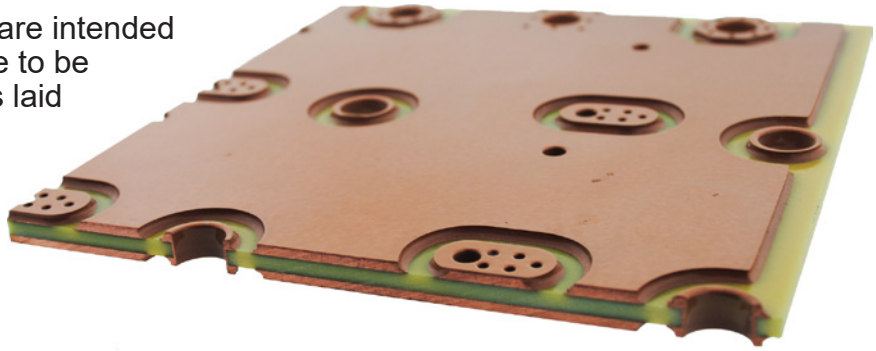
EXTREME COPPER PRINTED CIRCUIT BOARDS

The special requirements for the design of Heavy Copper printed circuit boards, EXTREME Copper printed circuit boards and PowerLink printed circuit boards and other forms of component mounting and interconnecting structures incorporating copper weights ≤ 3oz/ft^2. Some sections of this standard are guidelines ONLY, and are noted as such.

The requirements contained in this standard are intended to establish design recommendations that are to be used in conjunction with the design principles laid out in IPC-2221, IPC-2222.

This standard's intended use is by printed circuit board designers who incorporate copper weights ≥ 3oz/ft^2 into their products.



GENERAL DESIGN CONSIDERATIONS

The general parameters to be considered before and during the design of any printed circuit board, but focuses on boards incorporating copper weights ≥ 3oz/ft2. The following parameters can and will have a major impact on reliability and performance of the end product. Epec believes the parameters listed in this section are a MINIMUM to be considered. A comprehensive listing of all parameters and their design/ performance tradeoffs is shown in IPC-2221.

IPC DEFINITIONS

IPC-T-50
Terms & Definitions for Interconnecting & Packaging Electronic Circuits

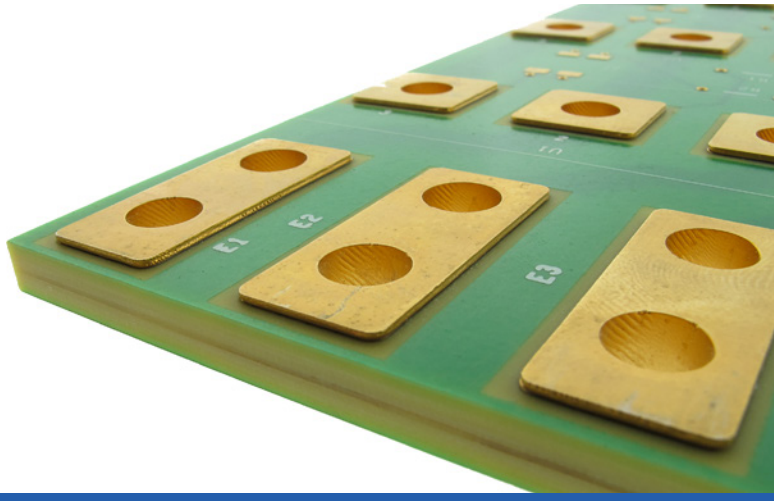
IPC-SM-840
Qualification and Performance of Permanent Solder Mask

IPC-2221
Generic Standard on Printed Board Design

IPC-6011
Generic Performance Specification for Printed Boards

IPC-6012
Qualification and Performance Specification for Rigid Printed Boards

IPC-4101
Specification for Base Materials for Rigid Board & Multi-layer Printed Boards



END-PRODUCT REQUIREMENTS

The end product requirements must be known before design start-up. Servicing and maintenance of the end product can directly influence conductor routing, part placement, board size, markings, coatings and final finish.

