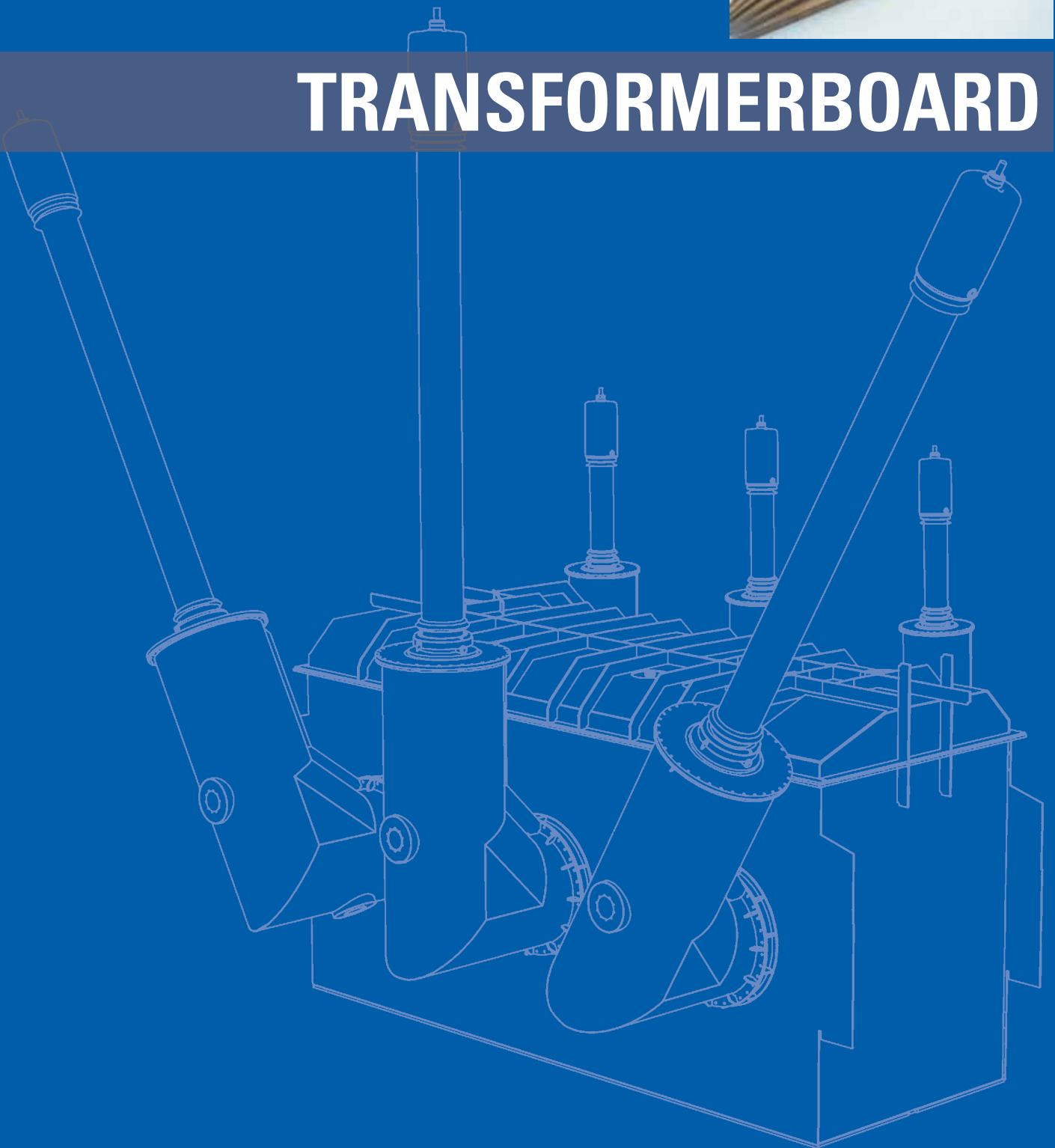




TRANSFORMERBOARD



CONTENTS



Kullar Plant



Transformerboard Factory

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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.

