Process
&
Capability Manual

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| Precoplat Präzisions Leiterplatten Technik GmbH mit Sitz in 47877 Willich |
| Registergericht: Amtsgericht Krefeld | Reg.-Nr.: HRB 1444 | USt-IdNr.: DE 120 156 920 |
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Nach DIN EN ISO 9001
Zertifikat-Nummer: 09011-2

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1 CHAPTER OVERVIEW

| Precoplat Präzisions Leiterplatten Technik GmbH mit Sitz in 47877 Willich |
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2 PRECOPLAT – A SHORT PROFILE

2.1 Who we are

Precoplat is one of the leading independent companies in the PCB industry of Germany, situated in Krefeld, a 25 min. drive away from the Duesseldorf International Airport. Constantly family owned, Precoplat`s dedicated staff grew slowly but steadily to 90 colleages - strongly attached to the industrial tradition of the Ruhr area. Powered by one of the most modern production facilities in a charming historical industrial complex of 297.000 sqf we are capable to produce more than 1 million sqf of PCB`s per year.

2.2 Objectives & markets

Our main business activity is focused on the production of Multilayer boards up to twelve layers and double sided PCBs. In the chapters below we provide you with the required in-house tolerance guidelines to ensure quality manufacturing of your printed circuit boards.

A very successful service we provide since the beginning of 2003 is our RAPID MASS PRODUCTION System (RMP) that is unrivaled in our industry. It is an express production service for middle and volume quantities. The main features are:

	RMP	normal cycle time
Standard* single/double sided boards	**3 days**	**~ 12 wd**
Standard* Multilayer boards	**4 days**	**~ 15 wd**

* Standard = 1 – 4 layer PCB in Hot Air Leveling Technology, soldermask, material FR 4, conventional drilling techniques, single sided silk screen printing. Additional time necessary if other features requested.

Further more our company is known for its intense partnership with our customers and an excellent service that starts with the technical support and ends up at the integration in our customer`s supply chain management. How we handle our customer's unique specifications or exceptions is what sets us apart.

2.3 Declaration of quality

Since we are not a broker, all of our boards are manufactured in our german facility with a broad range of advanced capabilities for high reliability, precision, and powerful PCB performance.

To achieve a maximum of quality we have to understand precisely the needs of our customers in order to transform them in products they really need. More than this: The results must be better than those of our competitors, therefore we are reaching for

- Superiority in technical and functional quality of the product
- Superiority in technical and economical support
- Superiority in delivery on time
- Superiority in the ability to produce with a maximum of efficiency and yield to offer our clients the most reasonable prices

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3 PRODUCTION DATA & TRANSMISSION

3.1 Production data requirements

Our professionally trained CAM engineers assure a seamless transition of your engineering data to the manufacturing floor. Following data formats could be supplied if you want to place an order

Extended Gerber 274X
Gerber (RS 274)
Barco DPF
ODB++

Mechanical drawings might be in HPGL or DXF format

Customer specifications – technical and commercial!

If you are unable to use an output file in the described data formats please contact our artwork department or sales engineer.

3.2 Data transmission

The most comfortable way to send your data is by Email. It is advisable to compress them as a „zip file“ (pkzip, arj, lharc or winzip are also accepted). It prevents information from getting lost. Make sure that your data are easily recognisable, i.e. put all data of one type in one zip file. To prevent the inclusion of viruses, do not use ‘self-extracting’ compression software. Before sending your E-mail, please indicate the name of the zip file in the message section. Do not forget to send your commercial order (indicating the zip file name) by E-mail or fax.

3.3 Design rule check

All CAD data supplied to us are checked using a standard design rule check and customized DFM-functions, which has been drawn up in accordance with the required IPC guidelines, our capability matrix and customer´s engineers. If you have any questions regarding this issue, please contact the head of our pre-production office, Mr. Vornholt. Should the CAD data prove not to be suitable for production, the person responsible for the data will be contacted by the pre-production engineer dealing with the order.

