PCL-FR-370HR

The processing guidelines contained in this document were developed through in-house testing and field experience. However, they should be considered to be starting points that will require further adjustment. Read the following review of processes for applicability to your particular Printed Wiring Board fabrication environment. Remember that the suggestions contained herein can't account for all possible board designs or processing environments. Additional adjustments by the fabricator will be necessary. Isola can and will assist with this process, but the fabricator, not Isola, is ultimately responsible for their process and the end results. Fabricators should verify that PWB's made using these suggestions meet all applicable quality and performance requirements.

Part 1: Prepreg Storage and Handling

Isola Group's prepreg bonding sheets for use in multilayer printed circuit board applications are manufactured to specifications that include physical and electrical properties and processing characteristics relative to the laminating application. Handling and storage factors have an important influence on the desired performance of the prepreg. Some parameters are affected by the environment in which prepregs are stored. They can also deteriorate over extended periods of storage. The prepreg received by the customer is a glass fabric that has been impregnated with a stated quantity of low volatile, partially polymerized resin. The resin is tack-free but somewhat brittle. Many lamination problems arise from resin loss off the fabric due to careless handling. The fabric used is based on the order and supplies the required thickness. In most cases the amount of resin carried by the fabric increases as the fabric thickness decreases.

Handling Suggestions:

Handle all prepreg using clean gloves. Use sharp, precision equipment when cutting or paneling prepreg. Treat all prepreg as being very fragile. Use extreme care when handling very high resin content prepreg (glass fabrics 1080 and finer).

Storage Suggestions:

Upon receipt, all prepreg should be immediately moved from the receiving area to a controlled environment. All prepreg should be used as soon as possible. A FIFO (first-in-first-out) inventory management system should be used. If not handled properly, 370HR prepreg will absorb moisture, which will lead to depressed Tg's and cure and affect flow in the press. If extended storage is required, separate facilities should be reserved with appropriate environmental control.

Prepreg properties will be maintained for six months when stored at 41°F and for at least 3 months when stored at 68°F and below 50% relative humidity.

Prepreg packages should be allowed to equilibrate to layup room conditions before opening to prevent moisture condensation on the prepreg. Stabilization time will depend on storage temperature. In cases where storage temperature is significantly below room temperature, keep prepreg in package or plastic wrapping during stabilization period to prevent moisture condensation. Storage should be in the absence of catalytic environments such as high radiation levels or intense ultraviolet light.

Prepregs are sold to IPC-4101B specifications. After delivery to the customer, retesting services are available, but passing retest results do not constitute a re-certification. Prepregs will be tested at the original manufacturing site or at another appropriate site to be determined by Technical Service.

Part 2: Innerlayer Preparation

Isola Group's 370HR laminates are fully cured and ready for processing. It has been the experience of most fabricators that stress relief bake cycles are not effective in reducing any movement of high performance laminates such as 370HR. Therefore, it is suggested that the movement of unbaked laminate be characterized and the appropriate artwork compensation factors are used.

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Dimensional Stability

The net dimensional movement of laminate after the etch, oxide and lamination processes is typically shrinkage. This shrinkage is due to the relaxation of stresses that were induced when the laminate was pressed as well as shrinkage contribution from the resin system. Most of the movement will be observed in the grain direction of the laminate.

There are situations that have been known to alter the proportion of shrinkage in grain versus fill direction in some board shops. These include autoclave pressing and cross plying laminate grain direction to that of prepreg. While both of these practices have their advantages, material movement must be uniquely characterized.

Table 1 illustrates the suggested approach to characterizing laminate movement and provides approximate artwork compensation factors for 370HR laminate when using a hydraulic press.

Table1: Initial Artwork Compensation Factors

Base Thickness	Configuration	Direction	Comp (in/in)
≤ 0.005”	signal / signal	Warp (grain)	0.0007 – 0.0009
“	“	Fill	0.0001 - 0.0003
“	signal / ground	Warp (grain)	0.0005 - 0.0007
“	“	Fill	0.0001 - 0.0003
“	ground / ground	Warp (grain)	0.0002 - 0.0004
“	“	Fill	0.0000 - 0.0002
0.006-0.009	signal / signal	Warp (grain)	0.0005 – 0.0007
	“	Fill	0.0001 - 0.0003
	signal / ground	Warp (grain)	0.0003 - 0.0005
	“	Fill	0.0000 - 0.0002
	ground / ground	Warp (grain)	0.0000 - 0.0002
	“	Fill	0.0000 - 0.0002
0.010-0.014	signal / signal	Warp (grain)	0.0002 – 0.0004
	“	Fill	0.0000 - 0.0002
	signal / ground	Warp (grain)	0.0001 - 0.0003
	“	Fill	0.0000 - 0.0002
	ground / ground	Warp (grain)	0.0000 - 0.0002
	“	Fill	0.0000 - 0.0002

Table 1 is for reference only. This table assumes that laminate and prepreg grain directions are oriented along the same dimension. Each shop must characterize material behavior given their particular lamination cycles, border designs and grain orientation of laminate to prepreg. It is also suggested that specific laminate constructions be specified and adhered to so that dimensional variations due to changes in construction are avoided. **Table 1** assumes that signal layers are either half or 1 ounce copper and ground layers are either one or 2 ounce copper.