The total closed production area of the plants has reached 62,000 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 we ensure,

- customer satisfaction and preference
- profitable growth
- perpetuity
- shareholder's satisfaction and pride fulfillment of social obligations.

Through continuous improvement of processes we are 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.

ENPAY has been awarded with the ISO 9001 Quality Management System Certificate both from TÜV SÜD and TSE.

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.



STOCK PREPARATION & BOARD MACHINE



Board Machine

About ENBOARD's Cellulose

Cellulose Production technology is very important for Transformerboard.

ENPAY's mill has highly sophisticated distributed control systems, a continuous digester, and modern bleaching and screening systems. The pulp used is pure, free of dirt and has exceptionally low shive levels.

In the production of ENBOARD Unbleached electrical grade pulp is used in order to obtain a high level of cleanliness, low conductivity, extracted pH and ash content.

The sulphate pulps are in great strength and excellent mechanical and chemical purity.



Stock Preparation

TRANSFORMERBOARD - ENBOARD

ENBOARD is high-quality insulating precompressed pressboard made from cellulose, of high chemical purity and permanent heat stability.

ENBOARD is cellulose based and produced from kraft unbleached softwood pulp having high chemical purity and low conductivity. It is produced on an intermittent board machine and compacted without added bonding agents in multi day-light press under heat and pressure to achieve required properties. The boards are characterized by high density, high purity, uniform thickness, dimensional stability, low compressibility, low shrinkage and high electrical strength.

ENBOARD has high dielectric strength to be 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.

ENBOARD a hard and rigid board having high purity with excellent electrical and mechanical properties, is specifically produced for the high voltage and extra high voltage Transformer Industry. The product is made from imported virgin softwood sulphate pulp in our new production line using "state of art technology". Separate conditioning and testing facilities have been established for uninterrupted and speedy testing and effective evaluation of the raw materials and the product.

Hard rigid sheets are light brown in color.

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

ENBOARD E3 - IEC 60641-3-1 TYPE B.3.1

Hard and rigid material, used for strips, cylinders, spacers, plates, supports, the most represented material in transformer insulation, acc. IEC 60641

ENBOARD E4 - IEC 60641-3-1 TYPE B.4.1

Mouldable material, used for extremely curved pieces like tubes and molded pieces.



Lead Exits up to 1250 kV - BIL 2300 kV



Kits



Angle Ring and Cap Sectors



Snout-Chimney Sectors

TECHNICAL DATA SHEET

ENBOARD - ENPAY TRANSFORMERBOARD E3 IEC 60641-3-1 TYPE B.3.1

PROPERTIES	Unit	Min.-Max. Range	ENBOARD E3			
			≤1.6	>1.6 - 3.0	>3.0 - 6.0	>6.0
Thickness	[%]	[max]	±7.5	±5		
Density	[g/cm ³]	[range]	1.00 - 1.20	1.10 - 1.25	1.15 - 1.30	
Tensile Strength MD	[MPa]	[min]	130		145	
Tensile Strength CMD	[MPa]	[min]	95		105	
Elongation MD	[%]	[min]	4			
Elongation CMD	[%]	[min]	5			
Compressibility C	[%]	[max]	7.2	4.9	3.6	
Compressibility Crev	[%]	[min]	55	61	76	
Shrinkage MD	[%]	[max]	0.5			
Shrinkage CMD	[%]	[max]	0.6			
Shrinkage Thickness	[%]	[max]	5			
Plybond Resistance	[N/30 mm]	[min]	250			
Moisture Content	[%]	[max]	6			
Ash Content	[%]	[max]	0.4			
Conductivity	[mS/m]	[max]	2.0 - 9.0			
pH	[-]	[range]	6 - 9			
Oil Absorption	[%]	[min]	13	11	9	7
Electrical Strength in air	[kV/mm]	[min]	12			
Electrical Strength in oil	[kV/mm]	[min]	45	35		

ENBOARD E3 THICKNESS TOLERANCES

Thickness (mm)	Thickness Tolerances (%)
1.0	±7.5
1.5	±7.5
2.0	±5.0
2.5	±5.0
3.0	±5.0
3.5	±5.0
4.0	±5.0
5.0	±5.0
6.0	±5.0
7.0	±5.0
8.0	±5.0

