

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 (PWB) fabrication environment. Remember that the suggestions contained herein can not 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 PWBs 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 improper 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 using a First-In-First-Out (FIFO) inventory management system. If not handled properly, FR408 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 should be stored at  $\leq 23$  °C and below 50% 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. Once the original packaging is opened, the prepreg should be used immediately. Remaining prepreg should be resealed in the original packaging with fresh desiccant. Storage should be in the absence of catalytic environments such as high radiation levels or intense ultraviolet light.

## Part 2: Innerlayer Preparation

Isola Group's FR408 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 FR408. Therefore, it is suggested that the movement of unbaked laminate be characterized and the appropriate artwork compensation factors are used.

### 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** (for reference) illustrates the suggested approach to characterizing laminate movement and provides *approximate* artwork compensation factors for FR408 laminate when using a hydraulic press.

**Table 1: 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

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.

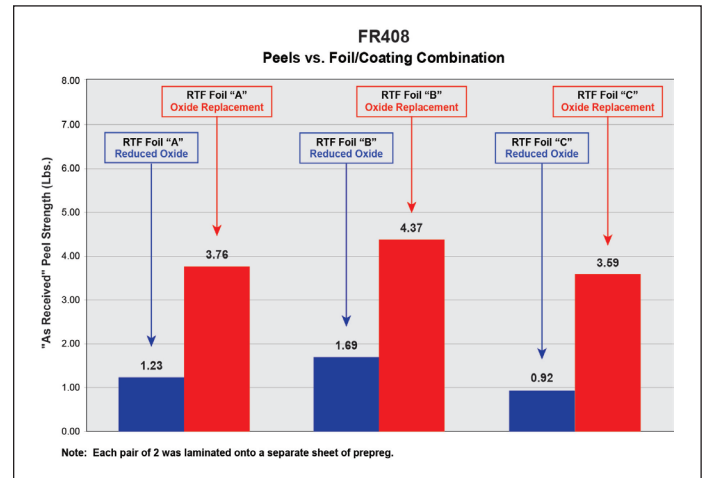
**Table 1** assumes that signal layers are either half or 1 ounce copper and ground layers are either 1 or 2 ounce copper.

## Imaging and Etching

FR408 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 FR408 multilayer boards to date. **However, tests indicate that the adhesion performance of FR408 with oxide replacements is superior to that of reduced oxide. Isola recommends oxide replacements of all lead-free applications. See graph below.**



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 oxidized innerlayers (15-30 minutes @ 80-100°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 60-90 minutes minimum @ 110°C or higher is considered a "best practice", especially for boards to be subjected to "lead-free" processes. Drying in racks is preferred.**

**Wet cores interfere with the curing of prepreg, leading to low Tg values and degraded performance. Users need to verify the effectiveness of their process to achieve dry cores.**

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

## Part 3: Lamination

### Standard Lamination

The amount of time at cure temperature, and to some extent the actual cure temperature of FR408, 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 an 80 minute cure for sub-assemblies depending on thickness and a **95-110 minute cure as recommended earlier for the final assembly**. This suggestion assumes a final assembly thickness  $\leq 0.150$ ".

Removal of FR408 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 suggested lamination parameters for the single-stage and dual-stage lamination cycles are shown in **Table 2** and **Table 3**. The lamination cycle selected will be a function of board stackup, complexity and thickness as well as the lamination presses capability. **Thicker boards may require additional dwell time at curing temperature to achieve full cure**. See "Standard Lamination" previously discussed.

Choosing a dual stage or "kiss" cycle for FR408 multilayer boards 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.

