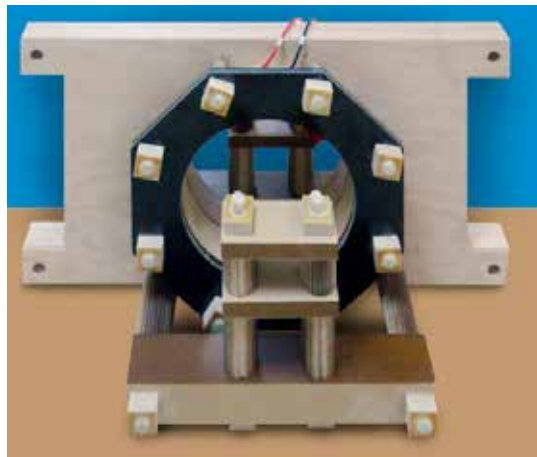
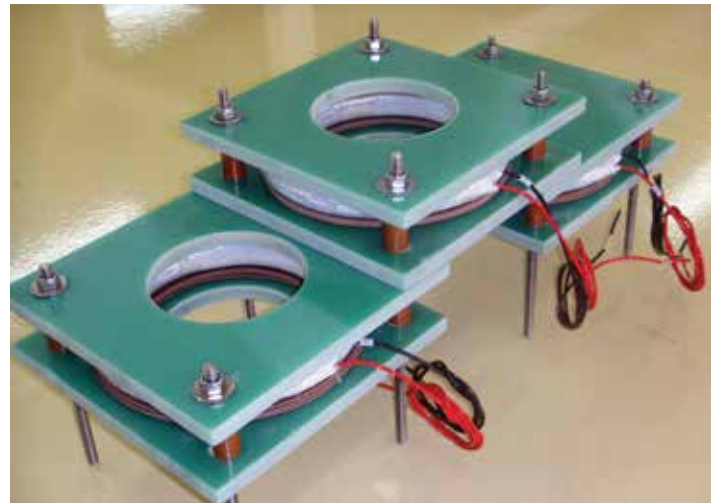
transformer oil like as main insulation of power transformers and they need to be dried during drying process of power transformers. Polyester based materials are preferred when the BCT will be fixed on turret and they do not need to be dried since the polyester based materials do not immerse moisture.



ASSEMBLED BCT

The BCTs can be designed and manufactured as a set in order for easy assembly and to reduce assembly cost of end-user. Various assembly materials can be used such as aluminium, transformer board, HGW and/or any other material customers request. The

assembled BCTs can be manufactured for each phase separately as well as a complete set for 3 phases. All metal parts used for fixing purposes are non-magnetic materials in order to avoid partial warming.



SEMI-FINISHED CURRENT TRANSFORMERS

MV AND HV SEMI-FINISHED CURRENT TRANSFORMERS

ENPAY Medium and High Voltage Semi-Finished Current Transformers are designed and manufactured according to ENPAY's own design or customer drawings. These Transformers are provided with suitable interlayer and outer insulation of polyester film. Internal insulation is made both conforming to their use in liquid or gas such as transformer oil, SF6, Silicon oil

etc. MV and HV current transformers can easily be designed in different dimensions up to 1200 mm outer diameter, 500 mm height and 500 kg weight of final product. Internal winding connections are made up with the latest technology allowing the lowest possible contact resistance together with the highest mechanical strength.



CT's for generators

GENERAL SPECIFICATIONS

STANDARDS: IEC 60044-1, IEC 60044-6, IEEE C 57.13, CAN3-C13-M83, AS 1675

PRIMARY CURRENT: Any requested value

SECONDARY CURRENT: 1A, 5A or any requested value

RATED BURDEN: Up to 200 VA

FREQUENCY: 50 Hz or 60 Hz

DESIGN: With Compensating Winding of without Compensation Winding

ACTIVE PARTS TEST LABORATORY

Active Parts Test Laboratory provides the tests for below products in climated condition by using conventional methods as an ISO/EN/IEC 17025 accredited test laboratory.