Imaging & Etching

370HR laminates are imaged using standard aqueous dry films and are compatible with both cupric chloride and ammoniacal etchants.

Bond Enhancement

Both reduced oxides and oxide alternative chemistries have been used successfully in fabricating 370HR multilayer boards to date. Make sure the oxide or oxide replacement coating exhibits a consistent, uniformly dark color.

If reduced oxides are used, consult the chemical supplier for post oxide baking considerations as excessive baking may lead to lower pink ring resistance. It is generally suggested that post-oxide baking be performed vertically, in racks. Suggest mild bake of oxided innerlayers (15-30 minutes @ 80 – 100 ^{o}C).

For conveyorized oxide replacements, an efficient dryer at the end of a conveyorized oxide replacement line should remove all moisture from the innerlayer surface. **However, drying of layers for 30 minutes minimum @ 100^{o}C or higher is considered a “best practice”, especially for boards to be subjected to “Lead-Free” processes. Baking in racks is preferred.**

Peel strengths may be slightly lower as compared to FR406 due to the higher modulus properties of the resin system.

The use of DSTFoil^{TM} will typically increase the bond strength by approximately 1 to 1.5 lbs as compared to non-DSTFoil copper foil.

If immersion tin adhesion treatments are used, the fabricator should test the coating to verify adequate bond strength is developed with 370HR prepregs.

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Standard Lamination

The 370HR prepreg materials achieve maximum fluidity at approximately 20°F lower temperatures as compared to standard FR-406 prepregs. Therefore, it is suggested that lamination press cycles with a delay kick over to high pressure (kiss cycle) be adjusted accordingly due to the lower melt and maximum fluidity temperatures. Additionally, vacuum assist lamination processes are suggested. Non-vacuum lamination processes should be reviewed by Isola technical service engineers prior to production implementation.

The amount of time at cure temperature, and to some extent the actual cure temperature of 370HR, will be determined by the thickness of the multilayer package being produced. Very thick boards will require a longer cure time to assure optimum material performance.

Sequential Lamination

Use a 70-75 minute cure for sub-assemblies depending on thickness and a **90 minute cure** for the final assembly. This suggestion assumes a final assembly thickness ≥ 0.125”.

Table 2 outlines general suggestions for lamination pressure based on press type used.

Table 2 – 370HR Lamination Pressure

LAMINATION METHOD	SUGGESTED PRESSURE RANGE
Hydraulic Pressing: **(without vacuum assist)**	**300 - 350 PSI** **(21.1 – 24.6 Kg/cm^2)** **(20.7 – 24.1 Bar)**
Hydraulic Pressing: **(with vacuum assist via vacuum frames or bags)**	**250 - 300 PSI** **(17.6 – 21.1 Kg/cm^2)** **(17.2 – 20.7 Bar)**
Hydraulic Pressing: **(vacuum enclosure)**	**200 - 250 PSI** **(14.1 – 17.6 Kg/cm^2)** **(13.8 – 17.2 Bar)**
Autoclave Pressing:	**150 - 175 PSI** **(10.6 – 12.3 Kg/cm^2)** **(10.3 – 12.1 Bar)**

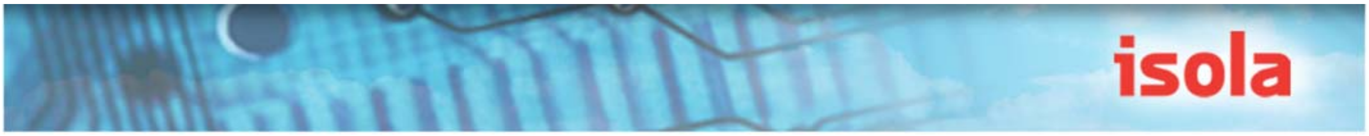
Removal of 370HR flash should be performed by routing rather than shearing to minimize crazing along the panel edges.

