



**USING  
NIPPON GRAPHITE INDUSTRIES  
HEAT SEAL COMPONENTS**

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# 1. Bonding

## 1-1 Bonding Equipment

### 1.) Mechanical Construction

The bonding equipment should be constructed not to flex or warp during operation. It should include an integrated heat controller with a pulse or constant heater installed in either the head mount or the head itself. It should include a roll winding system for a silicon bonding pad to be placed between the bonding head and the materials to be bonded, although insert-type bonding pads are also acceptable.

### 2.) Heating

The bonding equipment should allow the connector to be subjected to a temperature range between room temperature and 180°C. Pulse heater units should be equipped with a feedback thermocouple and an active cooling system. Constant heat units should feature a digital temperature controller similar to the Omron Model E5EX: heat distribution is important and is critical at finer pitches. Machines to be used at pitches less than 0.5mm should be designed to minimize heat distortions across the blade. For more information on heat and alignment accuracy, please see the addendum on fine-pitch connectors at the end of this document.

### 3.) Pressure

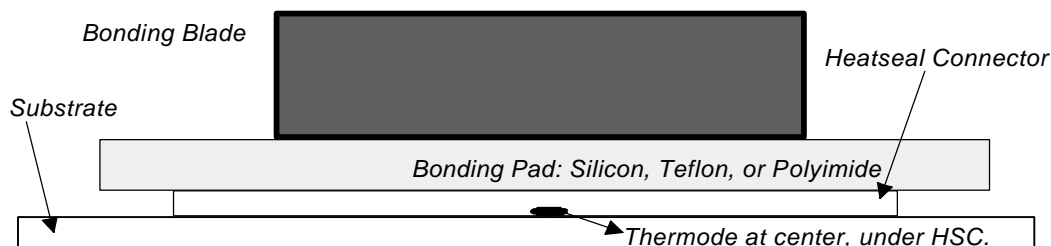
The bonding equipment must allow for stable, repeatable bonding at 30-45Kgf/cm<sup>2</sup>.

### 4.) Stage and Fixtures

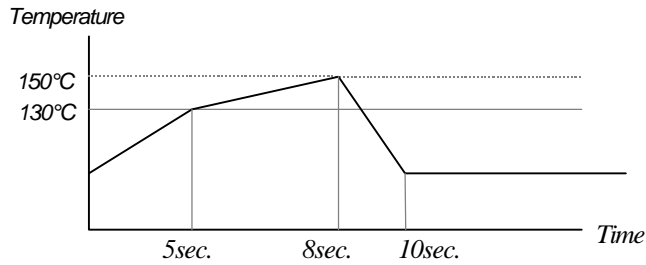
The bonding stage and fixtures must be designed not to warp under the heat and pressure of the bonding cycle. They should also be designed to be as thermally inert as possible. Suitable materials for bonding fixtures are Bakelite, Aluminum (provided that the fixture does not adversely pull heat from the bonding surface), or Stainless Steel (again, it must not create hot or cold spots within the bonded substrate). The stage, fixture, or other support that lies directly under the bondhead during the bonding cycle may also have active constant heat to counteract any thermal sink effects or heat buildup. This is particularly important in any equipment designed to be used with rapid cycles for extended periods of time.

## 1-2 Bonding Temperature ( $T_a$ )

NGI heatseal adhesives are designed to flow at 130C. Damage will occur to the adhesive system at 180C. NEVER exceed 180C during operation. The correct bonding temperature is determined by placing a thermocouple as shown below and running a bonding cycle.



A typical bonding profile will last from 8-15 seconds. While each machine and connector generates a different profile, a typical profile would look similar to this one.



The adhesive will not flow properly if the temperature is not maintained above 130°C for at least 3 seconds. The profile above has temperature actively being applied for 3 full seconds after 130°C is reached, and the connector itself will retain some heat even after the blade has been removed at 8 seconds into the profile. In any case, the temperature of the adhesive should never be allowed to reach 170°C. Doing so can damage the adhesive and may cause mechanical failure of the connection.

### **1-3 Bonding Pressure,**

Bonding pressure differs slightly depending on the adhesive system being used. While bonding pressure is important with all heat seal connectors, users will find that Planar type connectors are the most forgiving and Monosotropic the least. It is critical that correct, accurate, and repeatable pressures are obtained when bonding fine pitch anisotropic and monosotropic connectors. The pressure ranges for the three types of heat seal connectors are listed below. 35 Kgf/cm<sup>2</sup> is the recommended starting point for process optimization for all constructions.