- LV, MV and HV Bushing Type Current Transformers without primary winding according to IEEE C57.13, IEC61869
- LV, MV and HV Switchgear Current Transformer without primary winding according to IEEE C57.13, IEC61869
- Magnetic Properties of Electrical Steel and Strip by means of Epstein Frame according to IEC60404-2
- Magnetic Properties of Electrical Steel and Strip by means of single sheet tester according to IEC60404-3^(*)
- Surface insulation resistance of magnetic sheet&strip according to IEC60404-11^(*)



All Routine tests for above products and mentioned in above standarts are in the scope of ENPAY Accreditation Certificate.

^(*)Out of scope

Conditions of Test Laboratory

Covered Area: 120m²

Temperature: 23 ±2C°

Relative Humidity: 45 ±10% Rh

ENPAY Active Parts Test Laboratory is able to perform the test on CTs not only at 50Hz and but also at 60Hz, within below limits for most important test.

- Accuracy test can be performed up to 9000 A at 200 VA, at 50 Hz and up to 7000 A at 200 VA at 60 Hz.
- Magnetization Curve test can be performed up to 9000 V at 50 Hz and up to 7000V at 60 Hz.

Measurement Quality of Active Parts Test Laboratory:

Well known measurement equipments are used and all test equipments are calibrated by accredited calibration companies according to defined calibration periods for each, but especially accuracy test system is calibrated by National Metrology Institute (UME) in Turkey. In the mean time all equipments are internally verified with certified samples such as current transformers certified by PTB and KEMA, magnetic steel sheet certified by PTB between two calibration period in order to assure measurement reliability.

Enpay performs the tests with below uncertainty for main tests:

Uncertainty for Current Transformers Accuracy Measurement;

R.E. (%)	Ph.Dis. (min)
±0,05	±3

Uncertainty for Magnetic Stell Sheet Measurement with Epstein Frame;

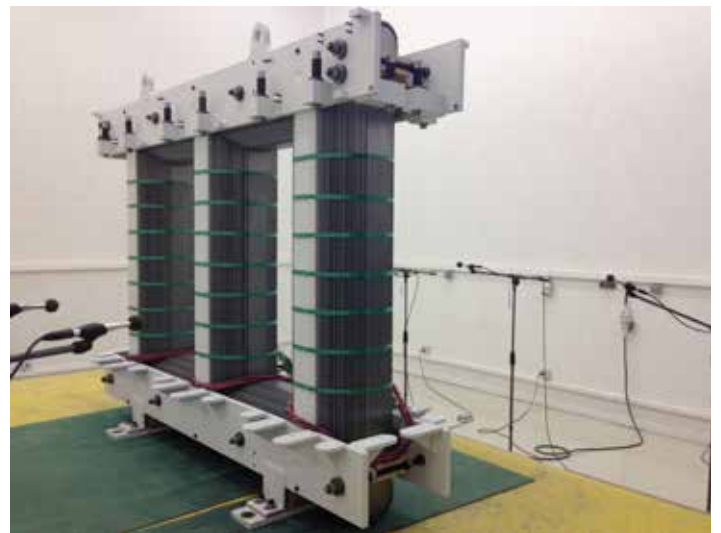
Iron Loss		Induction	
Bmax (mT)	Loss (W/kg)	Heff (A/m)	Induction (mT)
1000	±0,014803	3 A/m	±2,963
1300	±0,015903	13,5 A/m	±16,031
1500	±0,021825	30 A/m	±172,438
1700	±0,033278		
1900	±0,043365		

In order to prove our measurement quality, ENPAY Active Parts Test Laboratory participates to measurement comparison organizations organized by UME in Turkey.

Some of them are:

- Comparison of Measurement of Current Transformers for Accuracy Measurement at 2011.
- Comparison of Measurement of 10m Ω Current Shunt at 2013.
- Comparison of Measurement of Magnetic Steel Sheet at 2014.
- Comparison of Measurement of Current Transformers for Accuracy Measurement at 2016.
- Comparison of DC Resistance Measurement at 2017.

TRANSFORMER CORE NOISE TEST LABORATORY



No-load noise test on bare cores by sound pressure method according to IEC 60076-10.

- Background noise: approx. ~20 dBA
- Theoretical range of measurement: 28-125 dBA
- Noise test room inner dimensions: 8m x 6m x 4,5m

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