ENBOARD - ENPAY TRANSFORMERBOARD E4

IEC 60641-3-1 TYPE B.4.1

PROPERTIES	Unit	Min.-Max. Range	ENBOARD E4	
			≤1.6	>1.6 - 3.0
Thickness	[%]	[max]	±7.5	±5
Density	[g/cm ³]	[range]	0.95 - 1.05	0.90 - 1.00
Tensile Strength MD	[MPa]	[min]	80	
Tensile Strength CMD	[MPa]	[min]	65	
Elongation MD	[%]	[min]	9.0 - 10.0	
Elongation CMD	[%]	[min]	9.5 - 10.5	
Shrinkage MD	[%]	[max]	0.7	
Shrinkage CMD	[%]	[max]	0.8	
Shrinkage Thickness	[%]	[max]	4	
Plybond Resistance	[N/30 mm]	[min]	250	
Moisture Content	[%]	[max]	8	
Ash Content	[%]	[max]	0.4	
Conductivity	[mS/m]	[max]	2 - 5	
pH	[-]	[range]	6 - 9	
Oil Absorption	[%]	[min]	35	
Electrical Strength in air	[kV/mm]	[min]	10	
Electrical Strength in oil	[kV/mm]	[min]	35	

ENBOARD E4 THICKNESS TOLERANCES

Thickness (mm)	Thickness Tolerances (%)
1.0	±7.5
1.5	±7.5
2.0	±5.0
2.5	±5.0
3.0	±5.0

ONLINE TESTING

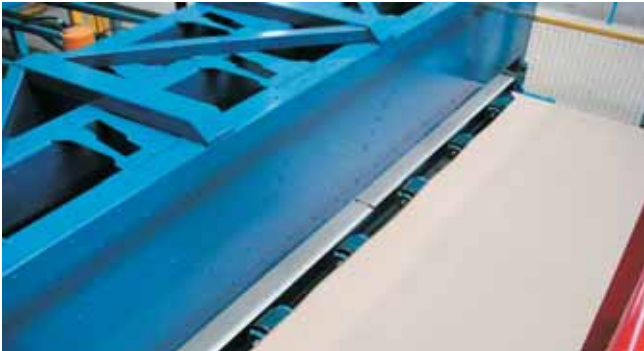
METAL DETECTORS

ENBOARD sheets go through metal detections in two stations:

1. Metal detections after the board machine
2. Metal detections after press



100% controlled Wet Material sheets



%100 controlled ENBOARD

- ENBOARD sheets are controlled by 100%.
- Metal Detector is used for inspection of ENBOARD in order to detect even the smallest magnetic and non-magnetic metal particles.
- Metal Detectors are highly-sensitive multi-segment sensor for inspection of Transformerboards with high processing speed and flat metal detector.

SURFACE INSPECTION CONTROL SYSTEM



Surface inspection is applied to 100% of ENBOARD sheets, which enable accurate statistics for optimizing the quality of ENBOARD. Surface inspection is applied to both sides of the boards.

THICKNESS MEASUREMENT



- ENBOARD thickness is continuously measured.
- ISO 9001 standard prescribes that the quality of manufactured goods has to be guaranteed and be documented.
- Statistical Process Control (SPC) is applied for thickness measurement.
- Any deviations are measured by conducting thickness measurement.

MOISTURE AND DENSITY MEASUREMENT



The continual availability of product properties allows for easy adjustment of the production process in order to ensure a high standard of product quality.

For the production of ENBOARD, the moisture content of the material used is important.

ELBC AND ELBP LAMINATED BOARD

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

ELBC and ELBP are produced from the boards with 3-4-5 mm thickness.

The densities of Laminated boards vary between 1.20 and 1.25 g/cm³. These boards are A class (105 °C) insulation materials. They are in pure cellulose color.

ELBC is produced according to IEC 60763-3-1 TYPE LB 3.1.1 standards. ELBP is produced according to IEC 60763-3-1 TYPE LB 3.1.2 standards.

