Application Note AN15
Reflow Soldering of Bridgelux LED Arrays

Introduction

The Bridgelux family of LED Array products delivers high performance, compact and cost-effective solid-state lighting solutions to serve the general lighting market. These products combine the higher efficiency, longer lifetime, and reliability benefits of LEDs with the light output of many conventional lighting sources.

The Bridgelux LED Arrays have been uniquely designed to be easily assembled into lighting fixtures. Unlike LED components, the Bridgelux LED Array is a lighting solution which can be directly mounted to a heat sink without a secondary substrate or circuit board. This results in not only a simple plug and play design but also in an industry leading low system level thermal resistance. To connect the LED Array to a driver, wires must be soldered to the solder pads on the LED Array. Soldering wires may be done manually as discussed in Application Note AN11 or with automated equipment and a solder reflow process as is outlined in this application note.

This application note describes a process for attaching wires onto Bridgelux LED Arrays using a lead free solder reflow process. Included is an overview of the soldering process, a list of required materials, fixtures, equipment, a recommended reflow oven temperature profile, and post process recommendations for solder joint inspection. It should be noted that the process described in this application note may require modifications depending on customer specific requirements. It is the responsibility of the customer to qualify the final assembly process to ensure compliance with guidelines depicted in this application note.

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Solder Reflow Process Flow Chart

The soldering process described in this application note was developed in cooperation with Nexlogic Technologies of San Jose California. A flow chart containing key steps in the soldering process is included below. Details of the individual steps are described throughout this application note.

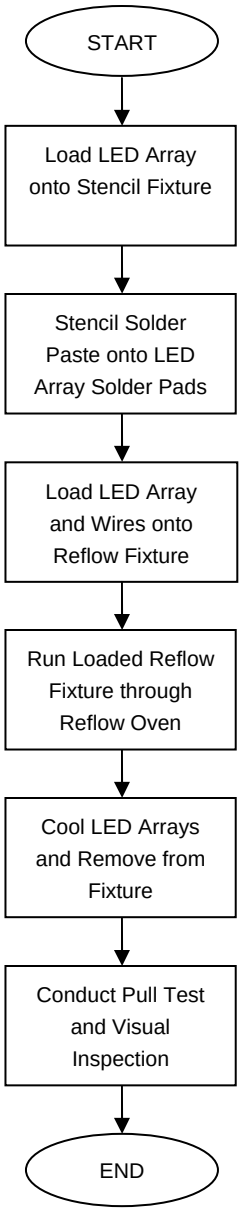

Figure 1: Solder reflow process flow chart

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Required Materials

The following materials are required to attach wires to Bridgelux LED Arrays using the reflow solder process outlined in this application note.

Bridgelux LED Arrays

All Bridgelux LED Array product configurations are compatible with this reflow soldering process. Prior to engaging in reflow solder attach, please review application note AN11 (Assembly Considerations for Bridgelux LED Arrays) to ensure an understanding of LED Array handling requirements. Please note that Bridgelux LED Arrays should be handled with care and gripped from the sides using gloves, finger cots, or tweezers. The yellow resin area of the LED Array should not be touched to avoid damage to the product.

Bridgelux is in the process of determining the need for pre-baking the Bridgelux LED Arrays to remove moisture prior to reflow soldering. At this time Bridgelux recommends treating the LED Array products using the guidelines of JEDEC MSL 3. Parts left out of a sealed desiccated bag for more than one week must be pre-baked for 24 hours at 85°C prior to reflow soldering. This application note will be updated as further information and guidelines are available.

Solder Paste

The process defined in this application note uses Alpha OM338, a RoHS compliant lead-free solder paste composed of 96.55 Sn / 3.0 Ag / 0.5 Cu. This solder does not require additional solder flux or post cleaning, simplifying the process. The melting point of this non-eutectic solder paste is 217°C. The process described in this application note enables the solder pads of the LED Arrays to reach 240°C to ensure consistent melting of this solder paste.

The solder paste may be dispensed in precise amounts using a pneumatic volumetric dispenser or may be applied to the solder pads using a stencil process, common to the industry. The required volume of solder paste depends on the LED Array configuration (star or rectangle) and wire type (stranded or solid, wire gauge or diameter). This application note describes a process in which 2.8 mm^3 of solder paste is dispensed on a Star LED Array solder pad and 7.4 mm^3 of solder paste is dispensed on a Rectangular LED Array solder pad. The solder paste is dispensed using a stencil.

Once the solder paste is dispensed and exposed to air, the flux in the solder will begin to evaporate. As a result it is important to understand the recommended shelf life for the solder paste used. For the Alpha OM338 solder paste the recommended shelf life is 6 hours. Discard any unused solder paste after 6 hours of exposure to air.

Wires

The wires used to develop the reflow process described in this application note are 22 AWG, stranded, pre-tinned, Teflon insulated wires. Teflon insulation is required for soldering in a reflow oven. Wires with other insulation materials (such as PVC) are not suitable due to the low melting temperatures of the insulation materials.

Wires must be prepared by first cutting them to the desired length and then stripping 3mm of insulation from both ends. Stripping excess lengths of insulation is not recommended as it may create a short to the aluminum substrate of the LED Array once assembled. If non-pre-tinned wire is used, the tips of the wires must be tinned before soldering (see AN11, Handling and Assembly of Bridgelux LED Arrays, for details on pre-tinning of wires).

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Solid wires may also be used. To use solid wires, minor changes in the process depicted in this application note may be required. Changes to the volume of solder paste dispensed or changing the reflow oven temperature profile may be required. Standard IPC soldering practices should be used.

Using pre-formed wire lengths (pre-cut, pre-stripped, and pre-tinned as shown in Figure 2a) can simplify the soldering process. Using wires cut from a spool typically results in curvature in the wire (Figure 2b) which may add additional process steps or precautions.

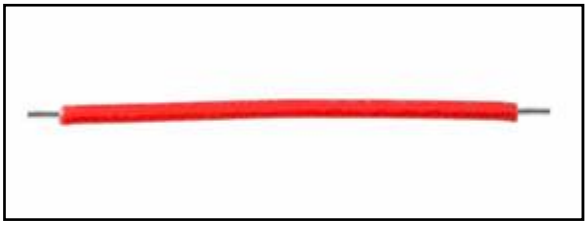

Figure 2a: Pre-formed wire lengths

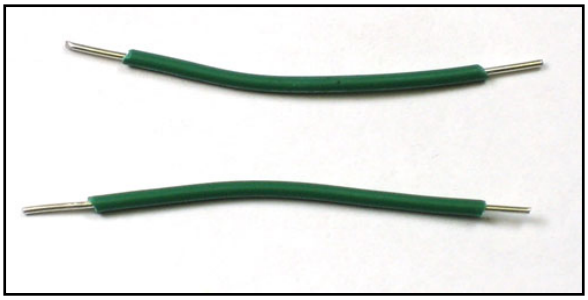

Figure 2b: Wire from a spool cut to size, note curvature in the wire

DI Water

DI (De-ionized) water may be used to remove excess solder flux from the solder reflow fixture.

Isopropyl Alcohol (IPA)

IPA may be used to remove excess solder paste from the solder stencils.

Lint-Free Wipes

Lint-free wipes may be used in conjunction with DI water or IPA for removing excess solder flux from the solder reflow fixture or solder paste from the solder stencil.

Tweezers

Tweezers are useful for handling the parts from the side and may be used to load and unload parts from the fixtures.

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Dispensing Solder Paste

Dispensing of solder paste onto Bridgelux LED Arrays requires the following fixtures and equipment:

1. Solder stencil alignment plate
2. Solder stencil
3. Spatula

The process for dispensing solder onto the LED Arrays is as follows:

1. Load the LED Arrays onto the solder stencil alignment plate (Figures 3a and 3b).
2. Place the solder stencil on top of the LED Arrays (Figures 4a, 4b and 5).
3. Apply the solder paste to the solder pads using a spatula or squeegee (Figure 6).
4. Remove the solder stencil from the solder stencil alignment plate by gently lifting it from the solder stencil alignment plate.
5. The LED Arrays with solder paste (Figures 7a and 7b) may then be transferred from the solder stencil alignment plate to the solder reflow fixture.

Figures 3a and 3b illustrate solder stencil alignment plate designs for dispensing solder flux onto multiple LED Arrays. The configuration shown illustrates one of many possibilities. The LED Arrays may be arranged in a single vertical row, rotated to align the solder pads vertically, or may be more densely packed. Such changes would simplify the application of solder paste using both manual and automated equipment, resulting in increased capacity per fixture. Detailed drawings of suitable alignment plates are contained in the Appendix.