Single-Stage and Dual-Stage Press Cycle Lamination

The following 2 pages outline the suggested lamination parameters for the Single-Stage and Dual-Stage lamination cycles. The lamination cycle selected will be a function of board stackup, complexity and thickness as well as the lamination press’s capability. Note that the attached graphs are for reference purposes only and may require adjustment depending on the board size, thickness and complexity. Thicker boards may require additional dwell time at curing temperature to achieve full cure. See “Standard Lamination” above. Choosing a dual stage or “kiss” cycle for 370HR may improve results in some applications. Use these cycles to enhance the wetting of the glass along the extreme edges and corners of the panel or to minimize circuit image transfer (“telegraphing”) on foil constructions.

All cycles include a pressure reduction step in the lamination cycle, which facilitates stress relief of the package during the cure step. Further, all cycles assume vacuum is maintained throughout the heating cycle and all cycles presume that the book is cooled to a temperature well below the Tg of the material before the press is opened. All three conditions are considered to represent “best practice” conditions during lamination by Isola.

However, while use of both the pressure drop cycle and cooling well below Tg in the “hot” press are strongly suggested, they are considered to be “optional” and the PCB fabricator may have equipment or capacity limitations which prevent following these suggestions.



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Single-Stage Lamination (No “kiss” cycle):

1. Load/center the package as quickly as possible. **Pull vacuum for 20 minutes on lifters.**

2. Apply full pressure of 200-350 psi (14.1 – 24.6 kg/cm^2) on the panels. Suggest 275 PSI (19.3 kg/cm^2 or **19 Bar**) for initial pressure setting. See **Table 2**.

3. Adjust heat rise to approximately 8-12ºF/min (4.5-6.7ºC/min), as measured between 175°F (79ºC) to 275°F (135ºC) by controlling the platen ramp rate and/or by using the right amount of pressure padding. **Note: 370HR prepregs have slightly lower resin flow than standard FR406. Some board designs may require additional adjustments to ROR and/or pressure for better results**

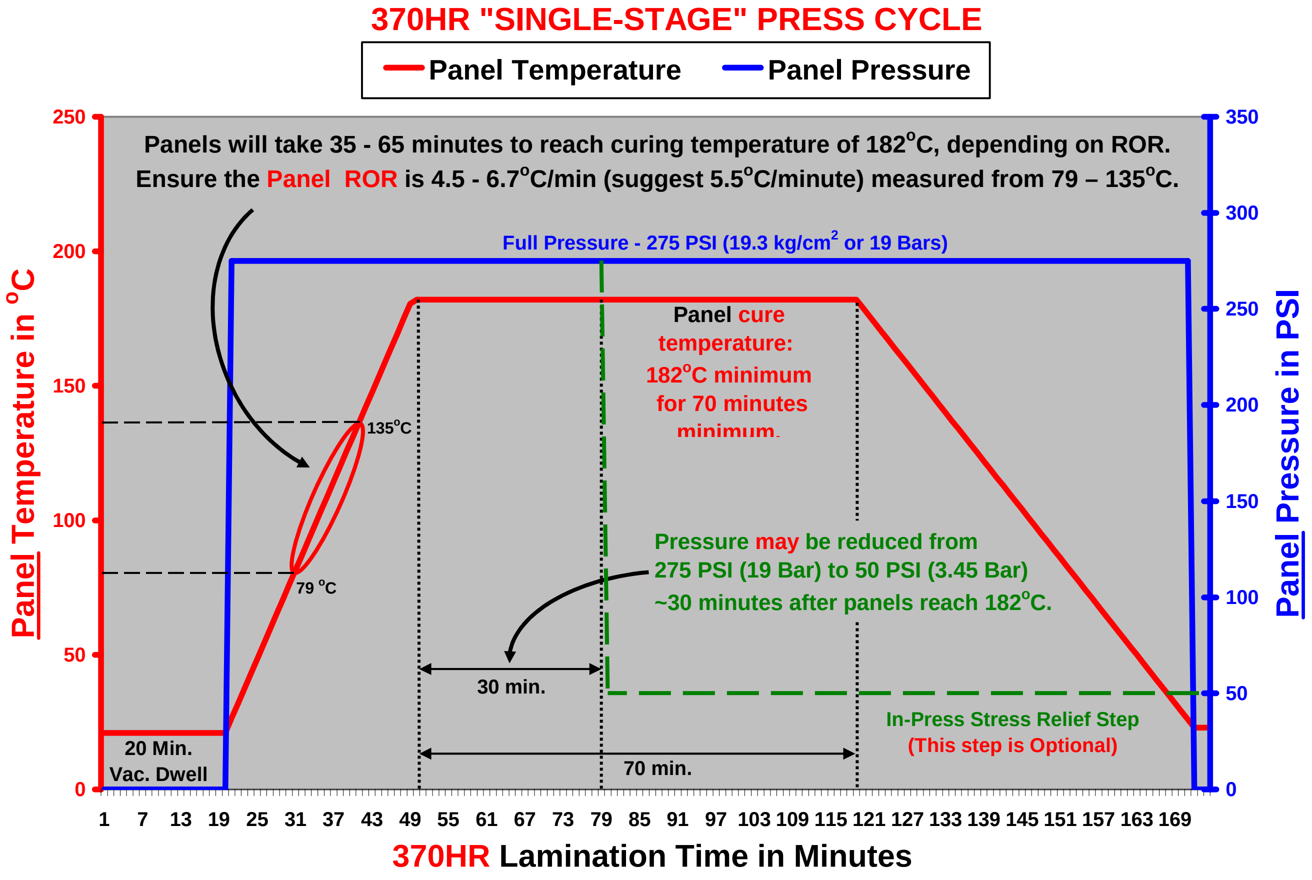
4. Cure for a minimum of 70 minutes @ 360 ^{o}F (182ºC) once the center of package reaches 360°F. **90 minute cures are appropriate for high layer count boards or boards exceeding 0.125” in thickness. Boards below 0.070” in thickness may be cured for 70 minutes.**