PERFORMANCE CONSIDERATIONS

Finished printed circuit boards manufactured by Epec meet or exceed the performance requirements of IPC-6011. There are three general end product performance classes that IPC-6011 has established. Class 1 is “general electronic products”, Class 2 is “dedicated service electronic products” and Class 3 is “high reliability electronic products”. Please see IPC-6011 or IPC-2221 for more information on the 3 classes. Epec requires all products to be class specified and any exceptions or additions to the specifications to be clearly indicated on the master drawings.

MATERIAL TYPE & PROPERTIES

There are several material choices available to the designer, ranging from standard printed circuit board epoxy resins to advanced dielectrics with specialized properties. There are a number of properties the designer must consider, including but not limited to; temperature (soldering and operating), electrical properties, structural strength, flame resistance, machine ability, CTE, thermal conductivity and thermal stability. Laminate materials should be selected from materials listed in IPC-4101.

It is important to note that for high current designs the temperature rise due to current flow in the conductor, when added to all other sources of heat at the conductor/laminate interface, do not exceed the maximum operating temperature specified for the laminate or the assembly. See IPC-2222 for maximum operating temperature for laminate materials. Materials used (prepreg, copper-clad, copper foil, heatsink, etc.) and minimum dielectric thickness/spacing must be specified on the master drawing.

INSPECTION & TRACEABILITY

All products manufactured by Epec are subject to in-process inspections and final inspections in accordance with the performance class specified on the master drawings. Quality assurance evaluations on finished product normally consist of the following: material, conformance inspections and process control evaluations. Test specimens (coupons) are used as representatives of the printed circuit boards fabricated on the same panel. Coupons are used for most destructive quality evaluations and evaluations that require a specific design that doesn’t exist on the printed circuit board.

Epec uses coupons on each panel processed for process control evaluation purposes. Layer to layer registration, copper thickness on each layer and in plated through holes, plating adhesion, solderability, soldermask thickness and soldermask adhesion are some of the process parameters evaluated.

Material quality assurance is based on statistical sampling normally performed by the material manufacturer. All material that becomes part of the finished product is certified to be in accordance with the master drawing and/or procurement documentation. Conformance evaluations required by the end user must be outlined on the master drawing. The master drawing must include a configuration of the coupon to undergo conformance evaluation.

When feasible, coupons are located in the center of each panel to best reflect plating characteristics. All coupons (whether for conformance or process control evaluations) are identified by board part number, revision, lot number, logo, and date code.

FINAL FINISHES

HASL (Hot Air Solder Leveling)
Dipped in a bath of molten solder to cover all bare copper. Excess solder is removed with hot air knifes as it is drawn out of the bath.

Hard Gold
Electroplated gold (nickel/cobalt hardener) over electroplated nickel. Primarily used for edge board contacts.

ENIG (Electroless Nickel Immersion Gold)
Immersion (chemically applied) pure gold over electroless nickel (also chemically applied. Primarily used for wire bonding or to prevent oxidation of the underlying plating.

OSP
Immersion process. Clear, thin organic solderability protective coating (OSP) that protects the underlying plating from oxidation. Useful where flatness is required on surface mount lands. When OPS coatings are used, solderability retention and storage life must be agreed to and documented.

Immersion Tin
Immersion Tin (chemically applied) (90% to 95%) with the balance being Bismuth over bare copper. Primarily Used for a cost effective RoHS Compliant finish, which is also, REVERSE compatible with lead based systems.

Immersion Silver
Immersion Pure Silver (chemically applied) over bare copper. Primarily used as an RoHS compliant finish where Tin & ENIG may not be desirable.

ELECTRICAL TESTING

There are several types of bare board electrical testing. Continuity/discontinuity (testing for opens or shorts), insulation resistance (assures sufficient conductor spacing), dielectric withstanding voltage (assures sufficient dielectric thickness), conductor resistance (assures correct conductor cross-sectional area) and capacitance (assures correct dielectric thickness) are some of the electrical tests available. Epec performs all bare board testing according to IPC-9252. Some electrical testing (such as conductor resistance) is difficult to perform and is normally only performed on certain customer specified conductors that have a tight operational range.

BOARD SIZE & TYPE

There is a limit to the size of board that can be produced. This limitation is mainly due to equipment factors. Epec uses several different panel sizes in order to maximize manufacturability and minimize costs. The panel size used depends on a number of factors including: circuit complexity, pallet size or board size, number of layers, copper weight, and process parameters. The engineering department of Epec chooses the production panel size during contract review.