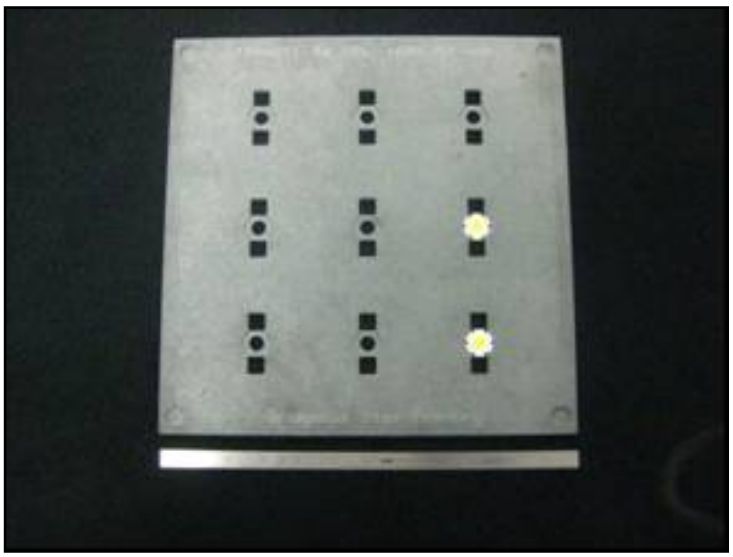

Figure 3a: Solder stencil alignment plate for Star LED Arrays

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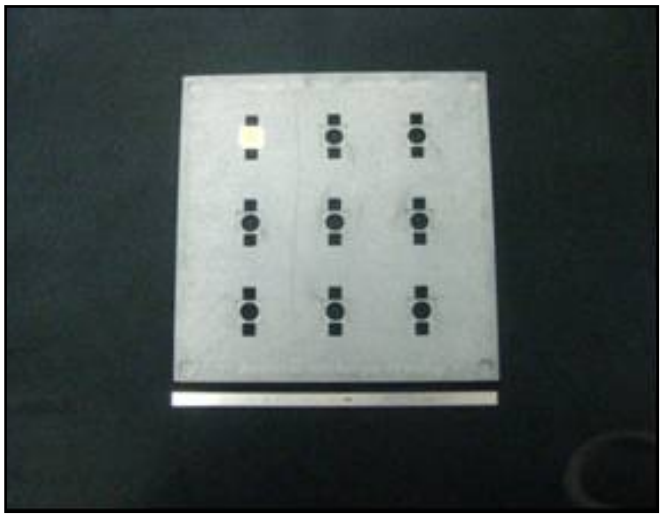

Figure 3b: Solder stencil alignment plate for Rectangular LED Arrays

The solder stencil is cut from a 20mil (0.5 mm) thick steel plate and has cut outs in the shape and size of the LED Array solder pads. The thickness of the solder stencil determines the volume of solder paste dispensed on the solder pads of the LED Arrays. There are additional cut-outs on the solder stencil for clearance of the resin portion of the LED Array and for alignment features on the solder stencil alignment plate. Close-up pictures of the solder stencil cut-outs for Bridgelux LED Arrays are shown in Figures 4a and 4b. Detailed drawings for solder stencils are included in the Appendix.

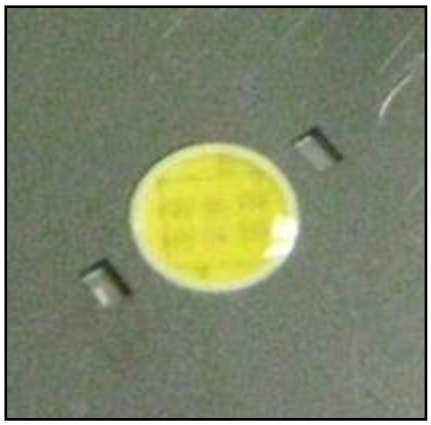

Figure 4a: Star LED Array solder stencil cut-outs

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Figure 4b: Rectangular LED Array solder stencil cut-outs

After the LED Arrays are loaded into the solder stencil alignment plate, the solder stencil is placed on top of the solder stencil alignment plate as shown in Figure 5.

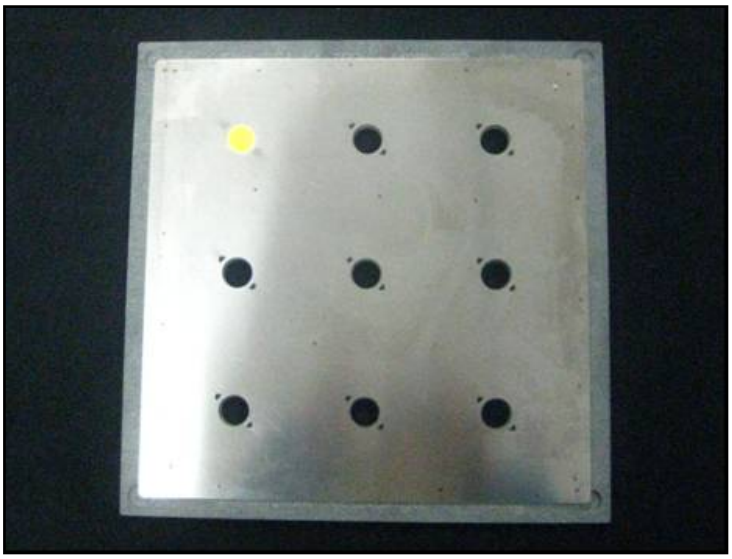

Figure 5: Solder stencil alignment plate (bottom) and solder stencil (top)

Once the solder stencil is in place, solder paste may be applied to the solder pads of the LED Arrays. For volume production multiple LED Arrays may have solder stenciled onto the pads simultaneously. This process may be done manually using a spatula or with automated equipment using squeegees for high volume assembly.

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Figure 6: Application of solder paste using stencil and spatula

Care must be taken in applying the solder paste to avoid dispensing solder paste onto the optical emitting area of the LED Array. It is possible to develop a solder stencil with masks to cover the optical area and to ensure that solder paste is not deposited on the resin area. Designing a solder stencil with such protection features is recommended for high volume production.

Once the solder paste is deposited, the solder stencil is removed by lifting it form the solder stencil alignment plate. This exposes the LED Arrays with solder paste deposited onto the solder pads, as shown in Figures 7a and 7b. Excess solder paste can be removed from the solder stencil using IPA and a lint-free wipe.

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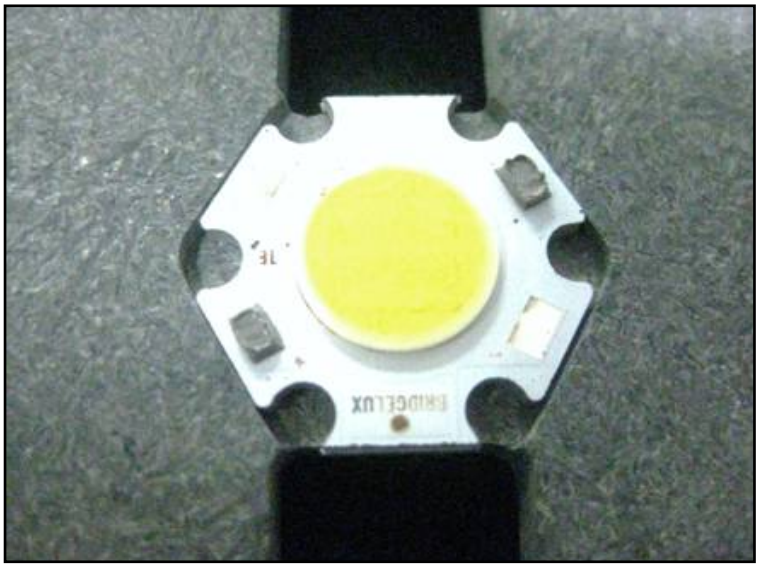

Figure 7a: Star LED Array with solder paste

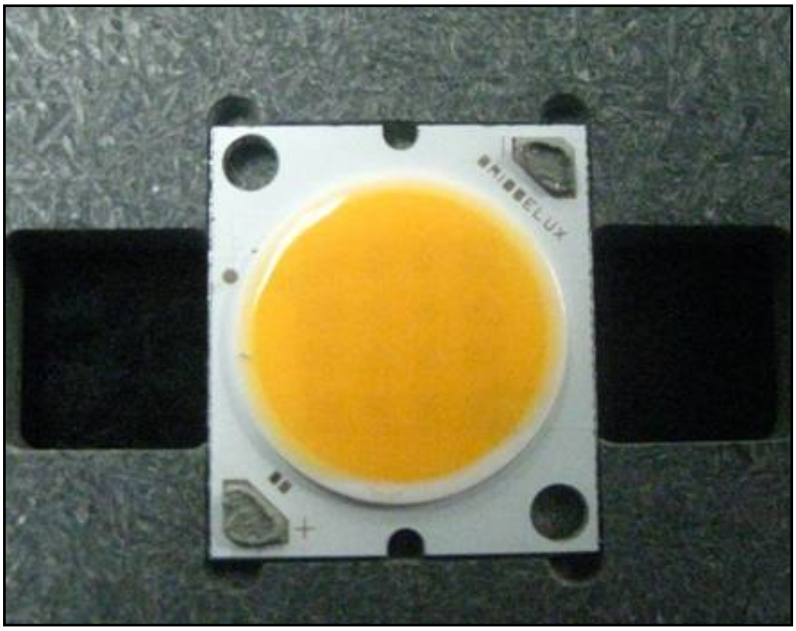

Figure 7b: Rectangular LED Array with solder paste

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Solder Reflow Fixture

The solder reflow fixture consists of two components, a top and a bottom plate. The fixture is made of Durostone and is usable for a minimum of 5,000 cycles through a solder reflow oven.

Features of the solder reflow fixture include:

1. Cut-outs on the top and bottom plates where the LED Arrays sit to allow heat to be convected to the LED Array for the top and the bottom of the reflow oven.
2. Wire guides on the bottom plate to hold the wires in place and centered on the solder pad.
3. Recesses on the top and bottom plates to allow for curvature of the wires.
4. Alignment features on the top and bottom plates to ensure that the plates are correctly oriented.
5. Screws to secure the top and bottom plates together during the reflow soldering process.

Detailed drawings of all fixtures can be found in the Appendix.

The use of the solder reflow fixture is straightforward:

1. The LED Arrays (with solder paste pre-deposited on the solder pads) are loaded onto the bottom fixture plate (Figure 8).
2. The wires are placed in the wire guides (Figure 9).
3. Ensure that the wire is lying flat on the bottom fixture plate and that the wire tip is flat and centered on the solder pad (Figures 10 and 11).
4. The tip of the wire that is not on the solder pad must not point upward (Figures 12 and 13) as this may cause the other end of the wire to lift form the solder pad during the clamping process.
5. After all LED Arrays and wires are loaded, place the top plate on top of the bottom plate and fix it in place using screws (Figure 16). The LED Array solder reflow fixture is then ready to be loaded onto the reflow oven.

When soiled, fixtures may be clean using DI water or wipes soaked with isopropyl alcohol.