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

**Table 2: FR408 General Lamination Parameters**

<b>Vacuum Time</b>	30 minutes (no pressure, product on risers)
<b>Curing Temperature</b>	185-200°C (365-392°F)
<b>Curing Time</b>	110 minutes above 185°C (365°F) 95 minutes above 191°C (375°F) Thicker boards should be cured near the top end of range.
<b>Resin Flow Window</b>	100-150°C (210-300°F) Maintain heat ramp in this temperature range.
<b>Heat Ramp</b>	2.2-4.5°C/min (4.0-8.0°F/min) The lower end of range is recommended only for low-mid layer count products. Higher layer count products or products requiring greater resin filling ( $\geq 2$ oz copper) should run $> 3.5$ °C/min. Platen temperature overshoot up to 215°C is acceptable to meet heat ramp requirements when using alternative oxides.
<b>Pressure</b>	See <b>Table 2</b> .
<b>Pressure Application</b>	-Single Stage Apply pressure after vacuum dwell time. -Dual Stage 50 PSI (3.5 Kg/cm <sup>2</sup> ) after vacuum dwell time, switch to high pressure $\leq 90$ °C (194°F) product temperature.
<b>Pressure Drop</b>	After 30 minutes at cure temperature, reduce pressure to 50 PSI (3.5 Kg/cm <sup>2</sup> ) in hot press (optional).
<b>Cool Down</b>	Cool to 135-140°C (275-285°F) at 2.8°C/min (5.0°F/min) with 50 PSI (3.5 Kg/cm <sup>2</sup> ) pressure prior to removing or transferring the load.

**Table 3** outlines general suggestions for lamination pressure based on press type used.

**Table 3: FR408 Lamination Pressure**

Lamination Method	Suggested Pressure Range
Hydraulic Pressing (without vacuum assist)	300-350 PSI 21-24 Kg/cm <sup>2</sup>
Hydraulic Pressing (with vacuum assist via vacuum frames or bags)	250-300 PSI 17-21 Kg/cm <sup>2</sup>
Hydraulic Pressing (vacuum enclosure)	200-250 PSI 14-18 Kg/cm <sup>2</sup>

## Part 4: Drill

### General

The FR408 materials exhibit increased thermal stability of the resin system and generate little or no smear. To assure effective removal of the resin debris during drilling, undercut drill geometries and high helix tools are **strongly recommended** on drills up to 1.0 mm in diameter. 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 and Chipload

Relative to standard FR-4 parameters, use lower chiploads to drill FR408 printed circuit boards. The parameters in **Table 4** provide a *moderate initial starting point for typical board designs*. Thick boards with heavy copper or special cladding such as invar will require more conservative drill parameters. Boards with numerous 2 oz. copper innerlayers or boards with coarse glass weave may require more conservative parameters.

**High cutting speeds and high chiploads are associated with rough holes and fracturing around the glass yarn.**

### Stack Height and Hit Count

Stack heights and hit counts will vary according to construction and overall thickness of the boards being drilled. For thicker boards, above 2.5 mm (100 mils) overall, with high layer counts, drill one high. Use undercut bits for particularly demanding designs. Aluminum entry and lubricated backing help create good quality hole walls but are not essential in all applications.

## Part 5: Hole Wall Preparation

### General

When FR408 is properly cured and drilled, it will generate very little smear. The main purpose of desmear processing on this material is to remove debris and provide an acceptable texture to the hole walls.

**Plasma desmear followed by a mild permanganate desmear is the preferred process. Cracking and other reliability issues can be minimized by optimizing the exposure times in each of these processes.**

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:**

plasma etch parameters, 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, vertical or horizontal process equipment and equipment agitation parameters.

**Table 4: Suggested Drilling Parameters For Initial FR408 Setup**

Drill Size		Spindle Speed	Surface Speed Per Minute		Infeed		Chipload		Retract	
Inch	mm	RPM	SFPM	SMPM	Inch min.	Meter min.	Mil Rev.	mm Rev.	Inch min.	Meter min.
0.0098	0.25	120,000	309	94	32	0.81	0.27	0.007	600	15
0.0118	0.30	105,000	325	99	70	1.78	0.67	0.017	800	20
0.0138	0.35	94,000	339	103	78	1.98	0.83	0.021	800	20
0.0157	0.40	85,000	350	107	85	2.16	1.00	0.025	1000	25
0.0197	0.50	75,000	387	118	100	2.54	1.33	0.034	1000	25
0.0248	0.63	60,000	390	119	90	2.29	1.50	0.038	1000	25
0.0295	0.75	50,000	387	118	85	2.16	1.70	0.043	1000	25
0.0354	0.90	43,000	399	122	75	1.91	1.74	0.044	1000	25
0.0394	1.00	38,000	392	119	68	1.73	1.79	0.045	1000	25
0.0500	1.27	32,000	419	128	62	1.57	1.94	0.049	1000	25
0.0591	1.50	28,000	433	132	56	1.42	2.00	0.051	1000	25
0.0787	2.00	22,000	454	138	50	1.27	2.27	0.058	1000	25