Designs using copper weights ≥ 3oz/ft2 will be subject to these requirements due to the nature of the production processes involved and the impact these requirements have on the end product's performance and reliability.

APPROXIMATE CURRENT FOR GIVEN TRACK DIMENSIONS (5°C TEMP RISE)

		Track Width (inch)								
Cu weight (oz/ft2)	Thickness (inch)	0.0625	0.1250	0.2500	0.5000	1.0000	2.0000	4.0000	8.0000	16.0000
1	0.0014	2.6	4.2	6.6	10.6	16.9	27.0	43.0	68.6	109.3
2	0.0028	4.2	6.6	10.6	16.9	27.0	43.0	68.6	109.3	174.3
4	0.0056	6.6	10.6	16.9	27.0	43.0	68.6	109.3	174.3	278.0
6	0.0084	8.7	13.9	22.2	35.4	56.5	90.1	143.6	229.0	365.2
8	0.0112	10.6	16.9	27.0	43.0	68.6	109.3	174.3	278.0	443.3
10	0.0140	12.3	19.6	31.3	50.0	79.7	127.0	202.6	323.0	515.1
12	0.0168	13.9	22.2	35.4	56.5	90.1	143.6	229.0	365.2	582.4
14	0.0196	15.5	24.6	39.3	62.7	99.9	159.3	254.1	405.2	646.1
16	0.0224	16.9	27.0	43.0	68.6	109.3	174.3	278.0	443.3	706.9
18	0.0252	18.3	29.2	46.5	74.2	118.3	188.7	300.9	479.9	765.2
20	0.0280	19.6	31.3	50.0	79.7	127.0	202.6	323.0	515.1	821.4
24	0.0336	22.2	35.4	56.5	90.1	143.6	229.0	365.2	582.4	928.7
28	0.0392	24.6	39.3	62.7	99.9	159.3	254.1	405.2	646.1	1030.3
32	0.0448	27.0	43.0	68.6	109.3	174.3	278.0	443.3	706.9	1127.2
36	0.0504	29.2	46.5	74.2	118.3	188.7	300.9	479.9	765.2	1220.2
40	0.0560	31.3	50.0	79.7	127.0	202.6	323.0	515.1	821.4	1309.9
45	0.0630	33.9	54.1	86.2	137.5	219.3	349.7	557.6	889.2	1418.0
50	0.0700	36.4	58.1	92.6	147.6	235.4	375.4	598.6	954.6	1522.2
55	0.0770	38.8	61.9	98.7	157.4	251.0	400.3	638.3	1017.8	1623.1
60	0.0840		65.6	104.7	166.9	266.2	424.4	676.8	1079.2	1721.0
70	0.0980		72.8	116.1	185.2	295.3	470.8	750.8	1197.3	1909.2
80	0.1120		79.7	127.0	202.6	323.0	515.1	821.4	1309.9	2088.7
90	0.1260		86.2	137.5	219.3	349.7	557.6	889.2	1418.0	2261.1
100	0.1400		92.6	147.6	235.4	375.4	598.6	954.6	1522.2	2427.3
120	0.1680			166.9	266.2	424.4	676.8	1079.2	1721.0	2744.3
140	0.1960			185.2	295.3	470.8	750.8	1197.3	1909.2	3044.3
160	0.2240			202.6	323.0	515.1	821.4	1309.9	2088.7	3330.7
180	0.2520			219.3	349.7	557.6	889.2	1418.0	2261.1	3605.5
200	0.2800			235.4	375.4	598.6	954.6	1522.2	2427.3	3870.6

**Based on IPC calculation for external track: I = .0647 * DT^(.4281) * (W * Th)^(.6732)*
Where I = amps, DT = temp rise (celsius), W = track width (in mils), Th = track thickness (in mils)

APPROXIMATE CURRENT FOR GIVEN TRACK DIMENSIONS (10°C TEMP RISE)