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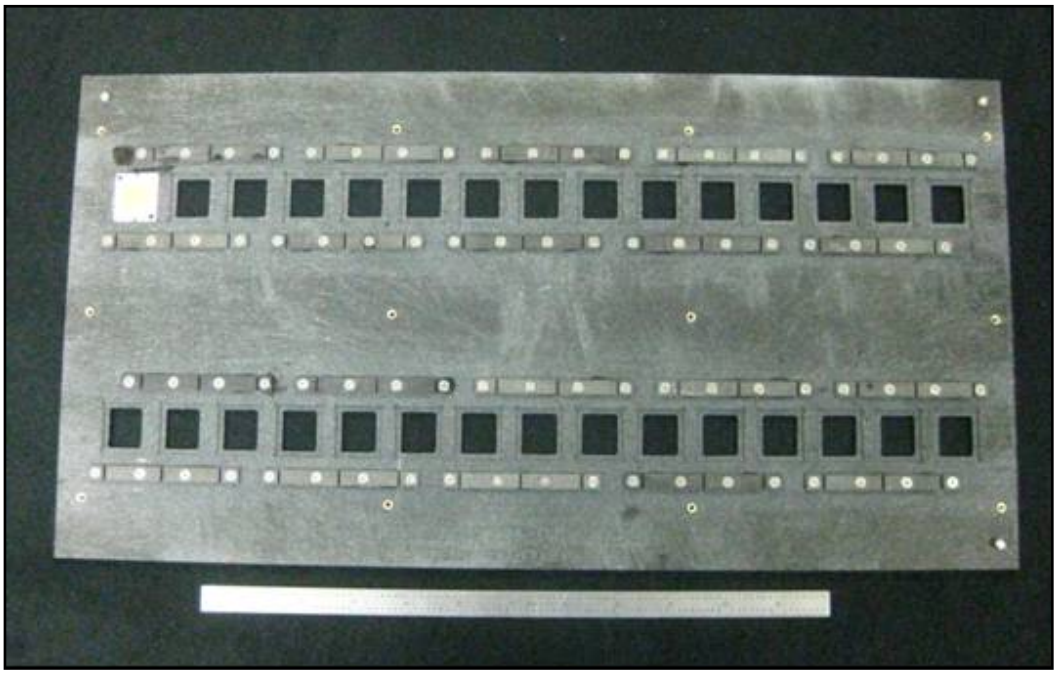

Figure 8: Solder reflow fixture bottom plate for Rectangular LED Arrays

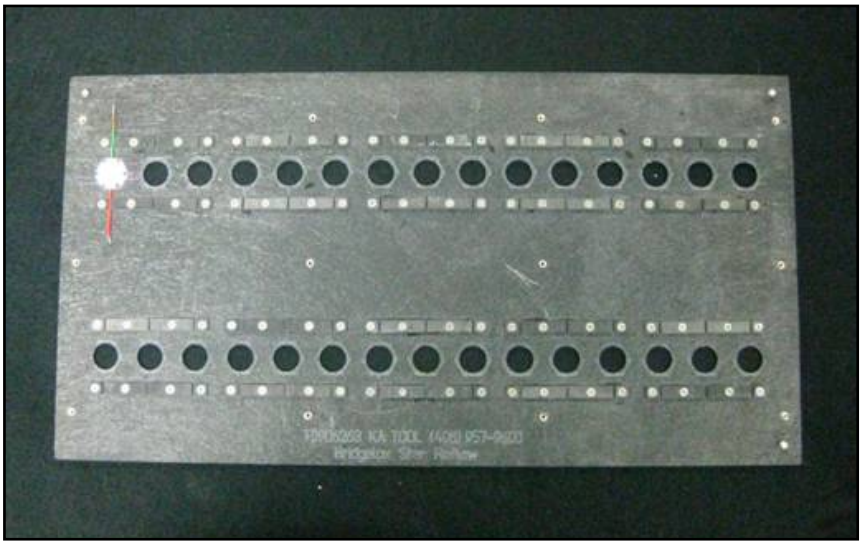

Figure 9: Solder reflow fixture bottom plate for Star LED Arrays

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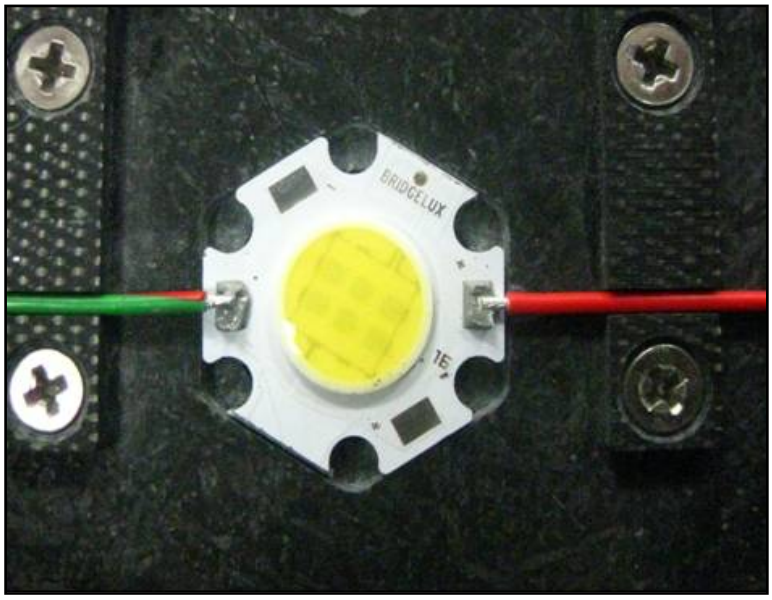

Figure 10: Solder reflow fixture close-up with Star LED Array and wire

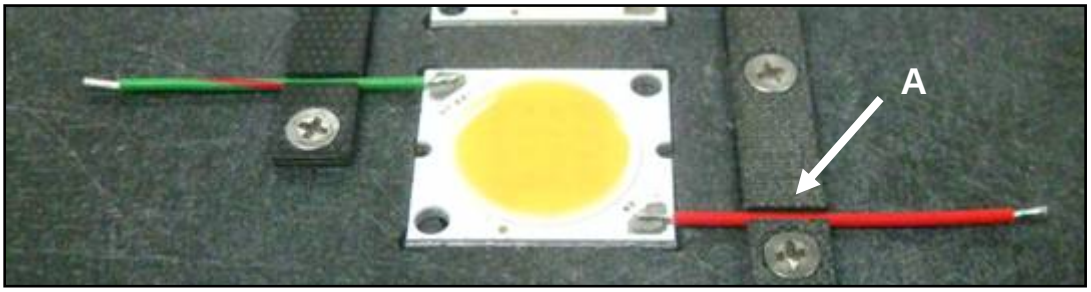

Figure 11: Solder reflow fixture close-up with Rectangular LED Array and wire ("A" shows wire holder/guide)

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Figure 12: Wires from spools with curvature must lay flat on the fixture

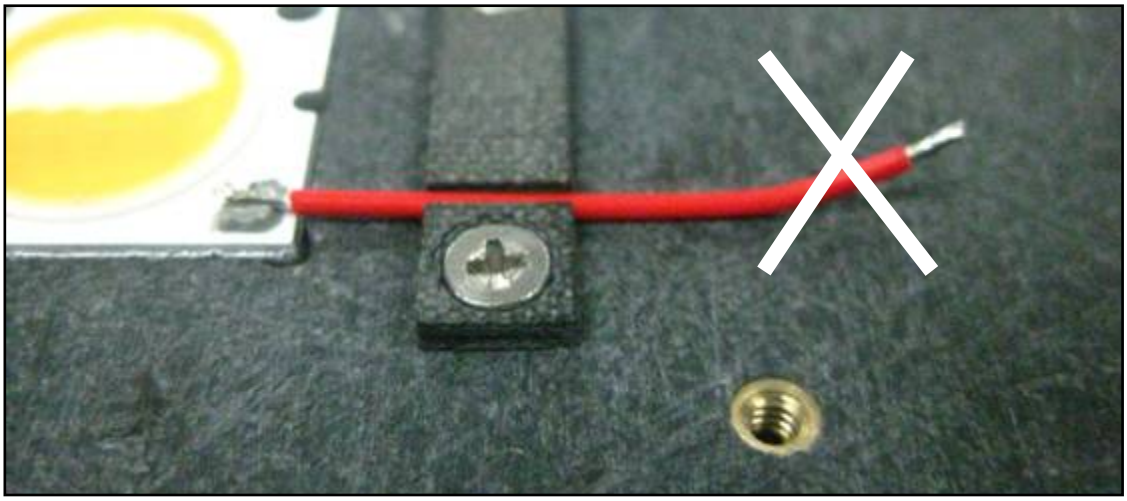

Figure 13: Wires from spools with curvature must not point upward

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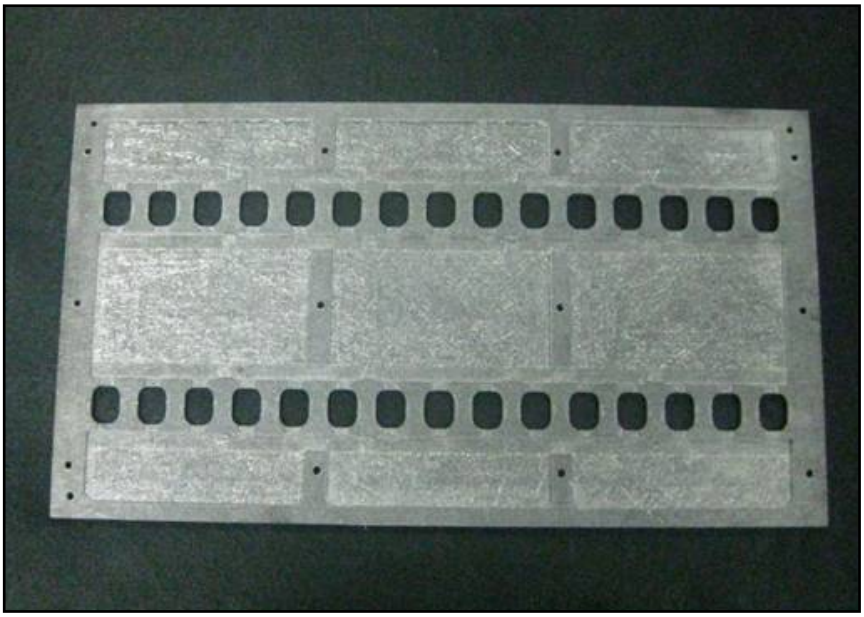