5. If possible, reduce the pressure to **50** psi (3.5 kg/cm^2) after package has been at cure temperature for 15 minutes. **This will relieve stress, which will assist subsequent Lead-Free processing.**

6. Cool material as slowly as possible or at 5ºF/minute (2.8^{o}C/minute) down from 360°F (185ºC) through 275°F (135ºC). Post baking is not required.

SUGGESTED 370HR SINGLE-STAGE PRESSURE-TEMPERATURE PROFILE

Please note: <u>This is not a press control program!</u> The graph represents the preferred pressure/temperature profile <u>panels</u> are subjected to during the lamination program cycle. Note that the actual high pressure setting chosen may differ from the 275 PSI suggested setting shown in this graph. Press pressure and cure duration selected may depend upon board design as well as other factors.



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Dual-Stage Lamination (with "kiss" cycle):

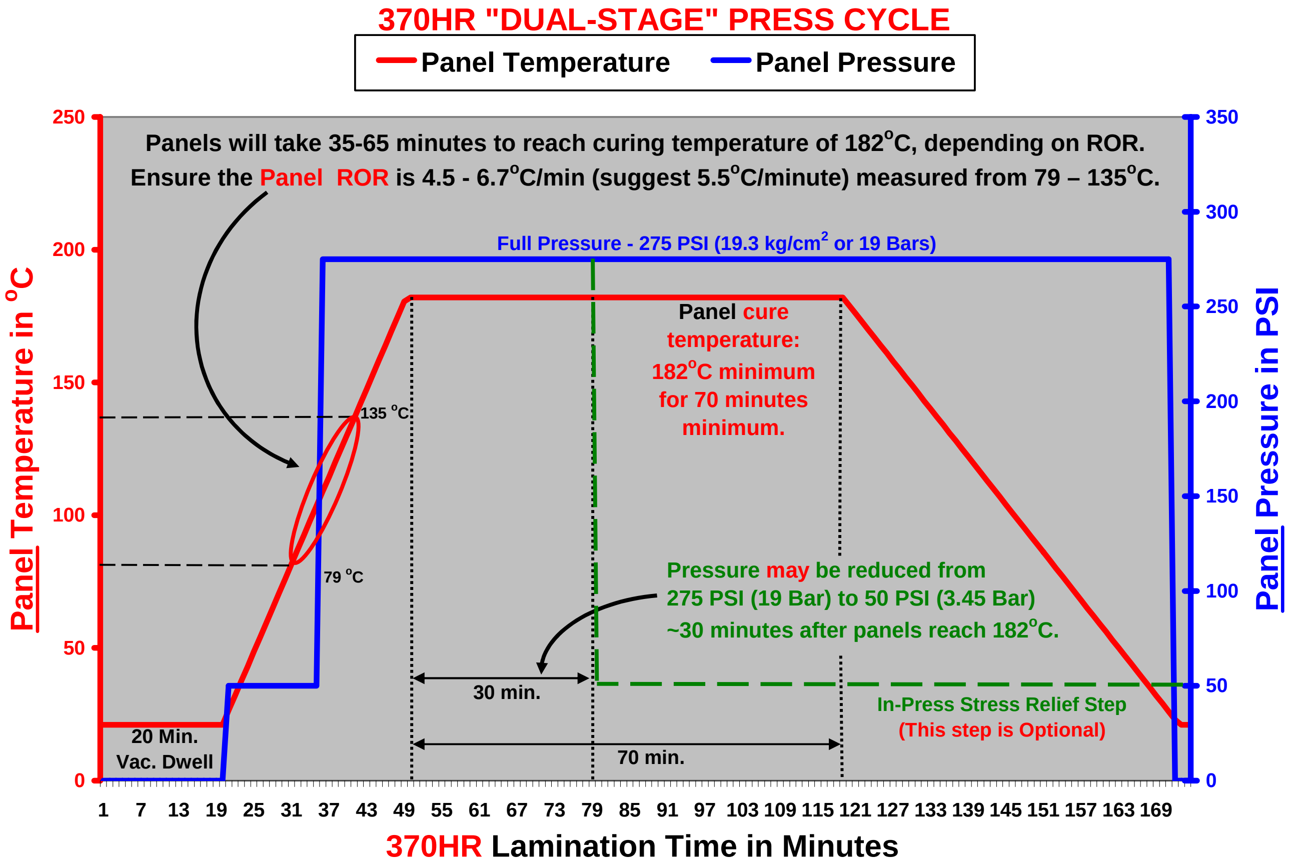
Choosing a dual-stage or "kiss" cycle for 370HR may improve results in some applications. Use these cycles to enhance the wetting of the glass along the extreme edges and corners of the panel or to minimize circuit image transfer ("telegraphing") on foil constructions.