		Track Width (inch)								
Cu weight (oz/ft2)	Thickness (inch)	0.0625	0.1250	0.2500	0.5000	1.0000	2.0000	4.0000	8.0000	16.0000
1	0.0014	3.5	5.6	8.9	14.3	22.7	36.3	57.8	92.2	147.1
2	0.0028	5.6	8.9	14.3	22.7	36.3	57.8	92.2	147.1	234.6
4	0.0056	8.9	14.3	22.7	36.3	57.8	92.2	147.1	234.6	374.0
6	0.0084	11.8	18.7	29.9	47.7	76.0	121.2	193.3	308.2	491.4
8	0.0112	14.3	22.7	36.3	57.8	92.2	147.1	234.6	374.0	596.4
10	0.0140	16.6	26.4	42.2	67.2	107.2	170.9	272.6	434.6	693.1
12	0.0168	18.7	29.9	47.7	76.0	121.2	193.3	308.2	491.4	783.6
14	0.0196	20.8	33.2	52.9	84.3	134.4	214.4	341.9	545.1	869.3
16	0.0224	22.7	36.3	57.8	92.2	147.1	234.6	374.0	596.4	951.1
18	0.0252	24.6	39.3	62.6	99.9	159.2	253.9	404.9	645.6	1029.5
20	0.0280	26.4	42.2	67.2	107.2	170.9	272.6	434.6	693.1	1105.2
24	0.0336	29.9	47.7	76.0	121.2	193.3	308.2	491.4	783.6	1249.5
28	0.0392	33.2	52.9	84.3	134.4	214.4	341.9	545.1	869.3	1386.2
32	0.0448	36.3	57.8	92.2	147.1	234.6	374.0	596.4	951.1	1516.6
36	0.0504	39.3	62.6	99.9	159.2	253.9	404.9	645.6	1029.5	1641.7
40	0.0560	42.2	67.2	107.2	170.9	272.6	434.6	693.1	1105.2	1762.4
45	0.0630	45.6	72.8	116.0	185.0	295.1	470.5	750.3	1196.4	1907.8
50	0.0700	49.0	78.1	124.6	198.6	316.8	505.1	805.4	1284.4	2048.0
55	0.0770	52.2	83.3	132.8	211.8	337.7	538.6	858.8	1369.5	2183.8
60	0.0840		88.3	140.8	224.6	358.1	571.1	910.6	1452.1	2315.5
70	0.0980		98.0	156.2	249.1	397.3	633.5	1010.2	1610.9	2568.7
80	0.1120		107.2	170.9	272.6	434.6	693.1	1105.2	1762.4	2810.3
90	0.1260		116.0	185.0	295.1	470.5	750.3	1196.4	1907.8	3042.2
100	0.1400		124.6	198.6	316.8	505.1	805.4	1284.4	2048.0	3265.8
120	0.1680			224.6	358.1	571.1	910.6	1452.1	2315.5	3692.3
140	0.1960			249.1	397.3	633.5	1010.2	1610.9	2568.7	4096.0
160	0.2240			272.6	434.6	693.1	1105.2	1762.4	2810.3	4481.3
180	0.2520			295.1	470.5	750.3	1196.4	1907.8	3042.2	4851.1
200	0.2800			316.8	505.1	805.4	1284.4	2048.0	3265.8	5207.7

**Based on IPC calculation for external track: I = .0647 * DT^(.4281) * (W * Th)^(.6732)*
Where I = amps, DT = temp rise (celsius), W = track width (in mils), Th = track thickness (in mils)

APPROXIMATE CURRENT FOR GIVEN TRACK DIMENSIONS (20°C TEMP RISE)