Figure 14a: Solder reflow fixture top plate for Star LED Arrays

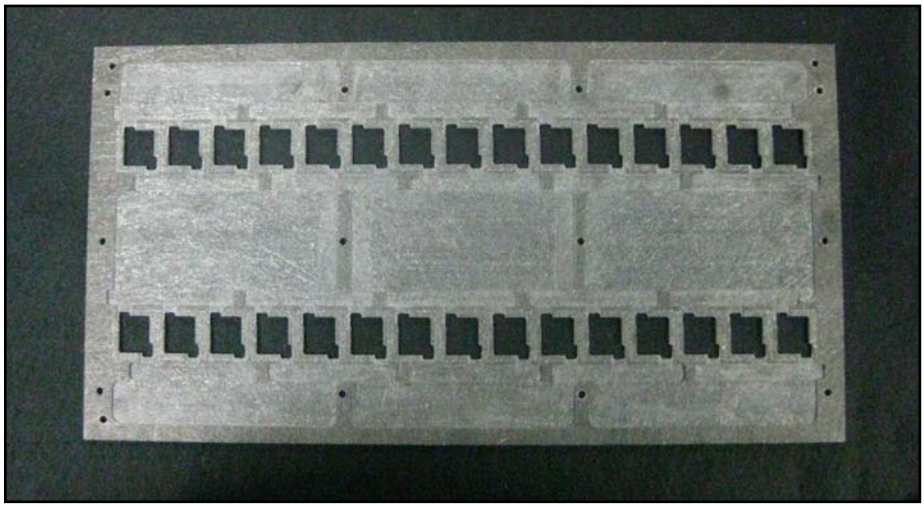

Figure 14b: Solder reflow fixture top plate for Rectangular LED Arrays

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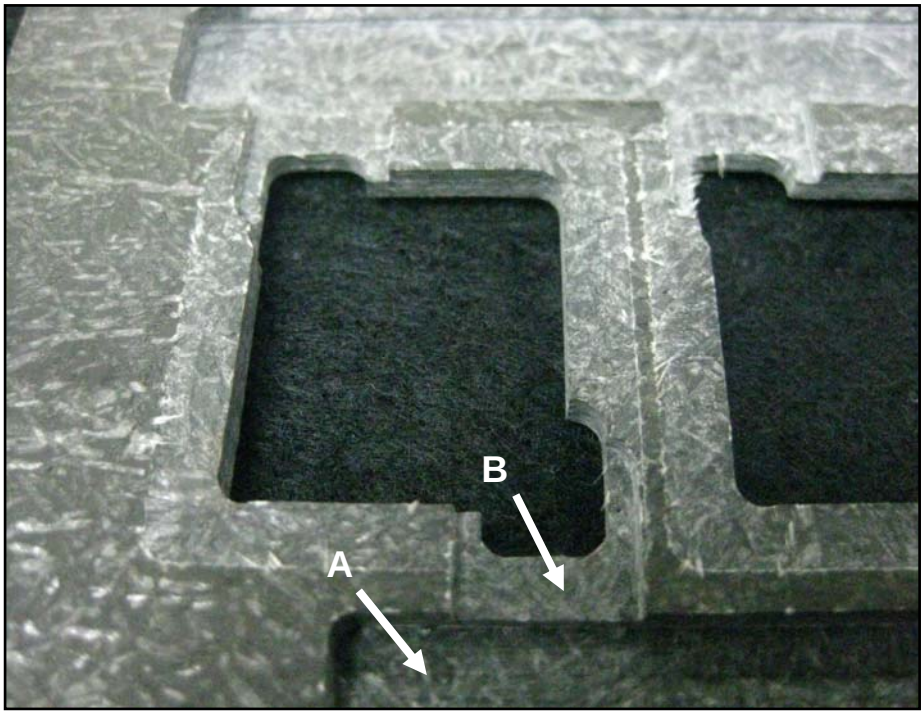

Figure 15: Solder reflow fixture top plate close-up. The trough area (denoted by the letter “A”) allows space for wires with curvature. Area “B” holds the tip of the wire in place near the solder pad.

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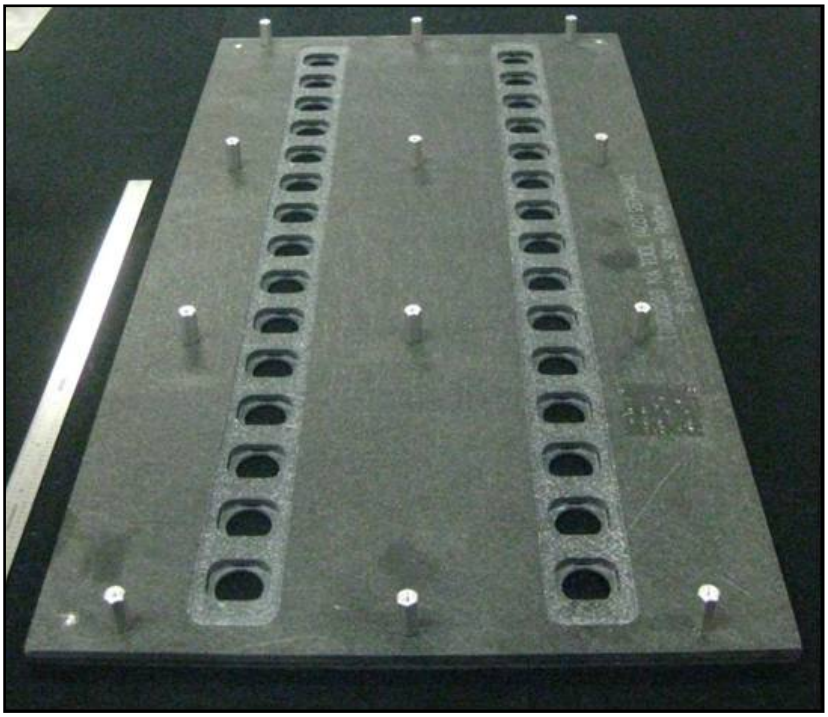

Figure 16: Solder reflow fixture for Rectangular LED Arrays with both plates clamped together using screws

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Solder Reflow Process Parameters

The solder reflow process described in this application note was developed using an Electrovert Bravo 8105 Reflow Oven by Speedline Technologies. This oven blows heat onto the fixture from both the top and the bottom zones at equal flow rates. The process defined requires that nitrogen blow through the reflow oven during the soldering process. Nitrogen prevents the oxidation of silver and copper within the solder and on the solder surface, resulting in a shinier and more robust solder joint.

Reflow soldering of Bridgelux LED Arrays requires effective control of heating and cooling. Both the rate of heating and cooling and the absolute temperatures reached are critical in assuring the formation of a reliable solder joint while avoiding damage to the LED Array during the reflow process.

The recommended temperature profile for reflow soldering SnAg solder paste is shown below in Figure 17. Note that solder temperature profiles are unique to specific fixtures. If the fixture whose dimensions are included in the Appendix is modified, a new reflow oven temperature profile must be established. When doing this, ensure that the LED Array resin temperature does not exceed 245°C, that the solder pad temperature reaches 240°C, and that the rate of heating and cooling is as described in Figure 17 and Table 1. Table 2 describes the reflow oven temperature settings by oven zone, both top and bottom.

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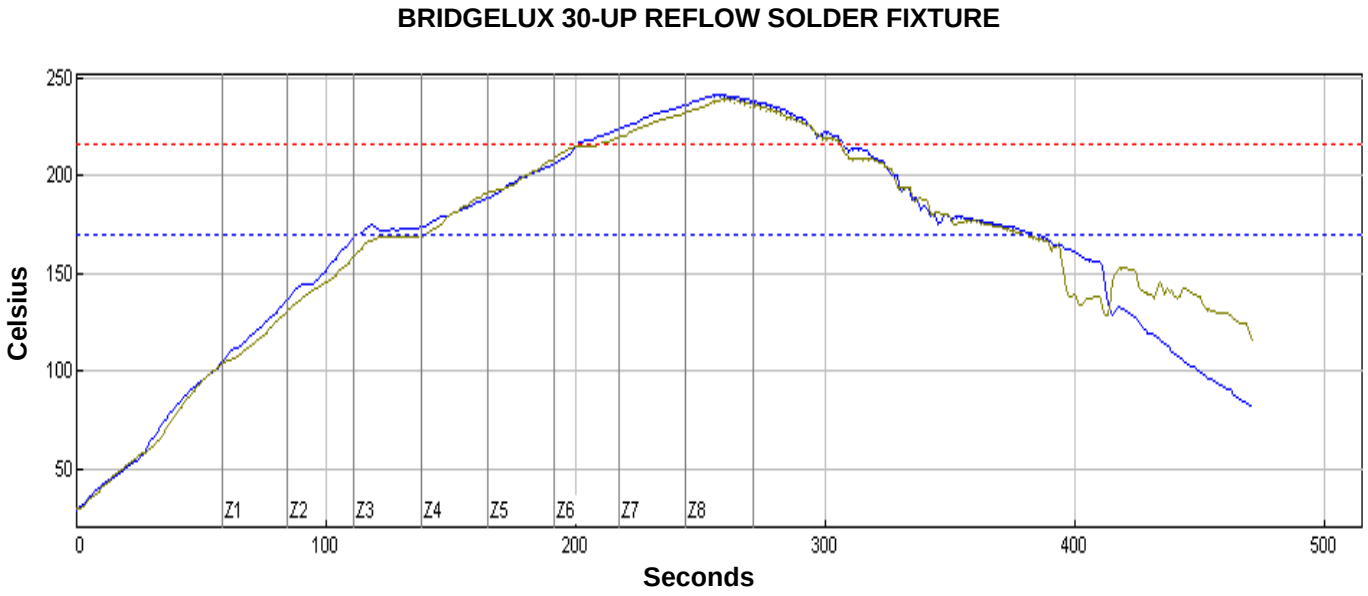