PLANAR:	35-45 Kgf/cm <sup>2</sup>
ANISOTROPIC:	35-45 Kgf/cm <sup>2</sup>
MONOSOTROPIC:	40-45 Kgf/cm <sup>2</sup>

### **1-4 Bonding Pads**

Bonding pads are recommended for all heat seal connector applications. Pads protect the hotbar from contamination and help allow the equipment to bond correctly even if coplanarity between the bonding back-up surface and bonding head has been disrupted. In general, all screen-printed connectors should use a silicon pad. The finer the pitch to be bonded, the thinner the pad used, down to a minimum of 0.3mm. All pad thickness should use a Rockwell hardness rating of 80. We currently recommend Sarcon® as the best material to use. Using Sarcon®, we would recommend that users follow the table below when starting to bond. These thicknesses should be followed as a general rule, with different thicknesses showing better results in some instances.

An important point to note is that while the thicker bonding pads may be more durable, they will also significantly increase the length of the bonding profile as the pad insulates the connector from the blade. For this reason, pads with thermally-conductive filler, such as Sarcon®, are recommended. The following table shows the recommended pad thicknesses for various connector pitches are shown below.

Another important note is that the bonding pads must be changed frequently, with no more than 30 cycles on any given area of the silicon. Failure to rotate the silicon pad in a timely fashion may cause

the silicon pad to begin to break down, releasing silicon oils which may cause adhesion problems for the connector, possibly leading to mechanical or electrical failure of the connection.

Pitch	>1.0mm	1.0mm<0.5mm	0.5mm<0.35mm	0.35mm<0.24mm
Adhesive System				
Planar	0.45mm	0.45mm	N/A	N/A
Anisotropic	0.45mm	0.45mm	0.45mm	0.3mm
Monosotropic	0.45mm	0.45mm	0.45mm	0.3mm

*\*For pitches less than 0.24mm, please see the Addendum on Fine Pitch Connectors*

## 2. Bonding Substrates

Gold, Tin, or Graphite-surfaced bonding pads are suitable for use with heatseal connectors. Solder plated pads or pads coated with an oxidization inhibitor are not suitable for use with heat seal connectors. Solder will oxidize over time and generate an unreliable contact unless the percentage of Tin is very high. Inhibitors are too varied in their chemical make-up for us to determine when, if, or how they will react with the connectors. They also form a film on the substrate which may limit the mechanical strength of the bond.

Substrates may be cleaned with IPA, acetone, or other solvents. ***It is recommend that you consult with your FPD (flat panel display) manufacturer to determine how the FPD is tested post-production. Many FPD manufacturers use a compression contact with a silicon-based elastomeric connector to do the final light-up test of their FPDs. If the cells are not thoroughly cleaned after this process, either at the point of manufacture or at your facilities, they will not generate reliable bonds.***

Similar to what may happen with the silicon bonding pads used in the bonding equipment, silicon oil is released from compression-type zebra connectors over time and will accumulate on the contact pads. This oil will form a barrier to the hotmelt adhesive on the connector and may inhibit the connectors' ability to perform either a mechanical or electrical bond. We cannot be responsible for contamination of the bonding substrate. For this reason, we strongly recommend that no silicone products are used with or near the heatseal connectors. Oil from an operator's fingertips will also create problems with bonding, although not nearly to the degree that silicon does. Fingertip covers or gloves are recommended for handling. Our factory operates with a complete ban on silicone products within production zones and a requirement that all workers handling the connectors wear cloth gloves. We recommend that the same procedures be followed for our customers sites as well.

## 3. Other Notes

### 3.1 Coplanarity

A high degree of coplanarity between the bonding head and the back-up support is required for an accurate bond. Coplanarity should be adjusted to within  $\pm 10\mu\text{m}$  ( $\pm 5\mu\text{m}$  if possible). We recommend the use of Fuji Prescale Ultra-Low Pressure Film to test for coplanarity. Please see the attached Addendum on Fine Pitch Connectors for more information.

### 3.2 Bonding Area

Strict attention should be made to the bonding area during design, setup, and operation. The following is a brief checklist that should eliminate the majority of problems associated with bonding area design:

1. Never overhang the bonding tool on your substrate. Unless the bonding head, substrate, and back-up bar are absolutely coplanar, this could create a pinch point where the bonding head overhangs the substrate. An excess of pressure at such a pinch point can cut the traces in the connector, cut the connector itself, or damage the substrate.
2. Always try to leave at least 2.0mm of dead space at both sides of your connector. While not absolutely necessary, these 2.0mm should have nothing in them except adhesive. They will help prevent the connector from delaminating at the edges.
3. The recommended minimum bonding ledge depth is 2.0mm. Some companies use smaller ledges, but be aware that this not only decreases the size of the mechanical connection of your bond, it also decreases the size of your electrical connection. At fine pitches, this can lead to a measurable increase in contact resistance. Correct design can limit some of these effects, so please consult with us if you need a smaller bonding ledge.
4. When bonding to a PCB, the total height differential between the top of the pad and the depth of the gap between it and its neighbor should be less than  $25\mu\text{m}$  for rough pitches ( $>1.0\text{mm}$ ) and
5. There should never be components mounted on the opposite side of the bonding area. Components in this area will inhibit the ability to adequately support that part of the board and may cause heat sinks or other issues that affect the quality of the bond.