		Track Width (inch)								
Cu weight (oz/ft2)	Thickness (inch)	0.0625	0.1250	0.2500	0.5000	1.0000	2.0000	4.0000	8.0000	16.0000
1	0.0014	4.7	7.5	12.0	19.2	30.6	48.8	77.8	124.1	197.9
2	0.0028	7.5	12.0	19.2	30.6	48.8	77.8	124.1	197.9	315.6
4	0.0056	12.0	19.2	30.6	48.8	77.8	124.1	197.9	315.6	503.2
6	0.0084	15.8	25.2	40.2	64.1	102.3	163.1	260.0	414.6	661.2
8	0.0112	19.2	30.6	48.8	77.8	124.1	197.9	315.6	503.2	802.5
10	0.0140	22.3	35.6	56.7	90.4	144.2	230.0	366.7	584.8	932.5
12	0.0168	25.2	40.2	64.1	102.3	163.1	260.0	414.6	661.2	1054.3
14	0.0196	28.0	44.6	71.1	113.4	180.9	288.5	460.0	733.5	1169.6
16	0.0224	30.6	48.8	77.8	124.1	197.9	315.6	503.2	802.5	1279.6
18	0.0252	33.1	52.8	84.3	134.4	214.2	341.6	544.8	868.7	1385.2
20	0.0280	35.6	56.7	90.4	144.2	230.0	366.7	584.8	932.5	1487.0
24	0.0336	40.2	64.1	102.3	163.1	260.0	414.6	661.2	1054.3	1681.2
28	0.0392	44.6	71.1	113.4	180.9	288.5	460.0	733.5	1169.6	1865.0
32	0.0448	48.8	77.8	124.1	197.9	315.6	503.2	802.5	1279.6	2040.5
36	0.0504	52.8	84.3	134.4	214.2	341.6	544.8	868.7	1385.2	2208.8
40	0.0560	56.7	90.4	144.2	230.0	366.7	584.8	932.5	1487.0	2371.2
45	0.0630	61.4	97.9	156.1	249.0	397.0	633.1	1009.5	1609.7	2566.9
50	0.0700	65.9	105.1	167.6	267.3	426.2	679.6	1083.7	1728.0	2755.6
55	0.0770	70.3	112.1	178.7	285.0	454.4	724.6	1155.5	1842.6	2938.2
60	0.0840		118.8	189.5	302.2	481.8	768.3	1225.2	1953.7	3115.4
70	0.0980		131.8	210.2	335.2	534.5	852.4	1359.2	2167.3	3456.1
80	0.1120		144.2	230.0	366.7	584.8	932.5	1487.0	2371.2	3781.1
90	0.1260		156.1	249.0	397.0	633.1	1009.5	1609.7	2566.9	4093.2
100	0.1400		167.6	267.3	426.2	679.6	1083.7	1728.0	2755.6	4394.0
120	0.1680			302.2	481.8	768.3	1225.2	1953.7	3115.4	4967.8
140	0.1960			335.2	534.5	852.4	1359.2	2167.3	3456.1	5511.1
160	0.2240			366.7	584.8	932.5	1487.0	2371.2	3781.1	6029.4
180	0.2520			397.0	633.1	1009.5	1609.7	2566.9	4093.2	6527.0
200	0.2800			426.2	679.6	1083.7	1728.0	2755.6	4394.0	7006.7

**Based on IPC calculation for external track: I = .0647 * DT^(.4281) * (W * Th)^(.6732)*
Where I = amps, DT = temp rise (celsius), W = track width (in mils), Th = track thickness (in mils)

APPROXIMATE CURRENT FOR GIVEN TRACK DIMENSIONS (30°C TEMP RISE)