Figure 17: Reflow oven temperature profile as measured on LED Array solder pad using thermocouples

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Max Rising Slope (°C/second)	Soak Time 170°C to 217°C (seconds)	Reflow Time 217°C (seconds)	Peak Temperature at Solder Pad (°C)
1.7	71.4	96.5	240.4

Table 1: Reflow oven temperature profile characteristics

	Conveyer Belt Speed		Temperature Per Oven Zone (°C)							
	(Inch/min)	(mm/min)	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
Top	26	660.4	165.0	180.0	205.0	240.0	260.0	270.0	280.0	285.0
Bottom	26	660.4	165.0	180.0	205.0	240.0	260.0	270.0	280.0	285.0

Table 2: Reflow oven temperature settings at various zones

When first attempting the reflow process it is recommended to use a thermal profiler (often called a mole) to characterize the reflow oven, such as the Slim KIC 2000. Firmly attach temperature probes to the solder pads and resin part of the LED Array to gather data on the reflow process to ensure that temperatures are within specified limits.

Bridgelux LED Arrays are rated for exposure to the recommended reflow temperature profile once.

Modifications to the solder profile may be required based on customer specific requirements. In the event that any deviations in fixturing, equipment, or process parameters are required it is the responsibility of the customer to qualify the process used to ensure that the recommended guidelines in this application note are satisfied to ensure a reliable solder joint without damaging the Bridgelux LED Array.

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Post Reflow Process Inspection Recommendations

Once the LED Arrays emerge from the reflow oven allow them to cool to room temperature prior to removing them from the solder reflow fixture. Note that the LED Arrays can be pushed out of the fixture by pressing on the bottom of the LED Array through the hole on the bottom fixture. Ensure compliance with appropriate handling procedures.

Solder Joint Inspection

Visually inspect the solder joint. Refer to IPC-A-610 for solder joint visual inspection criteria. Note that SnAg solder joints do not consistently have a specular or shiny appearance like that produced by PbSn solder. When conducting a visual inspection of the solder joints, look for wetting of the solder on the solder pad and wetting of the wire or strands of wire. Ensure that there are no pits, voids, or cracks in the solder. Variation in the appearance of the solder that comprises the solder joint is common. This may be due to variability in the amount of solder that is placed on the solder pad during the stenciling process or the wicking of solder by stranded wire. Figure 18 shows an example of an acceptable solder joint.

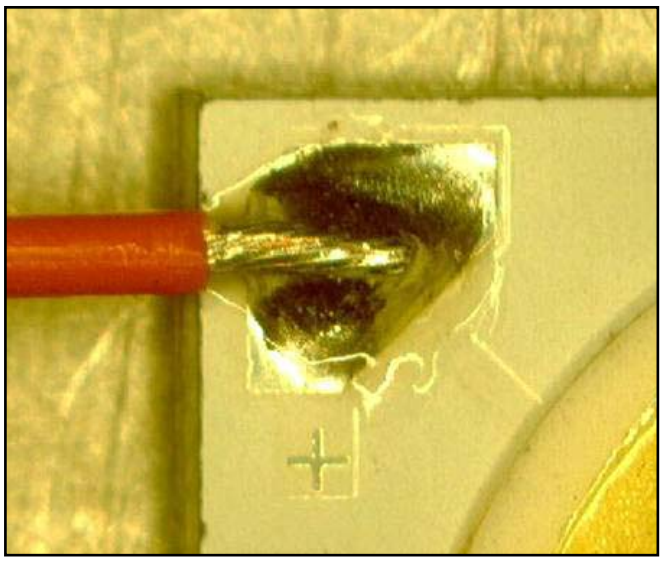

Figure 18: Example of an acceptable solder joint with proper wetting of the solder on the solder pad and on the stranded wire

Wire Pull Test

Verity proper attachment of the wire to the solder joint with a wire pull test. Pull the wire in the same direction that it is mounted. The wire should withstand a load of ten pounds (4.5 kg). When conducting a wire pull test hold the LED Array along the metal edges- do not touch the resin area of the LED Array. Do not pull the wire in a direction that is perpendicular to the LED Array as this may work-harden the wire and cause it to break when returned to its original position.

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Appendix – Fixture Drawings for Solder Reflow Process

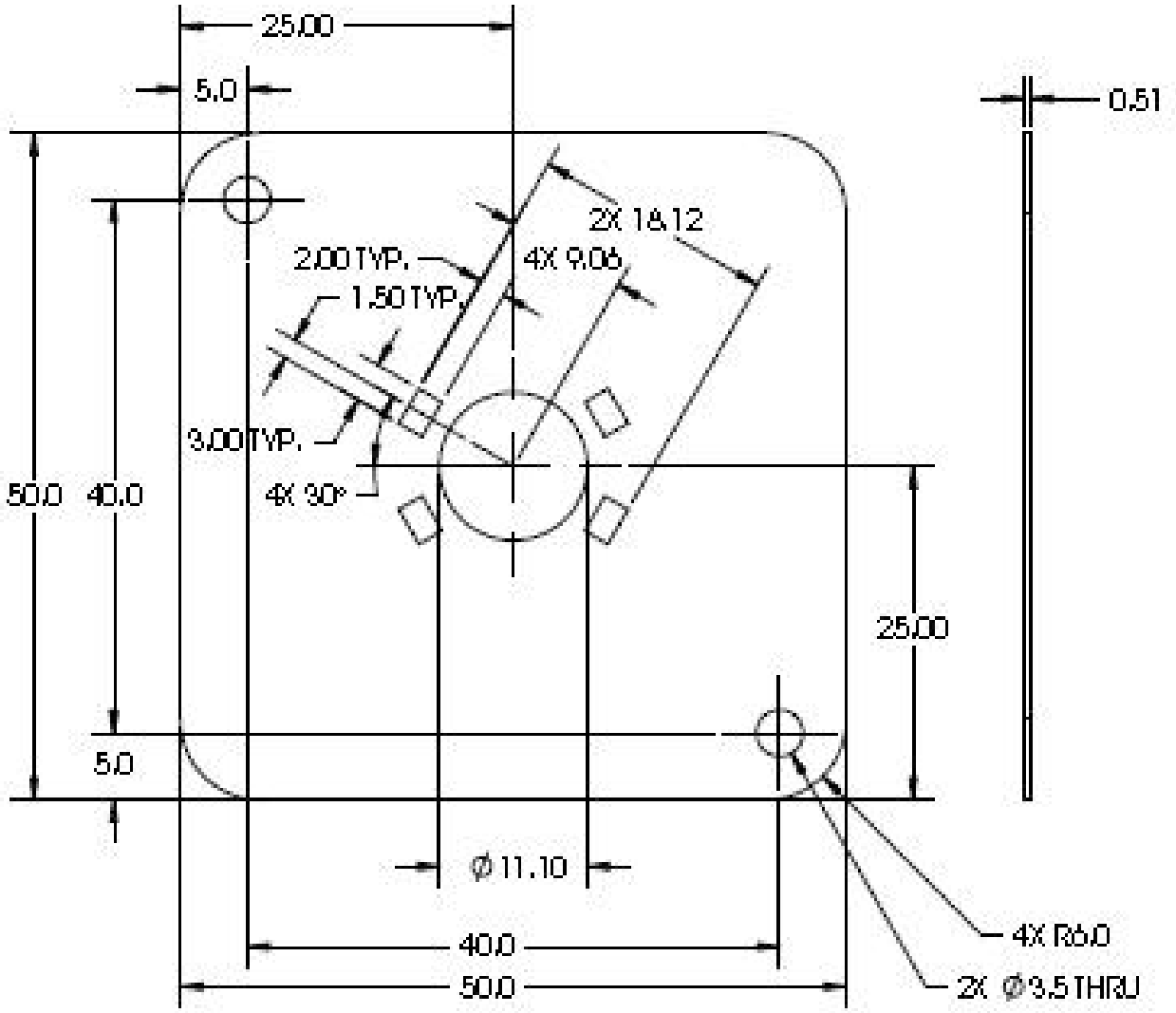

Figure A1: Single Star LED Array solder stencil drawing
(Drawing not to scale, all dimensions are in millimeters)