### 3.4 Post-Bond Testing

Post-Bond testing may be conducted in two ways, depending on the adhesive system being used: destructive peel testing or visual qualitative testing.

Destructive peel testing is described in the heat seal connector catalogs and consists of peeling the connector off in the X direction and measuring the peel strength. If the peel strength exceeds the specifications (for example, 500g for Anisotropic adhesives), the bond will generally be considered reliable.

Visual qualitative testing is also possible, but is somewhat subjective. However, when performed by an experienced operator it is an accurate, nondestructive way of testing a bond on glass. It can only be used on a clear (i.e. glass or plastic) substrate. For this test, five traces each from the left, right, and center bonding areas are examined under a microscope and the number of conductive particles trapped

between the glass and the connector trace are counted. It is important to count only those particles in complete contact, and not to include those with a thin film of adhesive remaining between the particle and the glass. To ensure that only those particles fully in contact with the glass are counted, we suggest that indirect lighting is used in the microscope. By varying the angle of the light source (or, alternately, the angle at which the substrate is held under the microscope) the person testing the bond can count the "glints" of light reflecting from the metallic conductive particles. Only those particles fully in contact with the glass will "glint" or clearly reflect the light -- those with a layer of adhesive film remaining between them and the glass surface will not. The tester should only count the glints.

Once counted, the following formula is used to determine the viability of the bond:

$$x-3S^35$$

The higher the value is above five, the greater the electrical reliability of the connection.

## 4. Materials

For further information and current pricing on the materials and equipment in this document, please contact us at:

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## Fine Pitch Connectors

### 1. Fine Pitch Connectors

#### 1.1 Types of Connectors

Fine-pitch connectors may be of either Monosotropic or Anisotropic construction and may feature screen-printed thickfilm conductive ink or etched copper traces. For the purpose of this discussion, fine-pitch connectors will be defined as those connectors with pitches less than 0.3mm. At pitches less than 0.2mm, NGI heatseal connectors are all copper-etched. These copper etched heatseal connectors, or **FlexEC** connectors, perform almost identically to NGI's thickfilm ink connectors, except as follows:

##### 1.1.1 Special Considerations for **FlexEC** Connectors

Standard **FlexEC** connectors use 18 $\mu$ m thick galvanic copper foil. The 18 $\mu$ m thickness should perform nearly identical to NGI's heatseal connectors in use. The only special consideration for general use would be the bending radius allowed for these connectors. Users requiring a radius of 0.5mm or less when assembling their product should contact us before designing their connector.

#### 2.1 General Concerns

As fine-pitch connectors have become more common, the procedures for working with them have also become both more obvious and more defined. This, in turn, has allowed solutions to the most common hazards to be developed.

The overriding characteristic which fine-pitch connectors share is that of sensitivity. Specifically, fine-pitch connectors are more sensitive to:

- Misalignment (see also: skew)
- Twist (misalignment in the theta axis)
- Non-coplanarity

These issues are discussed below.

### 2.1.1 Misalignment and Twist

Fine-pitch connectors must be precisely aligned -- both to prevent shorts or opens in the circuit and to prevent an unnecessarily high contact resistance. In connectors with pitches of greater than 0.7mm, a simple alignment hole system will allow accurate placement of the parts for bonding. At finer pitches, however, an active alignment system, whether manual or automatic, becomes more necessary.

At a 0.3mm pitch, a typical alignment system might feature a magnified viewing area for the operator to align the connector to the substrate. The connector would be placed on alignment pins, moved to the mounting area, and aligned under magnification before completing the bond cycle. At finer pitches, the operator may be more comfortable working with a CCD camera and a magnified image on a television monitor. As pitches become smaller, this solution becomes even more preferable due to the ability to split the viewing screen to show the left and right sides of the connector simultaneously, helping to prevent misalignment due to twist. This becomes especially important for connectors with a long 'W' dimension.

The use of alignment marks is optional. However, many companies feel that the use of an "open cross" (*fig A2.1.1*) alignment mark at either side of the connectors allows their operators the easiest method to accurately perform the alignment step. If an "open-cross" connector is used, we recommend that the dimensions of the mark on the connector be slightly smaller than the corresponding mark on the receiving substrate.