Develop dual-stage cycles based on the temperature of the stack at various locations. It is essential that the temperatures of the top and bottom panels in the stack be below full fluidity temperature when high pressure is applied. **Ensure that the temperature difference between the center and outside of the stack is less than 40°F (22°C) when full pressure is applied.** **Also note that exterior (top and bottom) panel temperature must be ≤ 210°F when full pressure is applied.**

1. Load/center the package as quickly as possible. **Pull vacuum for 20 minutes on lifters.**
2. Close press and apply **50** psi pressure (3.5 kg/cm²). Adjust heat rise to approximately 8-12°F/min (4.5-6.7°C/min), as measured between 175°F (79°C) to 275°F (135°C) by controlling the platen ramp rate and/or by using the appropriate amount of pressure padding.
3. Apply full pressure of 200-350 psi (14.1 – 24.6 kg/cm2) on the panels when the center of the stack reaches 200°F (93°C). Suggest 275 PSI (19.3 kg/cm² or **19 Bar**) for initial pressure setting. See **Table 2**. Make sure the outer (top & bottom) panel temperature is ≤ 210°F (99°C) when full pressure is applied.
4. Cure for a minimum of 70 minutes @ 360 °F (182°C) once <u>center</u> of package reaches 360°F. **Note: A 90 minute cure may be necessary for boards ≥ 0.125" thick.**
5. Use stress relief & cooling cycles as with single-stage lamination. Post baking is not required.

SUGGESTED 370HR DUAL-STAGE PRESSURE-TEMPERATURE PROFILE

Please note: <u>This is not a press control program!</u> The graph represents the preferred pressure/temperature profile <u>panels</u> are subjected to during the lamination program cycle. Note that the actual high pressure setting chosen may differ from the 275 PSI suggested setting shown in this graph. Press pressure and cure duration selected may depend upon board design as well as other factors.



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Part 4: Drill

General

The 370HR material exhibits greater modulus properties as a result of the increased thermal stability of the resin system. During drilling, the debris formation with 370HR is different from FR406 materials. Due to the increased thermal decomposition properties of the resin system, the drill debris remains as free particles and will not impact the drill flute relief volumes.

To assure effective removal of the resin debris during drilling, undercut drill geometries and high helix tools are recommended. On high layer count technologies and thicker overall board thicknesses, peck drilling parameters may be necessary. Suggested parameters are outlined below for typical multilayer designs.