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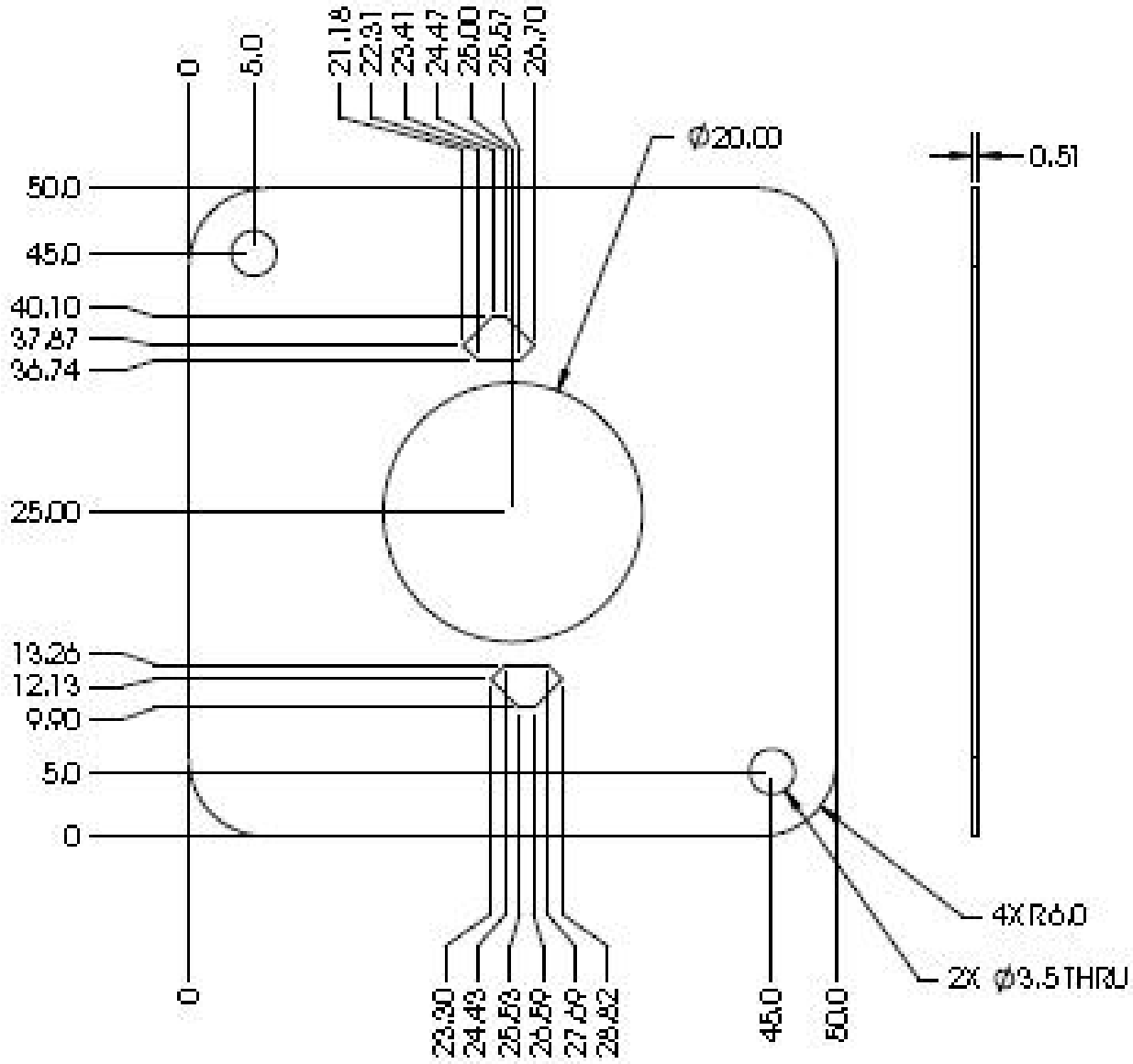

Figure A2: Single Rectangular LED Array solder stencil drawing
(Drawing not to scale, all dimensions are in millimeters)

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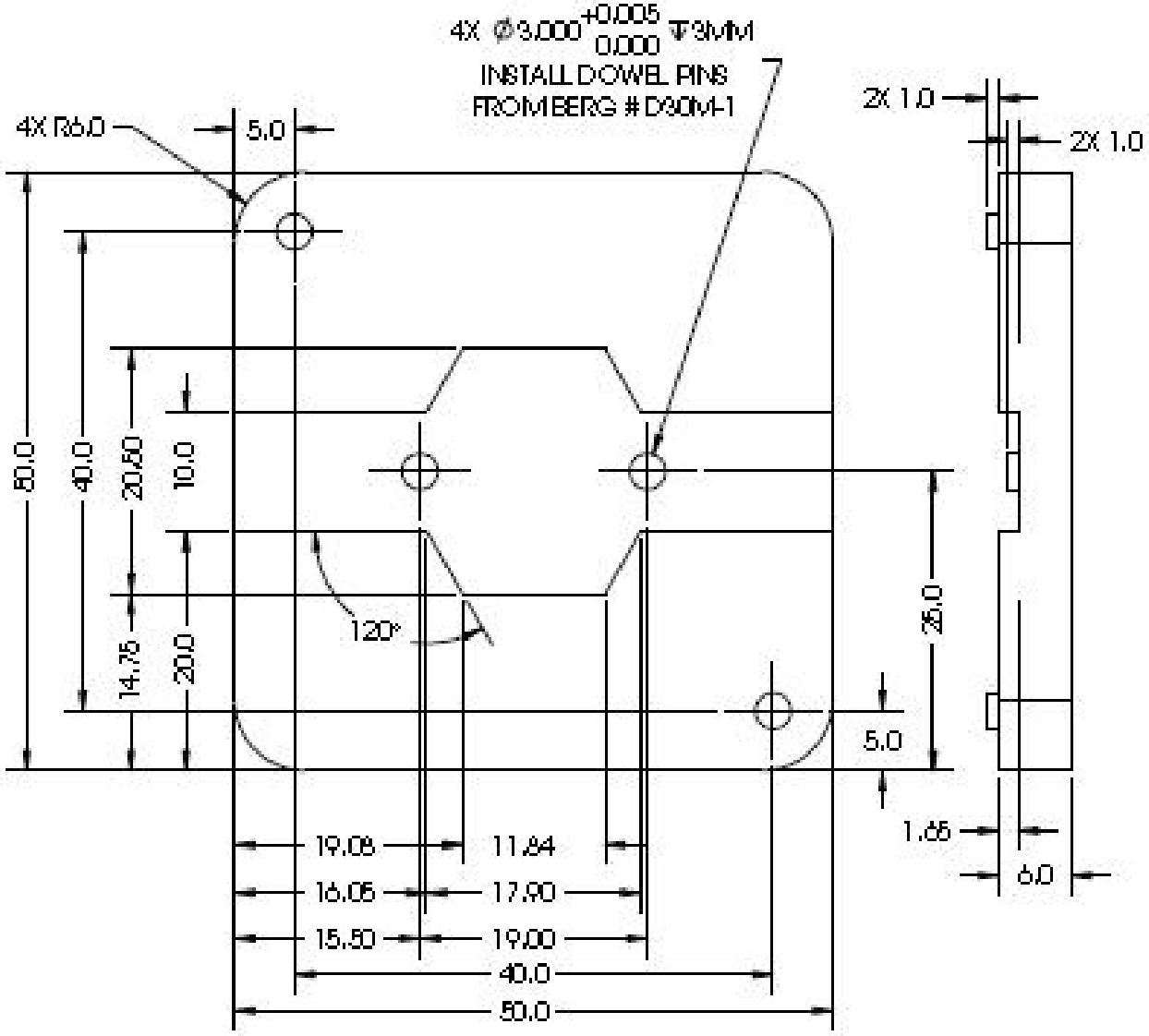

Figure A3: Single Star LED Array solder stencil alignment plate drawing
(Drawing not to scale, all dimensions are in millimeters)

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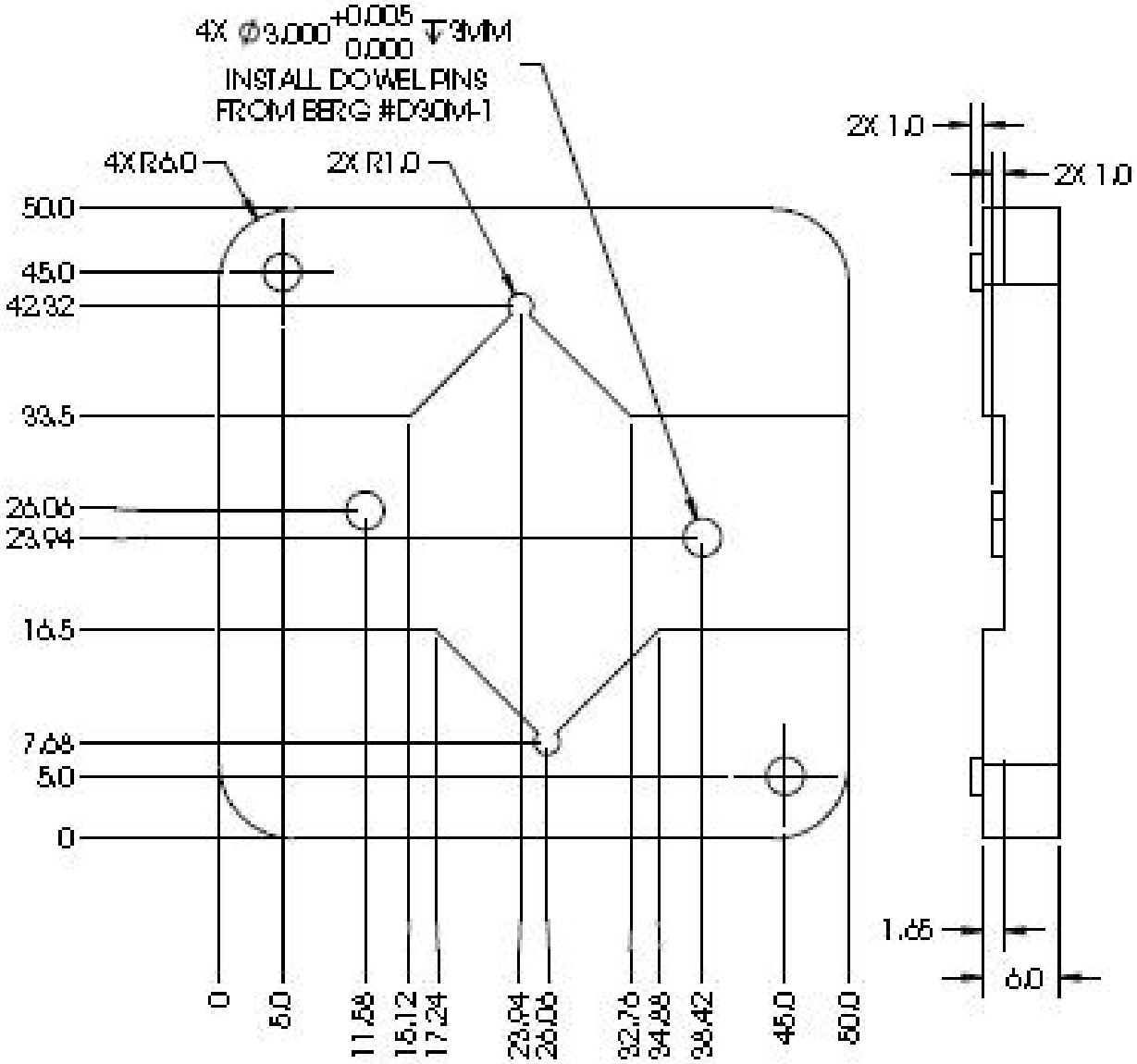