ELBC water based casein glue with a good transformer oil permeability is used in the production of Laminated Boards.

ELBP has got the highest mechanical strength and polyester glue resin is used inside. Boards are glued with each other by strong pressing method.

Their thickness generally varies between 6 mm and 120 mm. They can be produced with the dimension of 3000x2000 or less. ELBC are used in the production of ring, shield ring, press ring, supported parts, cable carriers, etc. in distribution and power transformer.



PRESS RINGS

The Rings are made of ELBC or ELBP Laminated Pressboard according to IEC 60763. ELBC and ELBP laminated boards are produced by using high quality ENBOARD E3 Pressboard.



LABORATORY FACILITIES



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.



Rapid Köthen Sheet Former



FQA - Fiber Quality Analyzer

ENPAY Laboratory utilizes the most sensitive, comprehensive and the fastest measuring device suitable with the ISO 16065-1 standards in order to perform the Fiber Quality Analysis. With this device, the length and the width of the fibers can be measured.



Moreover curl index, kink index, shives and vessel elements analysis can also be performed. According to the results of these tests and analysis, the settings on ENBOARD production process are achieved to be done extremely accurate.

Furthermore, the tests playing critical role in the production of transformerboard such as conductivity, ph, ash content are also being carried out in Enpay Laboratory along with Fiber Quality Analysis.



PFI Mill



SR - Schopper Riegler Freeness Tester

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:

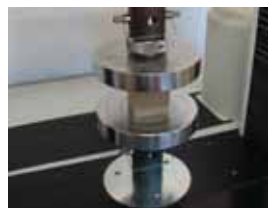
- average raw density
 - maximum raw density of the top layer
 - maximum raw density of bottom layer
 - actual position of sanding surface
- are shown in numerical form on the screen after the measuring process.



Universal Testing Machine
Max. Capacity: 50 kN



Tensile Strength and Elongation



Compressibility



Flexure Strength (3 Point Bending)



Laboratory Density and
Density Profile Measuring System

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 meter, degree of polymerization, water determination according to Karl Fischer, viscosity measurement according to Brookfield, ash content and determination of metallic particles are measured.



Necessary equipment for
Conductivity- pH Meter
according to IEC 60641



Degree of polymerization
according to IEC 60450



Water determination according
to Karl Fischer



Vacuum Oven

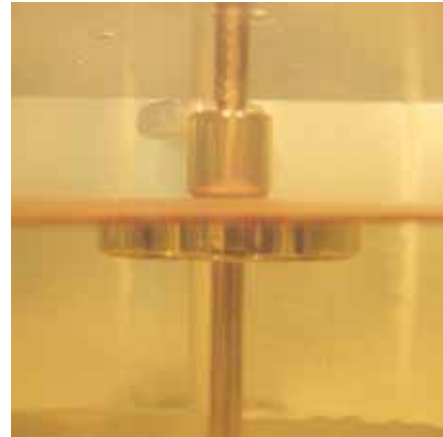


Brookfield
Viscosimeter

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



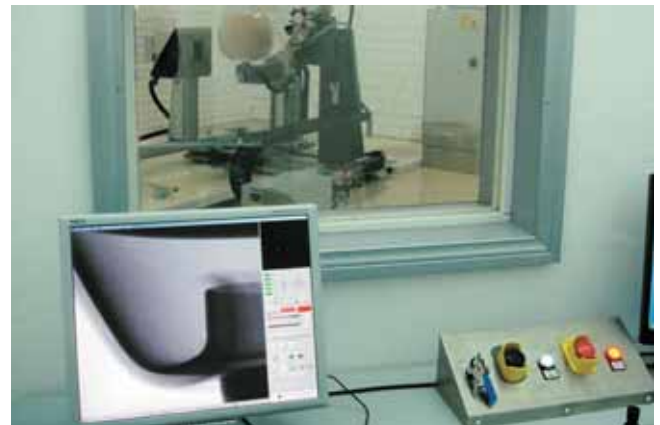
Electrodes System for Breakdown Test

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



- 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.