3.4 Order confirmation

After the clearance of all technical and commercial details, an order confirmation is sent to the customer. The order confirmation contains the following details (rough outline):

1. Basic technical data (dimensions of pcb; type of multilayer construction etc.)
2. Basic commercial data (ordered quantities; delivery time; pricing etc.)
3. Electrically tested or not electrically tested
4. Terms of delivey
5. Terms of payment.
6. Reference to our Terms of Trade in the Internet

When the order confirmation is completed, the preparation of the production process is finished and production will be started.

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4 QUALITY

4.1 Quality Standards

All boards are produced according to the standard IPC-A-600 Class 2 or class 3, if shown separately both in the procurement documents and in our order confirmation. Following standards are also in the range of our production capabilities:

PERFAG 1
PERFAG 2
PERFAG 3
IPC-SM-840
IPC-R-700
IPC-A-600
IPC-6012
IPC-2221

4.2 Quality procedures

Precoplat follows the standards of DIN/ISO 9001. Production parameters, conditions of production and raw materials are evaluated and registered by the use of calibrated measuring equipment.

non-destructive testing

Automatic and optical inspection routines follow the guidelines of IPC-A 600, class 2. Specific inspection procedures can be adapted to other specifications on demand.

destructive testing

Microsection to accertain plating precipitation and surface protection thickness
plating adhesion tests
Multilayer boards are submitted to regular and steady thermal shock tests

Documentation of parameters

- Production parameters
- time-stamps, involved staff members
- and quality linked results

are automatically documented and electronically recorded for at least 10 years.

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4.3 Electrical testing

The final test procedure of a PCB is the electrical testing to detect cuts and shorts. Our engineers generate a test programm defining a netlist of all start and ending points generated out of the gerber data of the customer. As a middle and high volume manufacturer we use a fixture testing system that simultaneously tests all nets against each other. The basic technology of fixture testing is, that conductive needles linked to the test machine are lead by a fixture to the test points of the PCB. The test result is then compared to the electrical netlist. A failure is detected if a net resistance is measured

- **bigger than 50 Ohm (cut)**
- **smaller 10 MOhm (short)**

Alternatively the electrical test can be performed by flying probe systems. Bare board testing involves using capacitance and resistance tests; each of our machines uses a combination of both.

Capacitance testing for a bare board involves testing for opens and shorts by "charging" a net or plane and then probing each net to measure the induced capacity. Inaccuracies occur with this method because of the inherent variability in producing circuit boards. However field measurement or field effect testing for shorts uses a very similar approach.

Resistance testing measures the resistance found in the net. As electric current flows through a conductor collisions between electrons and atoms interfere with the flow of the electrons. This is known as resistance and it's measured in ohms.

Rejected PCBs are separated, repaired and retested or finally rejected if repair is not feasible.

5 RANGE OF PRODUCTION FACILITIES

5.1 Laminates (base materials)

The following table includes the most common required laminates used in thicknesses from 0,50 mm to 3,2 mm. Further qualities are available on request, eg. CTI >400.

All properties available for material thickness above 0,5 mm

Designation	NEMA	IPC-4101	Tg C°	CTE < Tg ppm/K	CTE > Tg ppm/K	Decomposition Temperature C°	T260 min	T288 min	feature
epoxy-paper-glass	CEM1	10	100	-	-		-		
epoxy-glass	**FR4**	**21**	**135**	**70**	**270**	**310**	**20**	**3**	**standard**
epoxy-glass	FR4	24	150	70	270	310	20	3	higher Tg
epoxy-glass	FR4	94	150-200	70	270	310	20	3	low halogen
epoxy-glass	FR4	99	150	45	240	325	30	5	therm. Filler
epoxy-glass	FR4	124	150	45	230	325	30	5	therm. Filler

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Thicknesses of copper foils (before plating):

- **18 µ**
- **35 µ**
- **50 µ**
- **70 µ**
- **85 µ**
- **105 µ**

Copper Clad Laminates (*Multilayer core material thickness is exclusive copper thickness)

FR 4 in mm
0,10*
0,20*
0,25*
0,36*
0,41*
0,50*
0,71*
0,80
1,00
1,08*
1,55
2,00
2,40
3,00
FR 4 CTI > 400
1,00
1,55
CEM 1
1,00
1,55
CEM 3
1,55

If other materials are requested please contact our customer service.