## Chemical Desmear

Trials performed by chemical suppliers show that FR408 is more chemically resistant than typical FR-4 resin systems.

We recommend the use of butyl carbitol based desmear chemistries instead of the NMP based desmear chemistries.

**The NMP chemistries are more aggressive (provide greater weight loss) but can cause reliability issues after lead-free thermal stress.**

Absorption of solvent swellers into the FR408 resin has been associated with fracturing between drilled holes. For that reason, we recommend minimizing the dwell times in the chemical desmear process. We also recommend that boards are desmeared without solvent swellers.

## Plasma Desmear

Plasma desmearing can consistently etch the chemically resistant FR408 resin system, and when properly run provides good hole wall texturing. 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.

## Hole Wall Condition Verification

It is recommended that users take test samples for hole wall inspection after drill and deburring and after desmearing. The post drill condition indicates hole cleanliness and hole wall damage. Post desmear indicates desmear effectiveness and resin texturing. SEM pictures of holes cut vertically in half have been effective for executing this verification.

## 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".

**Permanganate chemistry alone should not be used to attain a full 3-point etchback for FR408.**

A combination of plasma and chemical processing is suggested. Testing indicates that the plasma provides nearly all of the resin removal. Chemical desmear should be used primarily for hole cleaning and conditioning.

If plasma is not available, chemical etchback for 3-point connections must be done with extreme care on FR408 to minimize copper wicking. This is not recommended. If chemical processing alone is used, it will be necessary to either extend the dwell times in chemical baths or subject the boards to a double-pass through the chemical desmear system. Consult the chemical supplier for suggested conditions. **The slow dissolution rate of FR408 resin into chemical etching alone may not result in true 3-point etchback.**

## Secondary Drilling

As common with most high Tg epoxy materials with increased modulus properties, 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

Due to the greater modulus properties of the FR408 materials, modifications of the final PWB rout fabrication process may be necessary. **Table 5** lists initial starting parameters using chip breaker or diamond cut tool designs. **Note that parameters listed may require further adjustment.**

**Table 5: Suggested Routing Parameters for Initial FR408 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

Chip breaker or diamond cut tool designs recommended.

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/stack-ups 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 FR408 materials.** Your Isola Technical Account Manager may also be able to provide some initial suggestions, but these should be reviewed with the scoring equipment supplier and validated through testing by the individual PWB fabricator.

## Part 6: Packaging and Storage

FR408 finished boards have low moisture sensitivity and good shelf life. However, Isola recommends using best practices in storage and packaging, as noted below, to reduce risk during lead-free assembly.

FR408 boards should be dry prior to packaging to ensure the most robust lead-free performance. For some complex, high reliability designs, baking prior to solder mask application can be implemented to ensure maximum floor life in assembly processing. Printed boards made for high temperature assembly from FR408, which require a long shelf life, the best protection is provided using a Moisture Barrier Bag (MBB) with a Humidity Indicator Card (HIC) and adequate drying desiccant inside the MBB to prevent moisture absorption during shipment and long-term storage.

Upon opening the MBB, the boards should be processed within 168 hours when maximum shop floor conditions are at < 30°C (85°F)/60% RH. MBB bags that are opened for inspection should be resealed immediately to protect the boards from moisture uptake.

## Part 7: Health and 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 FR408 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 8: Ordering Information

Contact your local sales representative or visit: [www.isola-group.com](http://www.isola-group.com) for further information.

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[www.isola-group.com/products/FR408](http://www.isola-group.com/products/FR408)

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