		Track Width (inch)								
Cu weight (oz/ft2)	Thickness (inch)	0.0625	0.1250	0.2500	0.5000	1.0000	2.0000	4.0000	8.0000	16.0000
1	0.0014	5.6	9.0	14.3	22.8	36.4	58.1	92.6	147.6	235.4
2	0.0028	9.0	14.3	22.8	36.4	58.1	92.6	147.6	235.4	375.4
4	0.0056	14.3	22.8	36.4	58.1	92.6	147.6	235.4	375.4	598.6
6	0.0084	18.8	30.0	47.8	76.3	121.6	194.0	309.3	493.2	786.5
8	0.0112	22.8	36.4	58.1	92.6	147.6	235.4	375.4	598.6	954.6
10	0.0140	26.5	42.3	67.5	107.6	171.6	273.6	436.3	695.7	1109.3
12	0.0168	30.0	47.8	76.3	121.6	194.0	309.3	493.2	786.5	1254.2
14	0.0196	33.3	53.1	84.6	134.9	215.2	343.1	547.2	872.5	1391.3
16	0.0224	36.4	58.1	92.6	147.6	235.4	375.4	598.6	954.6	1522.2
18	0.0252	39.4	62.9	100.2	159.8	254.8	406.4	648.0	1033.3	1647.8
20	0.0280	42.3	67.5	107.6	171.6	273.6	436.3	695.7	1109.3	1768.9
24	0.0336	47.8	76.3	121.6	194.0	309.3	493.2	786.5	1254.2	1999.9
28	0.0392	53.1	84.6	134.9	215.2	343.1	547.2	872.5	1391.3	2218.6
32	0.0448	58.1	92.6	147.6	235.4	375.4	598.6	954.6	1522.2	2427.2
36	0.0504	62.9	100.2	159.8	254.8	406.4	648.0	1033.3	1647.8	2627.5
40	0.0560	67.5	107.6	171.6	273.6	436.3	695.7	1109.3	1768.9	2820.7
45	0.0630	73.0	116.5	185.7	296.2	472.3	753.1	1200.8	1914.9	3053.4
50	0.0700	78.4	125.0	199.4	317.9	507.0	808.4	1289.1	2055.6	3277.9
55	0.0770	83.6	133.3	212.6	339.0	540.6	862.0	1374.5	2191.8	3495.1
60	0.0840		141.4	225.4	359.4	573.2	914.0	1457.4	2324.0	3705.9
70	0.0980		156.8	250.1	398.7	635.8	1013.9	1616.8	2578.2	4111.2
80	0.1120		171.6	273.6	436.3	695.7	1109.3	1768.9	2820.7	4497.9
90	0.1260		185.7	296.2	472.3	753.1	1200.8	1914.9	3053.4	4869.0
100	0.1400		199.4	317.9	507.0	808.4	1289.1	2055.6	3277.9	5226.9
120	0.1680			359.4	573.2	914.0	1457.4	2324.0	3705.9	5909.5
140	0.1960			398.7	635.8	1013.9	1616.8	2578.2	4111.2	6555.7
160	0.2240			436.3	695.7	1109.3	1768.9	2820.7	4497.9	7172.3
180	0.2520			472.3	753.1	1200.8	1914.9	3053.4	4869.0	7764.2
200	0.2800			507.0	808.4	1289.1	2055.6	3277.9	5226.9	8334.9

**Based on IPC calculation for external track: I = .0647 * DT^(.4281) * (W * Th)^(.6732)*
Where I = amps, DT = temp rise (celsius), W = track width (in mils), Th = track thickness (in mils)

RECOMMENDED MINIMUM TRACE WIDTH AND SPACING

Total Required Copper Weight (oz/ft2)																														
	0.25			0.5			1			2			3			4			5			6			7			8		
Starting Foil Copper Weight (oz/ft2)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
0.25	5	5	0.4	5	5	1	5	5	1.4	5	5	2.8	6	5	4.2	8	6	5.6	10	8	7.0	12	9	8.4	14	10	9.8	16	12	11.2
0.5	-	-	-	5	5	1	5	5	1.4	5	5	2.8	6	5	4.2	8	7	5.6	10	8	7.0	12	9	8.4	14	11	9.8	16	12	11.2
1	-	-	-	-	-	-	5	6	1.4	5	6	2.8	6	6	4.2	8	7	5.6	10	9	7.0	12	10	8.4	14	11	9.8	16	13	11.2
2	-	-	-	-	-	-	-	-	-	5	8	2.8	6	8	4.2	8	7	5.6	10	10	7.0	12	11	8.4	14	13	9.8	16	14	11.2
3	-	-	-	-	-	-	-	-	-	-	-	-	6	10	4.2	8	9	5.6	10	10	7.0	12	13	8.4	14	14	9.8	16	15	11.2
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	10	5.6	10	11	7.0	12	12	8.4	14	15	9.8	16	17	11.2
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	12	7.0	12	13	8.4	14	14	9.8	16	18	11.2
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	14	8.4	14	15	9.8	16	16	11.2
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	17	9.8	16	18	11.2
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	19	11.2
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A - Minimum Conductor Width (mils)
B - Minimum Conductor Spacing (mils)
C - Finished Conductor Thickness (mils)

Epec's Recommended Minimum Conductor Width/Spacing for Copper Weights up to 26oz/ft2
Consult Epec for Designs Requiring Copper Weights Greater Than 26 oz/ft2
Consult Epec for Designs Requiring Smaller Conductor Width or Space