Tolerances of bow and twist

Single Sided	Double Sided	Multilayer
1,5 %	1 %	1%

It has to be pointed out that the phenomenon of bow and twist strongly depends on the copper balance of the layout and/or build-up of a multilayer board. Especially if the PCB layout consists of unequally dispersed mass and line structures or the build-up of a multilayer is asymmetrical, twist and bow values within the mentioned tolerances are sometimes not feasible. In this case please contact our customer service to get advise.

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5.2 Available production panel sizes

With the objective in mind to handle as little different panel formats as possible (less machine set ups and stock costs) and to avoid material waste, we apply a continuous review of the most used panel sizes with regard to the degree of utilization.

	Single sided boards		Double sided boards		4-Layer boards Standard build-up MassLam		4-Layer with more than 6 Prepregs and 6-Layer to 24 Layer PinLam	
	Length	Width	Length	Width	Length	Width	Length	Width
Panel size 1	**618**	**512**	**614**	**512**	**614**	**512**	**600**	**499**
Panel size 2	**not available**		**584**	**512**	**584**	**512**	**not available**	
Panel size 3	**584**	**436**	**not available**		**not available**		**not available**	

Panel thickness

We accept a range of different board thicknesses irrespective of the number of layers. But be aware of the fact that due to the „exotic“ character of different thicknesses some of them need a longer lead time as they are not always on stock.

	Standard (mm)	Special (mm)	Technical limit single & double sided boards	Technical limit Multilayer
Max. panel thickness	1,55	2,4	3,2	3,2
Min. panel thickness	1,55	0,8	0,4	0,4

Maximum number of layers

Our multilayer production line is designed to manufacture up to 24 layers. The most applied build-ups are highlighted on our web-side in the topic „Technologies & Processes“.

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5.3 Drilling

If different or tighter tolerances are required, please contact our customer service.

Plated Through Holes	Standard	Special	Technical limit
Min. drill size	0,35 mm	0,15 mm	0,10 mm
Max. drilled hole size	6,40 mm	6,40 mm	6,40 mm
Min. spacing drill edge to drill edge*	0,20 mm	0,15 mm*	0,075 mm
Min. spacing drill edge to track/Pad outer layer*	0,20 mm	0,15 mm	0,075 mm
Min. spacing drill edge to track/Pad inner layer*	0,25 mm	0,20 mm*	0,10 mm
Surface Hot Air Leveling Finished size <= 6,4 mm tolerance	+0,10/- 0,05 mm	+0,09/- 0,06 mm	+0,08/- 0,05 mm
Finished size > 6,4 mm routing tolerance	+ 0,14/-0,05 mm	+ 0,10/-0,05 mm	+0,08/- 0,05 mm
Surface OSP or immersion Sn/Au/Ag Finished size <= 6,4 mm tolerance	+ 0,10 mm	+0,05/- 0,05 mm	+ 0,10 mm
Finished size > 6,4 mm routing tolerance	+ 0,12/-0,02 mm	+0,06/- 0,06 mm	+ 0,10 mm

*Please consider that a plated through hole should be drilled with an oversize of 150 µ to compensate the plating within the hole. E.g. if you wish a finished plated through hole size of 0,6 mm, the applied drill tool is 0,75 mm, unless otherwise tolerated.