Figure A4: Single Rectangular LED Array solder stencil alignment plate drawing
(Drawing not to scale, all dimensions are in millimeters)

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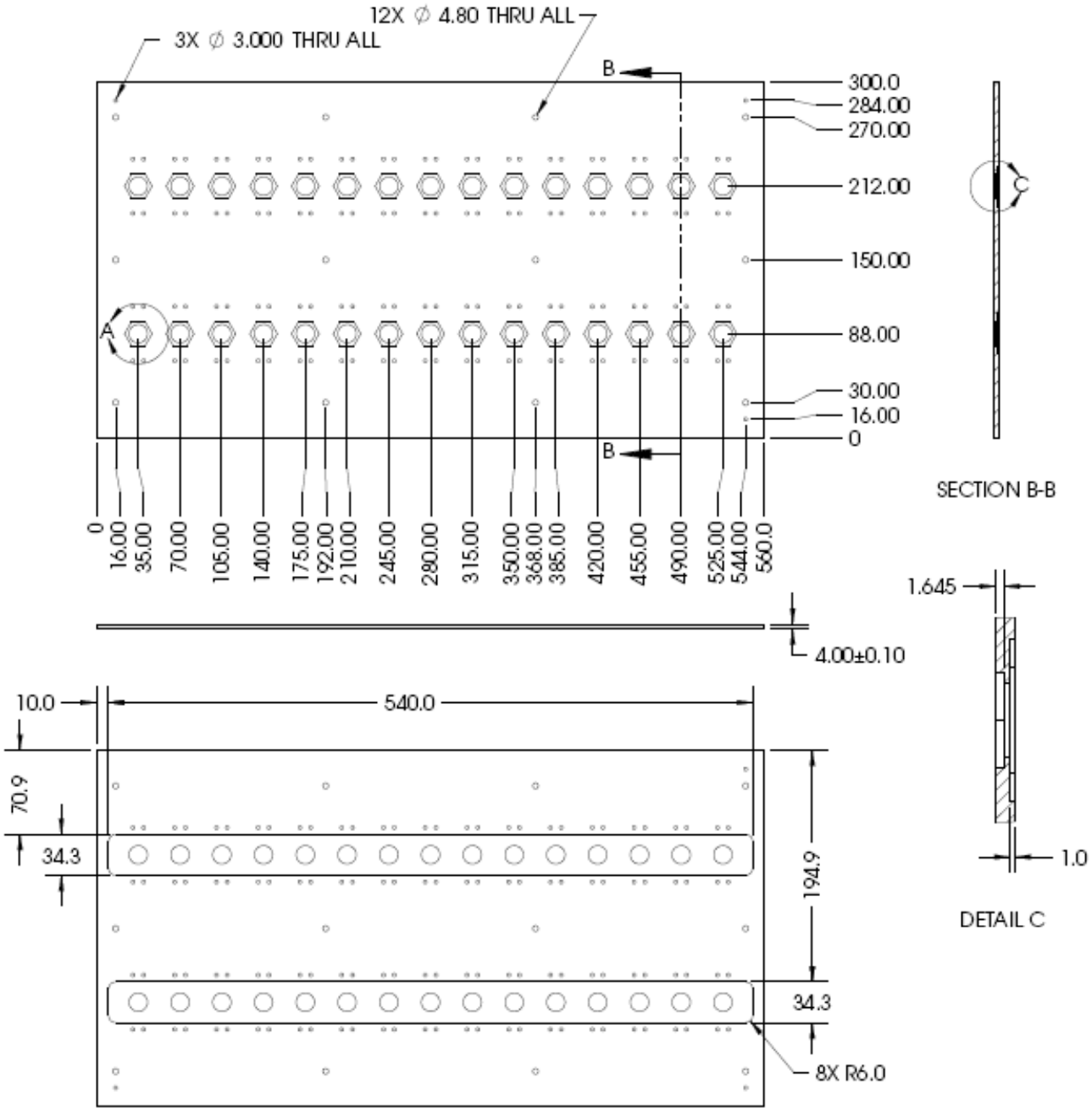

Figure A5a: Star LED Array solder reflow fixture bottom plate drawings
(Drawings not to scale, all dimensions are in millimeters)

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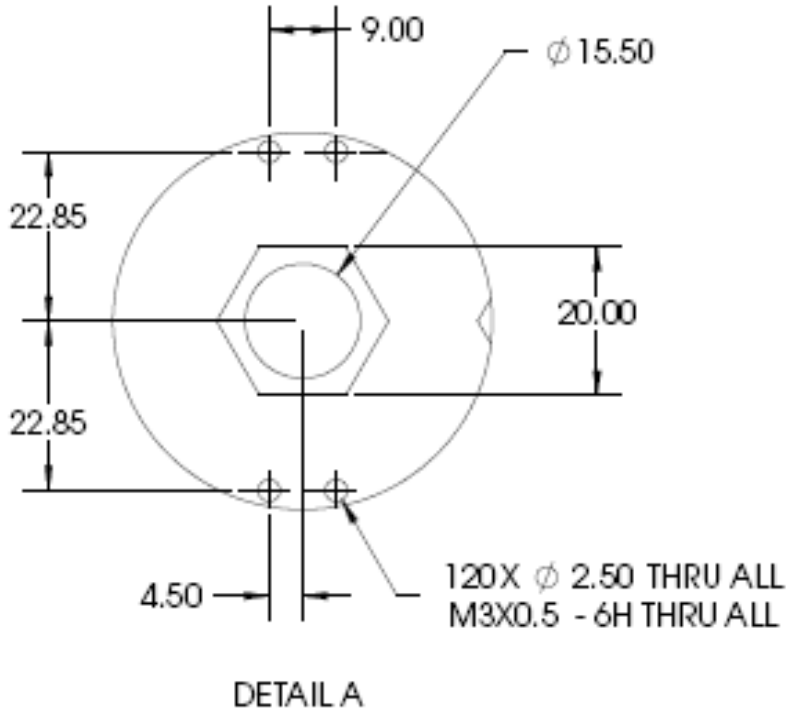

Figure A5b: Star LED Array solder reflow fixture bottom plate drawing detail
(Drawing not to scale, all dimensions are in millimeters)

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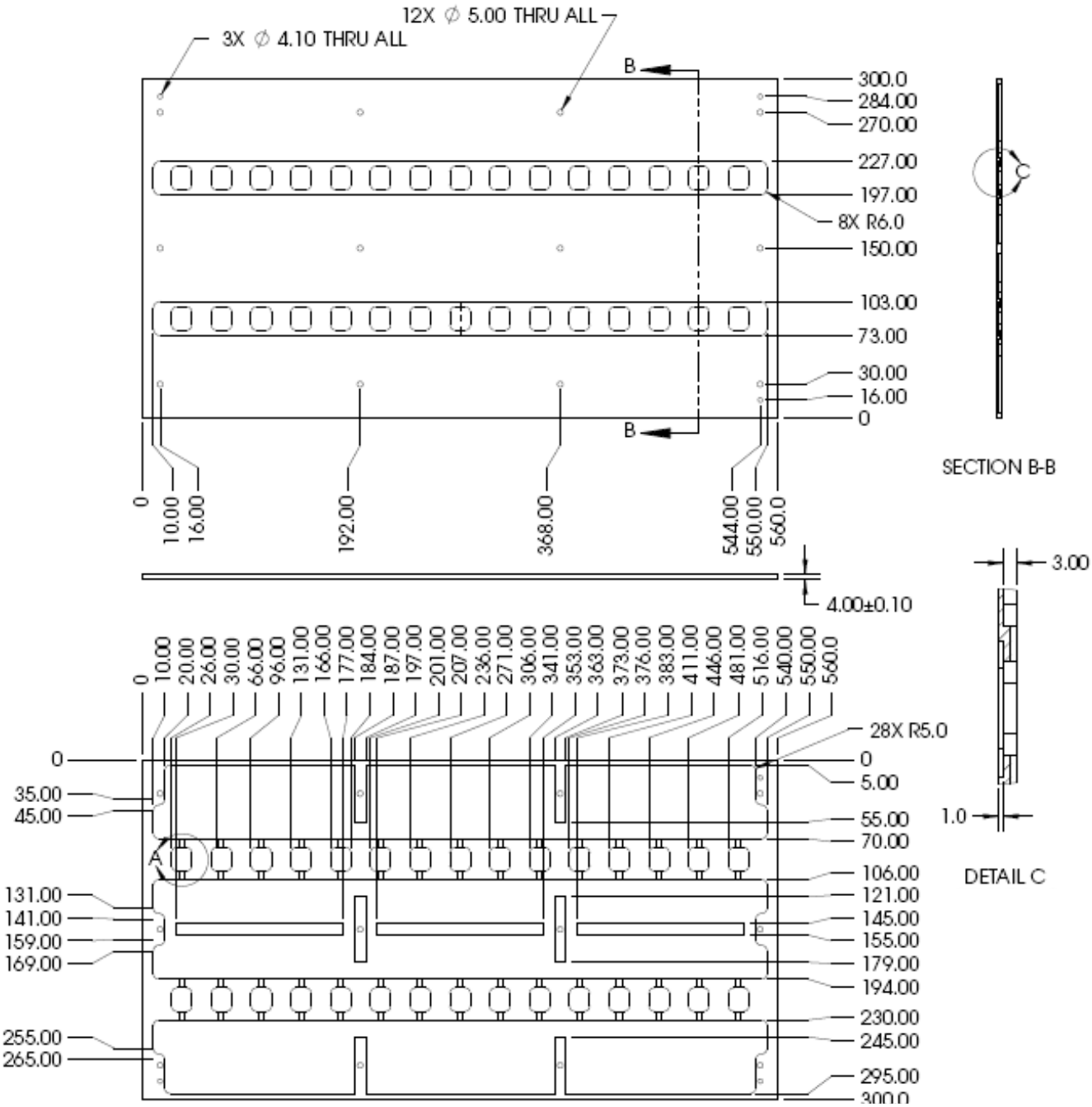