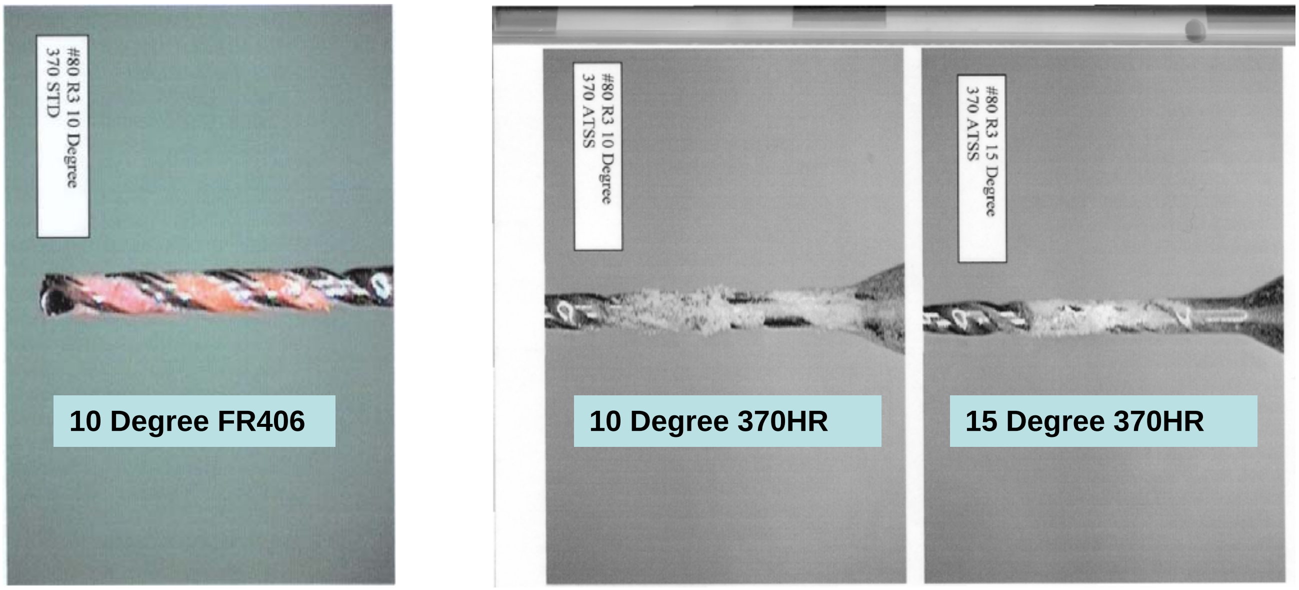
Cutting Speed & Chipload

The parameters in **Table 3** provide a moderate starting point for typical board designs. Thick boards with heavy copper or special cladding such as invar will require more conservative drill parameters.

Stack Height & Hit Count

Stack heights and hit counts will vary with the construction and overall thickness of the boards being drilled. Standard .060” thick boards have been successfully stacked 3 high for bit diameters down to 13.5 mils. As a general guideline, the sum of the board thickness in a multilayer drill stack should not exceed 200 mils. Maximum hit count for a small drill diameter is 1000. For drill diameters of 13.5 mils and greater, maximum hit count is 1500

The photos below illustrate 370HR drill debris as compared to standard FR406 drill debris.



10 Degree FR406 **10 Degree 370HR** **15 Degree 370HR**

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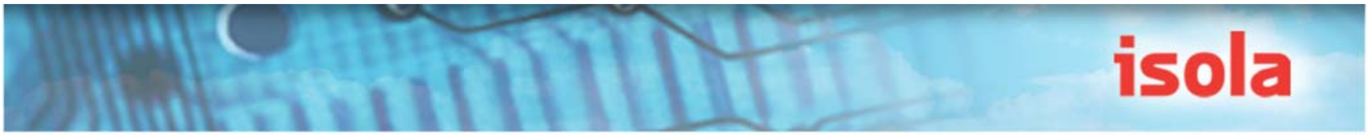
Table 3. Suggested Drilling Parameters For Initial 370HR Setup With Undercut Bits