Not Plated Through Holes	Standard	Special	Technical limit
Min. drill size	0,40 mm	0,20 mm	0,15 mm
Max. drilled hole size	6,40 mm	6,40 mm	6,40 mm
Min. spacing drill edge to drill edge**	0,20 mm	0,15 mm	0,10 mm
Min. spacing drill edge to track/Pad outer layer	0,20 mm	0,15 mm	0,05 mm
Min. spacing drill edge to track/Pad inner layer	0,25 mm	0,20 mm	0,10 mm
Finished size <= 2,0 mm tolerance	+/- 0,05 mm	+/- 0,03 mm	+/- 0,03 mm
Finished size <= 6,4 mm tolerance	+ 0,1/-0,05 mm	+/- 0,05 mm	+/- 0,03 mm
Finished size > 6,4 mm routing tolerance	+ 0,1/-0,05 mm	+/- 0,06 mm	+/- 0,04 mm

**depending on drill size

Offset PTH to NPTH	+/- 0,20 mm	+/-0,07 mm***	0,05 mm***

***Provided that the drilling process is performed in one mashine set up (tenting)

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5.4 Plating and aspect ratio

The thickness of copper plating is a result of exposure time and amperage in the electrolytic plating process. Basically a deposit thickness of 20 to 25 µ of copper are plated during the process on surface and in hole. Plating of thicker copper is possible for e.g. if the board needs to meet IPC class 3.

Copper clad laminate	Electrolytic copper plating	Final copper thickness
18 µ	ca. 20 µ	ca. 35 µ
35 µ	ca. 20 µ	ca. 55 µ
50 µ	ca. 20 µ	ca. 70 µ
70 µ	ca. 20 µ	ca. 90 µ
85 µ	ca. 20 µ	ca. 105 µ
105 µ	ca. 20 µ	ca. 125 µ

The capability of the electrolytic plating process is expressed in aspect ratio = maximum aspect ratio of board thickness/smallest drilled hole diameter that can be plated.

Standard	Special	technical limit
6	8	10

5.5 Exposure

Our technical range of line structuring theoretically reaches the level of 50 µ track width due to collimated light exposure systems. But with regard to the restrictions of material quality and the copper balance of the PCB-design we have to distinguish three levels of capability: Standard, special and technical limit

5.5.1 final copper thickness 18 µ

	Standard (µ)		Special (µ)		Technical limit (µ)	
	Outer layer / Inner Layer		Outer layer / Inner Layer		Outer layer / Inner Layer	
Track width	130	130	100	100	60	80
Track to track spacing	120	120	85	85	50	60
Annular ring	150	180	100	120	50	75

5.5.2 final copper thickness 35 µ

	Standard (µ)		Special (µ)		Technical limit (µ)	
	Outer layer / Inner Layer		Outer layer / Inner Layer		Outer layer / Inner Layer	
Track width	150	150	125	125	100	100
Track to track spacing	170	170	140	150	100	115
Annular ring	200	225	150	170	100	130

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5.5.3 final copper thickness 70 µ

	Standard (µ)		Special (µ)		Technical limit (µ)	
	Outer layer / Inner Layer		Outer layer / Inner Layer		Outer layer / Inner Layer	
Track width	200	200	150	150	120	130
Track to track spacing	250	300	200	250	180	220
Annular ring	250	300	200	250	150	150

5.5.4 final copper thickness 105 µ

	Standard (µ)		Special (µ)		Technical limit (µ)	
	Outer layer / Inner Layer		Outer layer / Inner Layer		Outer layer / Inner Layer	
Track width	300	300	250	250	180	180
Track to track spacing	360	360	280	280	250	250
Annular ring	300	300	250	250	200	200

5.5.5 final copper thickness 140 µ

	Standard (µ)		Special (µ)		Technical limit (µ)	
	Outer layer / Inner Layer		Outer layer / Inner Layer		Outer layer / Inner Layer	
Track width	350	350	300	300	250	250
Track to track spacing	400	400	360	360	320	320
Annular ring	350	350	300	300	250	250