RECOMMENDED MINIMUM TRACE WIDTH AND SPACING

Total Required Copper Weight (oz/ft2)																					
	10			11			12			13			14			15			16		
Starting Foil Copper Weight (oz/ft2)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
0.25	20	14	14.0	22	16	15.4	24	17	16.8	26	19	18.2	28	20	19.6	30	21	21.0	32	23	22.4
0.5	20	15	14.0	22	16	15.4	24	18	16.8	26	19	18.2	28	20	19.6	30	22	21.0	32	23	22.4
1	20	15	14.0	22	17	15.4	24	18	16.8	26	20	18.2	28	21	19.6	30	22	21.0	32	24	22.4
2	20	17	14.0	22	18	15.4	24	20	16.8	26	21	18.2	28	22	19.6	30	24	21.0	32	25	22.4
3	20	18	14.0	22	20	15.4	24	21	16.8	26	22	18.2	28	24	19.6	30	25	21.0	32	27	22.4
4	20	20	14.0	22	21	15.4	24	22	16.8	26	24	18.2	28	25	19.6	30	27	21.0	32	28	22.4
5	20	21	14.0	22	22	15.4	24	24	16.8	26	25	18.2	28	27	19.6	30	28	21.0	32	29	22.4
6	20	22	14.0	22	24	15.4	24	25	16.8	26	27	18.2	28	28	19.6	30	29	21.0	32	31	22.4
7	20	24	14.0	22	25	15.4	24	27	16.8	26	28	18.2	28	29	19.6	30	31	21.0	32	32	22.4
8	20	21	14.0	22	27	15.4	24	28	16.8	26	29	18.2	28	31	19.6	30	32	21.0	32	34	22.4
10	20	24	14.0	22	25	15.4	24	26	16.8	26	32	18.2	28	34	19.6	30	35	21.0	32	36	22.4
12	-	-	-	-	-	-	24	29	16.8	26	30	18.2	28	31	19.6	30	38	21.0	32	39	22.4
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	36	21.0	32	37	22.4
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A - Minimum Conductor Width (mils)
B - Minimum Conductor Spacing (mils)
C - Finished Conductor Thickness (mils)

Epec's Recommended Minimum Conductor Width/Spacing for Copper Weights up to 26oz/ft2
Consult Epec for Designs Requiring Copper Weights Greater Than 26 oz/ft2
Consult Epec for Designs Requiring Smaller Conductor Width or Space

RECOMMENDED MINIMUM TRACE WIDTH AND SPACING

Total Required Copper Weight (oz/ft2)															
	17			18			19			20			21		
Starting Foil Copper Weight (oz/ft2)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
0.25	34	24	23.8	36	26	25.2	38	27	26.6	40	28	28.0	42	30	29.4
0.5	34	25	23.8	36	26	25.2	38	27	26.6	40	29	28.0	42	30	29.4
1	34	25	23.8	36	27	25.2	38	28	26.6	40	29	28.0	42	31	29.4
2	34	27	23.8	36	28	25.2	38	29	26.6	40	31	28.0	42	32	29.4
3	34	28	23.8	36	29	25.2	38	31	26.6	40	32	28.0	42	34	29.4
4	34	29	23.8	36	31	25.2	38	32	26.6	40	34	28.0	42	35	29.4
5	34	31	23.8	36	32	25.2	38	34	26.6	40	35	28.0	42	36	29.4
6	34	32	23.8	36	34	25.2	38	35	26.6	40	36	28.0	42	38	29.4
7	34	34	23.8	36	35	25.2	38	36	26.6	40	38	28.0	42	39	29.4
8	34	35	23.8	36	36	25.2	38	38	26.6	40	39	28.0	42	41	29.4
10	34	38	23.8	36	39	25.2	38	41	26.6	40	42	28.0	42	43	29.4
12	34	41	23.8	36	42	25.2	38	43	26.6	40	45	28.0	42	46	29.4
15	34	38	23.8	36	46	25.2	38	48	26.6	40	49	28.0	42	50	29.4
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A - Minimum Conductor Width (mils)
B - Minimum Conductor Spacing (mils)
C - Finished Conductor Thickness (mils)