DRILL SIZE		SPINDLE SPEED	Surface Speed per Minute		SUGGESTED CUTTING SPEED							
					Min. INFEED & CHIPLOAD				Max. INFEED & CHIPLOAD			
inch	mm	RPM	SFPM	SMPM	inch min.	meter min.	mil rev.	mm rev.	inch min.	meter min.	mil rev.	mm rev.
0.0118	0.2997	100,025	309	94.18	50	1.270	0.50	0.013	85	2.159	0.85	0.022
0.0120	0.3048	99,949	314	95.71	52	1.321	0.52	0.013	86	2.184	0.86	0.022
0.0125	0.3175	99,924	327	99.67	55	1.397	0.55	0.014	92	2.337	0.92	0.023
0.0130	0.3302	99,900	340	103.63	57	1.448	0.57	0.014	97	2.464	0.97	0.025
0.0135	0.3429	99,879	353	107.59	60	1.524	0.60	0.015	104	2.642	1.04	0.026
0.0138	0.3505	99,922	361	110.03	65	1.651	0.65	0.017	112	2.845	1.12	0.028
0.0145	0.3683	100,103	380	115.82	75	1.905	0.75	0.019	122	3.099	1.22	0.031
0.0156	0.3962	99,900	408	124.36	85	2.159	0.85	0.022	134	3.404	1.34	0.034
0.0158	0.4013	100,086	414	126.19	100	2.540	1.00	0.025	144	3.658	1.44	0.037
0.0160	0.4064	100,029	419	127.71	103	2.616	1.03	0.026	147	3.734	1.47	0.037
0.0177	0.4496	99,917	463	141.12	110	2.794	1.10	0.028	157	3.988	1.57	0.040
0.0180	0.4572	99,949	471	143.56	111	2.819	1.11	0.028	158	4.013	1.58	0.040
0.0197	0.5004	96,947	500	152.40	111	2.819	1.14	0.029	157	3.988	1.62	0.041
0.0200	0.5080	95,493	500	152.40	110	2.794	1.15	0.029	156	3.962	1.63	0.041
0.0210	0.5334	90,946	500	152.40	107	2.718	1.18	0.030	152	3.861	1.67	0.042
0.0217	0.5512	88,012	500	152.40	105	2.667	1.19	0.030	149	3.785	1.69	0.043
0.0225	0.5715	84,883	500	152.40	102	2.591	1.20	0.031	145	3.683	1.71	0.043
0.0236	0.5994	80,926	500	152.40	98	2.489	1.21	0.031	140	3.556	1.73	0.044
0.0240	0.6096	79,578	500	152.40	99	2.515	1.24	0.032	141	3.581	1.77	0.045
0.0250	0.6350	76,394	500	152.40	102	2.591	1.34	0.034	145	3.683	1.90	0.048
0.0256	0.6502	74,604	500	152.40	104	2.642	1.39	0.035	148	3.759	1.98	0.050
0.0260	0.6604	73,456	500	152.40	106	2.692	1.44	0.037	151	3.835	2.06	0.052
0.0276	0.7010	69,198	500	152.40	105	2.667	1.52	0.039	111	2.819	1.60	0.041
0.0280	0.7112	68,209	500	152.40	111	2.819	1.63	0.041	117	2.972	1.72	0.044
0.0292	0.7417	65,406	500	152.40	112	2.845	1.71	0.043	118	2.997	1.80	0.046
0.0295	0.7493	64,741	500	152.40	111	2.819	1.71	0.044	117	2.972	1.81	0.046
0.0310	0.7874	61,608	500	152.40	111	2.819	1.80	0.046	117	2.972	1.90	0.048
0.0312	0.7925	61,213	500	152.40	110	2.794	1.80	0.046	116	2.946	1.90	0.048
0.0315	0.8001	60,631	500	152.40	114	2.896	1.88	0.048	120	3.048	1.98	0.050
0.0320	0.8128	59,683	500	152.40	114	2.896	1.91	0.049	120	3.048	2.01	0.051
0.0330	0.8382	57,875	500	152.40	115	2.921	1.99	0.050	121	3.073	2.09	0.053
0.0335	0.8509	57,011	500	152.40	113	2.870	1.98	0.050	119	3.023	2.09	0.053
0.0350	0.8890	54,567	500	152.40	112	2.845	2.05	0.052	118	2.997	2.16	0.055
0.0354	0.8992	53,951	500	152.40	111	2.819	2.06	0.052	117	2.972	2.17	0.055
0.0360	0.9144	53,052	500	152.40	110	2.794	2.07	0.053	116	2.946	2.19	0.056
0.0370	0.9398	51,618	500	152.40	110	2.794	2.13	0.054	116	2.946	2.25	0.057
0.0374	0.9500	51,066	500	152.40	109	2.769	2.13	0.054	115	2.921	2.25	0.057
0.0380	0.9652	50,259	500	152.40	108	2.743	2.15	0.055	114	2.896	2.27	0.058
0.0390	0.9906	48,971	500	152.40	107	2.718	2.18	0.055	113	2.870	2.31	0.059
0.0394	1.0008	48,474	500	152.40	107	2.718	2.21	0.056	113	2.870	2.33	0.059
0.0400	1.0160	47,747	500	152.40	105	2.667	2.20	0.056	111	2.819	2.32	0.059



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Part 5: Hole Wall Preparation

General

Good desmear and electroless copper deposition performance are more easily achieved when the drilled hole quality is good. The generation of smooth, debris free hole walls is influenced by the degree of resin cure, drilling conditions and board design considerations. The elimination of 7628 or similar heavy glasses (whenever possible), coupled with properly adjusted drill parameters on fully cured boards has been shown to improve overall drilled hole quality. This helps reduce smear generation, which improves desmear performance and can ultimately help to reduce copper wicking.

Factors which influence chemical desmear rates, **AND THEREFORE THE SUGGESTIONS IN THIS DOCUMENT**, include: resin type, chemistry type, bath dwell times, bath temperatures, chemical concentrations in each bath and the amount of solution transfer through the holes.

Factors which influence the amount of solution transfer through the holes include: hole size, panel thickness, work bar stroke length, panel separation in the rack and the use of solution agitation, rack vibration and rack "bumping" to remove air bubbles from the holes.

Chemical Desmear

Conventional permanganate desmear systems are effective for removal of 370HR resin from interconnect posts. Dwell times and temperatures typically used for most high performance, high-Tg materials should be satisfactory. Consult the chemical supplier for suggested conditions.