5.6 Soldermask (values refer only to green solder mask)

	Standard (µ)	Special (µ)	Technical limit (µ)
Annular oversize of Pads	70	50	30
Minimum (mask) dam width	80	60	50
Min. SMD to SMD spacing*	200	170	150

* Minimum spacing between Pads or SMD`s required to print a solder mask bridge

5.7 Metallic finishing techniques

	Thickness	characteristics
Electrolytic copper	20µ - 30µ	depends on exposure time
Hot air leveling	2µ – 30µ	leadfree
Electrolytic nickel/gold*	1µ – 3µ gold	up to 8µ nickel
Immersion nickel/ (flash) gold*	0,05µ – 0,1µ gold	up to 8µ nickel
Immersion nickel/ (bond) gold*	0,3µ gold	up to 8µ nickel
Immersion chemical tin*	1µ	very high planarity
Organic surface protection (OSP)	organic coating of copper	ENTEK PLUS Cu - 106

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5.8 Text printing, additional printing techniques

Silk screen printing

	Standard µ	Special µ	Technical limit µ
Silk screen to Pads spacing	300	250	200
Silk screen to PTH spacing	300	250	200
Line width	200	175	140
Minimum size of letters	1250	1000	800

Carbon key pad printing

	Standard (µ)	Special (µ)	Technical limit (µ)
Track to track spacing	500	350	300
Minimum track width	700	600	500

Peelable mask

	Standard	Special	Technical limit
Max diameter of covered holes	1,8 mm	2,0 mm	2,6*mm
Thickness of peelable mask	300µ	400µ	500µ

*coverage cannot be guaranteed

5.9 Contour machining

Outerline-Contouring is performed by routing or V-cutting.

These techniques allow contouring within the standard „DIN 7168 mittel“ (medium accuracy) and „fein“ (precise accuracy). Dependant on the size of the board following tolerances are given:

Board size:			fine	standard
0,5 mm	up to	6 mm	+/- 0,05 mm	+/- 0,10 mm
6 mm	up to	30 mm	+/- 0,10 mm	+/- 0,20 mm
30 mm	up to	120 mm	+/- 0,15 mm	+/- 0,30 mm
120 mm	up to	400 mm	+/- 0,20 mm	+/- 0,50 mm
400 mm	up to	1000 mm	+/- 0,30 mm	+/- 0,80 mm
1000 mm	up to	2000 mm	+/- 0,50 mm	+/- 1,20 mm

5.10 Offset drilling and routing

As a result of separate machine set-ups and the given Coefficient of Thermal Expansion (CTE) of the laminate a certain offset from the PTH-drill to the NPTH-drill or routing is inevitably, since the material has been exposed several times to thermal procedures like solder mask thermal curing, HAL etc.

	Standard µ	Special µ	Technical limit µ
Offset PTH-drill to contouring*	+/- 200	+/- 130	+/- 50
Offset layout to contouring	+/- 200	+/- 130	+/- 50

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5.11 V-cutting (scoring)

Regarding V-cutting the same dimension tolerances are to be considered as for routing. Please pay attention to the fact that a certain circuit-free space depending on material thickness must be available around the outlines.

E.g. using material of 1,5 mm thickness by considering a dimension tolerance of +/- 0,2 mm tracks/pads etc. must have a spacing around the outlines of 0,40 mm. If the dimension tolerance is required to be without plus values the applied minus tolerance has to be added to the respective circuit-free spacing.

Material Thickness	circuit-free spacing at the outlines
up to 1,00 mm	0,45 mm
1,10 mm to 1,60 mm	0,50 mm
1,70 mm to 2,00 mm	0,70 mm
2,10 mm to 2,50 mm	0,80 mm
2,60 mm to 3,20 mm	1,00 mm

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