PROCESSING OF TRANSFORMERBOARD

SAWING

With a band saw

Cutting speed: Average 1,700 m/minute
Saw blade: Thickness ~1 mm, width 20 to 30 mm,
number of teeth 4 per 1"
(Figure 1, Figure 2)

Power requirement: 2 to 4 HP

With a circular saw

Cutting speed: Average 3500 m/minute
Saw blade: Blade diameter 150 to 500 mm,
number of teeth 48 to 128

Power requirement: 5 to 8 HP

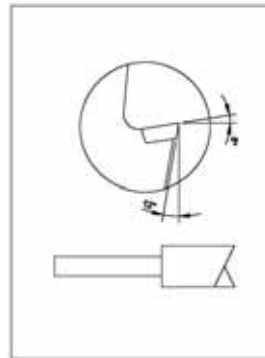


Figure 1

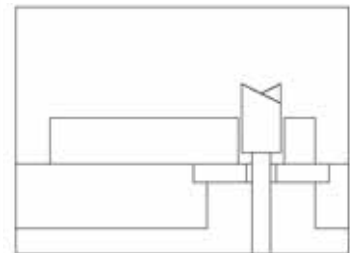


Figure 2

DRILLING

Hard metal tipped cutters that is suitable for wood should be used. Cycle and moving settings should be well-arranged.

MILLING AND ROUTING

Hard metal tipped cutters should be used.

GLUING

Use of casein glue is recommended, without heat application. It should be used as minimal as possible.

SANDING

All surfaces can be sanded with cylindrical or belt type sanders.

BENDING OF SHEETS

Use equipment designed for bending heavy cardboard. For all thicknesses, getting the material wet is recommended according to bending type.

PUNCHING

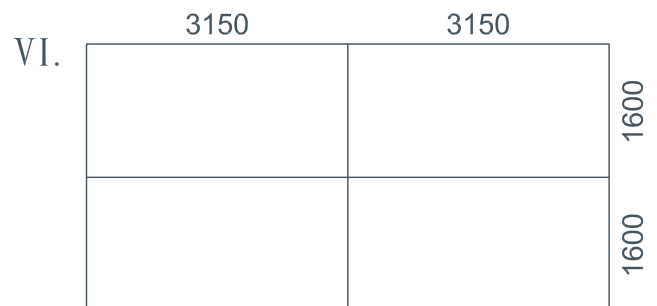
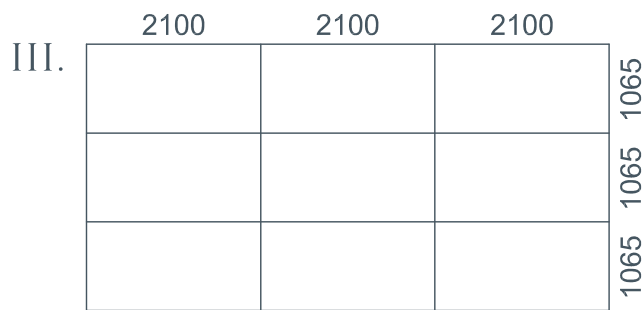
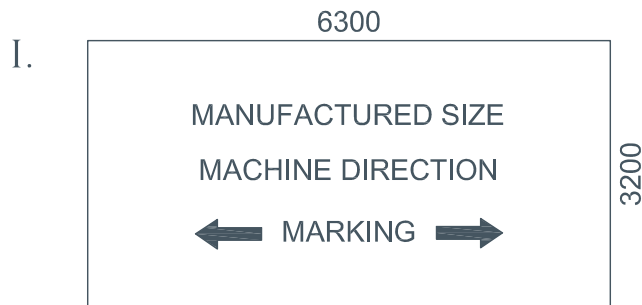
Steel rule dies or regular punching tools can be used up to a material thickness of 4 mm.

PLANING

Hard metal tipped cutters should be used.

SHEET SIZES

ENBOARD can be sized according to customer demands. There are some basic information such as Brand name, Date, ...etc. are printed in the direction of production line output on board.