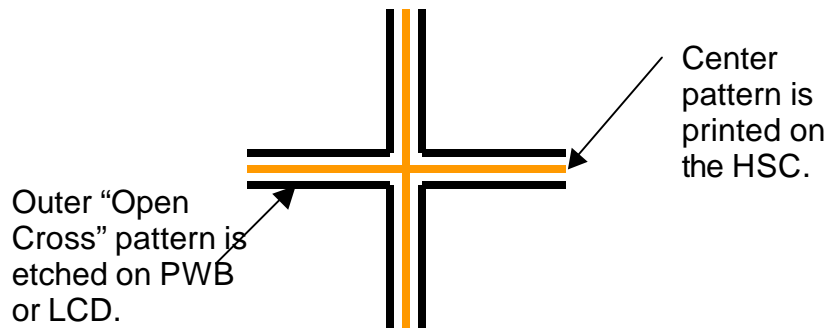


Fig 2.1.1

Other companies, however, prefer to align directly to the substrate traces. This has the advantage of saving space on the substrate, but the operator must take care to make sure that the entire connector is not shifted too far in either the X or Y directions. Shifting too far in the X direction may result in the connector being mounted offset to the substrate. Shifting too far in the Y direction may push the connector too far into the substrate, possibly causing problems, or may pull it away from the substrate, limiting the effective bond area while possibly lowering mechanical strength, raising contact resistance, and contaminating the bonding blade or area with heatseal adhesive.

Twist may also create problems. Particularly at pitches of 0.3 mm and smaller, twist can result in higher contact resistance. It is important, therefore, for the end user to consider twist when designing the tooling for the alignment and bond equipment.

### **2.1.2 Non-coplanarity**

Coplanarity is important for all heatseal connectors, but becomes even more so for fine-pitch anisotropic heatseal connectors. As pitches become finer, the electroconductive particles within the anisotropic adhesive must likewise become smaller in diameter. This in turn limits the amount of gap available at any point along the bonding area which will still enable the particle to be crushed during bonding. While +/-10 $\mu$ m is the recommended tolerance for coplanarity for heatseal connectors of 0.3mm and larger, +/- 5 $\mu$ m is recommended for pitches less than this amount. The tolerance should be measured between the back-up support and the hotbar itself, using Fuji Prescale film or equivalent. That tolerance should translate well to a glass substrate during operation, but may not translate as well to a printed circuit board. Typically, however, a connector has a finer pitch along the glass or display side than it does on the PCB or driver side, which tends to limit this problem.

A bonding pad is also strongly recommended to help offset any non-coplanarity which exists and to prevent any contamination of the blade with adhesive during the bonding process. For pitches between 0.3mm and 0.2mm, end users may find that a piece of Sarcon<sup>®</sup> silicon tape (Rockwell hardness = 80, thickness = 0.45mm or 0.3mm) will help. For finer pitches, and in some cases the above pitches as well, a piece of polyimide or Teflon tape may work better. The polyimide or Teflon tapes should be between 25 $\mu$ m and 50 $\mu$ m in thickness. The thinner materials will complete the final bond with less skew (see explanation below), but offer less help in covering any non-coplanarity.

**Skew:** Skew is the amount the part moves after it has been aligned but before the adhesive cures during the bond cycle. Skew usually becomes a consideration at pitches of less than 0.2mm and occurs mainly due to non-coplanarity. Non-coplanarity causes skew when one corner of the hot bar hits the connector first and pushes it outward until the rest of the hotbar comes down. For this reason, floating hotbars or gimbaled hotbars are unworkable for fine-pitch heatseal bonding (and are not recommended for any heatseal application). This type of skew can easily misalign a connector by up to 0.1mm.

Skew may also occur due to physical differences in material composition, material thickness, or material distribution within the connector and substrate. For example, an excess of heat-conductive material in one part of a substrate may cause that portion to marginally heat-up faster or slower than surrounding areas. This causes a high-point of unmelted adhesive to form for a short period at the coolest part of the bonding area. The connector will slide down from that high point and skew away from true alignment. Typically, this type of skew generates only 1-3 $\mu$ m of misalignment and does not become a problem unless something else is generating a marginal bond in the first place.

Finally, skew may also occur due to differing coefficients of expansion in the connector and the substrate. In this case, skew manifests itself in bonds with traces that are aligned at the center of the connector but which grow in misalignment in the outward direction (X-axis) the further away from the center of the connector the trace is. Because this type of skew is

generated from heat, NGI's heatseal connectors rarely encounter this problem. Other heatseal technologies, however, require temperatures in the 180°C range and may generate substantial heat expansion-generated skew. If the problem is encountered, lowering the maximum temperature of the bond cycle may help, as will the following general anti-skew measures.

Skew may be combated by using equipment with a high degree of coplanarity, using a pulse heatseal machine, or mechanically clamping the connector in place following alignment and preceding final bond. If none of these methods is desirable or feasible, the alignment method may be adjusted to accommodate heat expansion-induced skew. Interested companies should contact us for more information.