Plasma Desmear

If available, Plasma can be used with or without a single permanganate pass (to be determined by each fabricator). Care must be exercised to avoid excessive resin removal if both plasma and permanganate are employed together. Plasma processing tends to improve overall hole quality, particularly in thick and/or high aspect ratio boards. Standard plasma gas mixtures and cycles are satisfactory.

3-Point Etchback

True 3-point "Etchback" exposes the innerlayer "post" on all three sides for subsequent plating processes. This will require a more robust approach compared to simple desmear, which is designed only to remove resin smear from the vertical surface of the innerlayer interconnect "posts".

Plasma will readily etch back 370HR resin. Standard plasma gas mixtures and process cycles designed for conventional FR-4 epoxy are satisfactory and are suggested for use as initial starting parameters for etchback of 370HR. The practice of following the plasma process with a chemical process is suggested rather than plasma alone to increase hole wall texture and remove plasma ash residues.

If plasma is not available, chemical etchback for 3-point connections can usually be accomplished using a double-pass through the permanganate line. Care must be taken when using a double-pass to minimize copper wicking. Consult the chemical supplier for suggested conditions.

Secondary Drilling

The use of entry and backer material may be necessary during the secondary drilling of larger hole sizes to avoid crazing/ fracturing at the hole perimeter. Additionally, sharper plunge point angle geometries may be necessary to avoid crazing around secondary drilled hole perimeters.

Routing and Scoring

Modifications of the final PWB rout fabrication process may be necessary. **Table 4** lists initial starting parameters using Chipbreaker or diamond cut tool designs. Note that parameters listed may require further adjustment.

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Table 4: Suggested Routing Parameters for Initial 370HR Setup

Tool Diameter		SPINDLE SPEED	Spindle Travel Speed	
inch	mm	RPM	inch min.	meter min.
0.0620	1.5748	45,000	20	0.508
0.0930	2.3622	35,000	40	1.016
0.1250	3.1750	25,000	50	1.270

For PWB designs requiring scored geometries, the testing of various Tgs and resin content materials has determined that adjustments to the process will be necessary. As the modulus strength of materials increases, the maximum resultant web thickness (dependent on the scored edge depth) must be decreased to avoid excessive fracturing upon breaking away the scored materials.

Individual board designs/stackups may require adjustment of score depth geometries. **Thinner web thicknesses are typically required.** This is influenced by layer count, glass types and retained copper in the design.

The customer should contact the scoring equipment and/or bit supplier for application specific suggestions for use with 370HR materials.

Your Isola Technical Account Manager may also be able to provide some initial suggestions, but these should be validated through testing by the individual PWB fabricator.

Part 6: Health & Safety

Always handle laminate with care. Laminate edges are typically sharp and can cause cuts and scratches if not handled properly. Handling and machining of prepreg and laminate can create dust (see 370HR Material Safety Data Sheet). Appropriate ventilation is necessary in machining/punching areas. The use of protective masks is suggested to avoid inhaling dust. Gloves, aprons and/or safety glasses are suggested if individuals have frequent or prolonged skin or eye contact with dust.

Isola Group does not use polybromidebiphenyls or polybromide-biphenyloxides as flame retardants in any product. Material Safety Data Sheets are available upon request.

Part 7: Ordering Information

Contact your local sales representative or:

Isola Group
3100 West Ray Road, Suite 301
Chandler, AZ 85226
Phone: 480-893-6527
Fax: 480-893-1409
For further information visit:
www.isola-group.com

Isola Asia Pacific (Hong Kong) Ltd.
Unit 3512 - 3522, 35/F
No. 1 Hung To Road, Kwun Tong,
Kowloon, Hong Kong
Phone: (852) 2418 1318
Fax: (852) 2418 1533
Info.hkg@isola-group.com

Isola GmbH
Isola Strasse 2
D-52348 Düren
Phone: +49(0)2421-8080
Fax: +49(0)2421-808164
E-Mail:info-dur@isola-group.com

MAS Italia s.r.l.
Via S. Sebastiano 21
I-51032 Bottegone (PT)
Phone: +39-05 739221
Fax: +39-0573-922265

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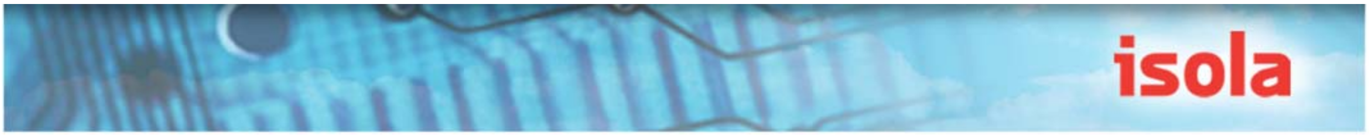

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