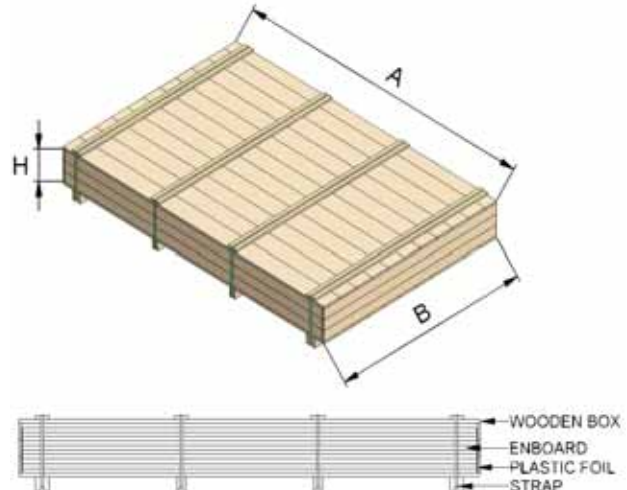
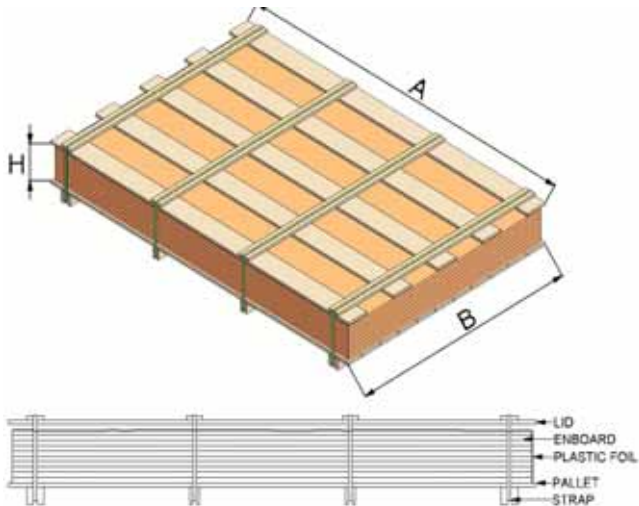
SHEET SIZES TOLERANCES

Standard Sheet Sizes (mm)	Tolerances (mm)
6300X3200	±50
4200X3200	±50
4200X1600	±50
3200X2100	±50
3150X1600	±50
2100X1600	±50
2100X1065	±50

PACKING AND TRANSPORT

PALLET WITH OR WITHOUT LID

BOX



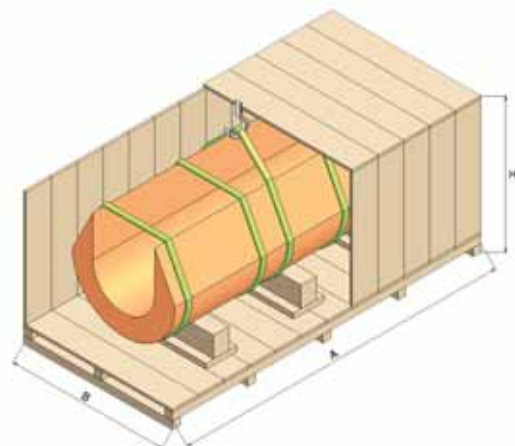
ENBOARD SHEET SIZES (mm)		PALLET - BOX GROSS SIZES (mm)		
		A	B	H*
4,200	1,600	4,250	1,650	200 - 400
3,200	2,100	3,250	2,150	200 - 400
3,150	1,600	3,200	1,650	200 - 400
2,100	1,600	2,150	1,650	200 - 400
2,100	1,065	2,150	1,115	200 - 400

H*: According to pallet weight.

U-FORMED PARCELS: The sheet in sizes of 6300x3200 mm are used in the packing.

ENBOARD SHEET SIZES (mm)		BOX GROSS SIZES (mm)	
		A	B
6300	3200	6400	Max.2300
4200	3200	4400	Max.2300

H: Maximum 2000 mm



DIRECTORY

ENPAY Endüstriyel Pazarlama ve Yatırım A.Ş.

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