Epec's Recommended Minimum Conductor Width/Spacing for Copper Weights up to 26oz/ft2
Consult Epec for Designs Requiring Copper Weights Greater Than 26 oz/ft2
Consult Epec for Designs Requiring Smaller Conductor Width or Space

RECOMMENDED MINIMUM TRACE WIDTH AND SPACING

Total Required Copper Weight (oz/ft2)															
	22			23			24			25			26		
Starting Foil Copper Weight (oz/ft2)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
0.25	44	31	30.8	46	33	32.2	48	34	33.6	50	35	35.0	52	37	36.4
0.5	44	32	30.8	46	33	32.2	48	34	33.6	50	36	35.0	52	37	36.4
1	44	32	30.8	46	34	32.2	48	35	33.6	50	36	35.0	52	38	36.4
2	44	34	30.8	46	35	32.2	48	36	33.6	50	38	35.0	52	39	36.4
3	44	35	30.8	46	36	32.2	48	38	33.6	50	39	35.0	52	41	36.4
4	44	36	30.8	46	38	32.2	48	39	33.6	50	41	35.0	52	42	36.4
5	44	38	30.8	46	39	32.2	48	41	33.6	50	42	35.0	52	43	36.4
6	44	39	30.8	46	41	32.2	48	42	33.6	50	43	35.0	52	45	36.4
7	44	41	30.8	46	42	32.2	48	43	33.6	50	45	35.0	52	46	36.4
8	44	42	30.8	46	43	32.2	48	45	33.6	50	46	35.0	52	48	36.4
10	44	45	30.8	46	46	32.2	48	48	33.6	50	49	35.0	52	50	36.4
12	44	48	30.8	46	49	32.2	48	50	33.6	50	52	35.0	52	53	36.4
15	44	52	30.8	46	53	32.2	48	55	33.6	50	56	35.0	52	57	36.4
22	44	53	30.8	46	54	32.2	48	55	33.6	50	66	35.0	52	67	36.4

A - Minimum Conductor Width (mils)
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DOCUMENTATION & FILE FORMATS

Documentation packages should consist of a master drawing and copies of the artwork masters. The package may be provided in either hard copy or electronic data. The layout should always be drawn as viewed from the primary side of the board. All drawings and electronic files should be identified with the board part number and revision status. Notes are especially important for the engineering review; outlining non-standard tolerances, plating requirements, board stack-up, and inspection criteria.

Epec prefers that all master artwork be sent in Gerber RS-274X (with embedded apertures) electronic file format. Alternatively, we also work with ODB++ files. Please contact us with any special electronic file requirements. All other electronic data (drawings, specifications, assembly part lists, etc.) may be sent in a variety of file formats although some (such as DXF and PDF) are preferred.

BOARD STACK-UP

A cross-sectional build diagram showing dielectric thicknesses and copper thicknesses is called a board stack-up. The board stack-up should be included on the master drawing along with any special build requirements. Note that the board stack-up must include a nominal value with tolerances for each separation and copper thickness. A minimum value may be used alternatively. The total board thickness tolerance is a cumulative total of all internal tolerances. In certain situations where a component or mounting point has a specific thickness requirement different than the rest of the board, please note it in the engineering notes on the master drawing.

HOLES & INTERCONNECTIONS

All lands (conductor pads) and annular rings should be maximized whenever possible provided that good design practice and all electrical spacing requirements are met. Class 3 designs incorporating copper weights ≥ 3 oz/ft2 must strive for the “ideal” pad diameter since this class of product doesn’t allow for breakouts.

The performance specifications for Class 1 and Class 2 may allow for partial breakouts (see IPC-6011). Circular pads are most common, but it should be noted that other pad shapes could be used to increase spacing and therefore producability. Fillets, keyholing, and corner entry pad shapes may be used provided breakout is allowed.

The thickness of copper in the barrel of the plated through hole and the thickness of copper on the external surface will not be the same in most cases.

The copper plating in the holes will be the same as the additional plating required to bring the base foil to the final copper weight. The minimum copper thickness in the barrel of a plated through hole is 0.0008”.

Epec allows for a copper thickness of 0.0020” in the barrel as a standard, although any thickness is achievable. Note any minimum PTH copper thickness requirement on the master drawing.