Figure A6a: Star LED Array solder reflow fixture top plate drawings
(Drawings not to scale, all dimensions are in millimeters)

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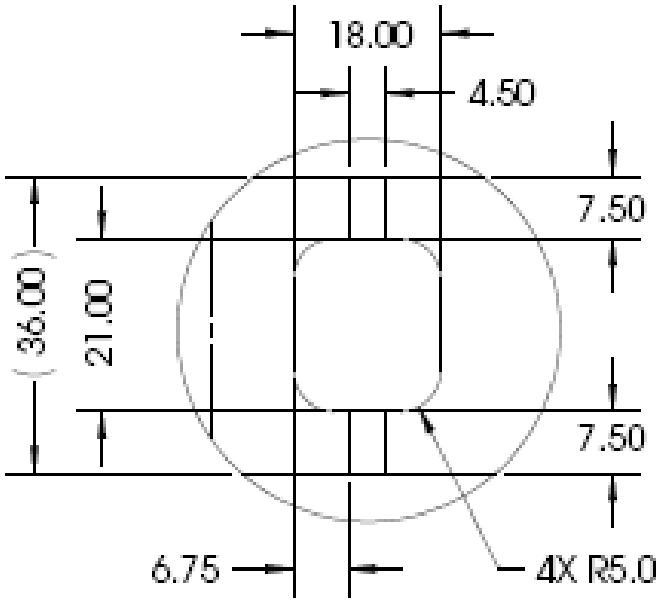

Figure A6b: Star LED Array solder reflow fixture top plate drawing detail
(Drawing not to scale, all dimensions are in millimeters)

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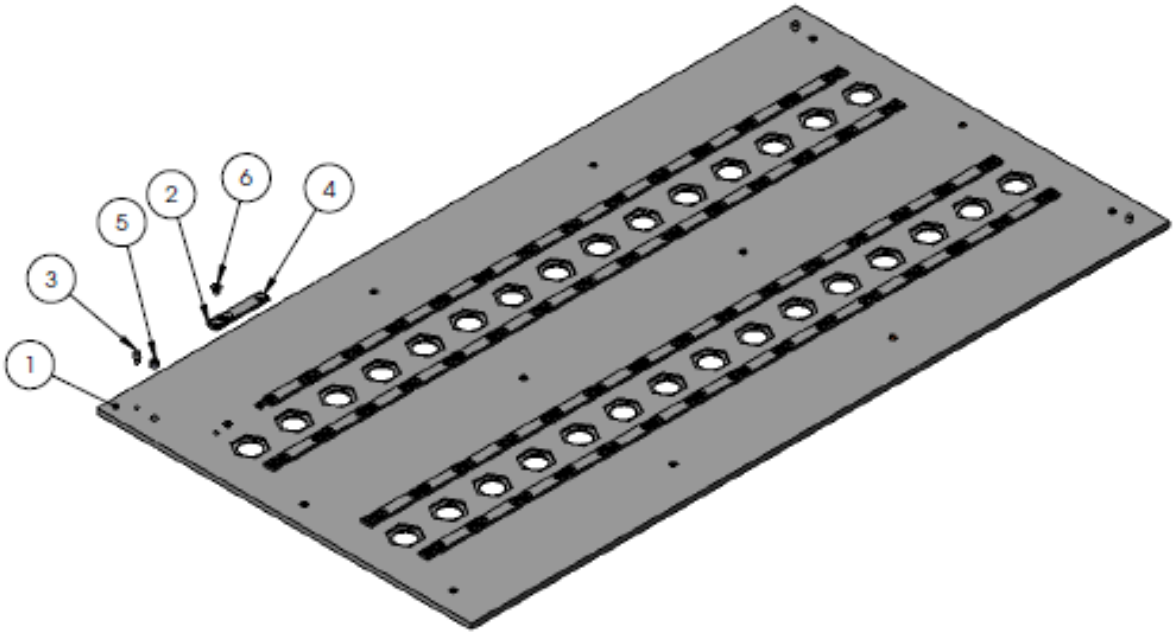

ITEM NO.	PART NUMBER	DESCRIPTION	Exploded/ QTY.
6	B18.6.7M - M3 x 0.5 x 5 Type I Cross Recessed FHMS –5N		120
5	STKB-M3-4_PEM	Thru-Threaded, Knurled - Types STKB, STKC	12
4	110581	BLOCK, FIXTURE, REFLOW, RECT,	56
3	HFP BA 3 - P4 - L3.5 - B4	PIN, GUIDE, 304 SST (MISUMI) OR EQUIV.	3
2	110580	BLOCK, FIXTURE, REFLOW, SQ.,	10
1	110577	PLATE, FIXTURE, REFLOW, STAR, BOT	1

Figure A7: Star LED Array solder reflow fixture bottom plate assembly drawing
See figures 11 and 12 for item numbers 2 and 4 in parts list above
(Drawing not to scale, all dimensions are in millimeters)

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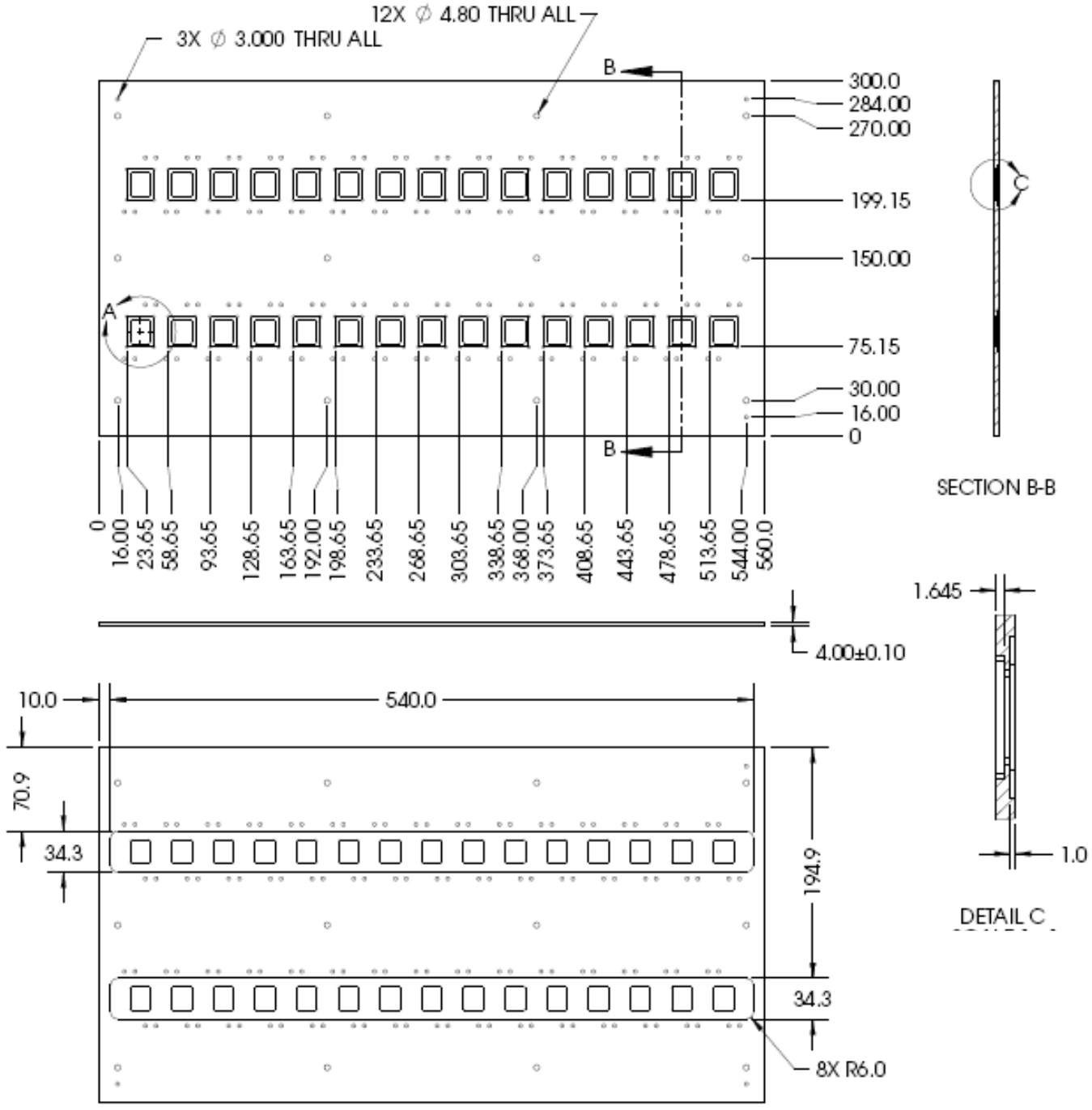

Figure A8a: Rectangular LED Array solder reflow fixture bottom plate drawings
(Drawings not to scale, all dimensions are in millimeters)

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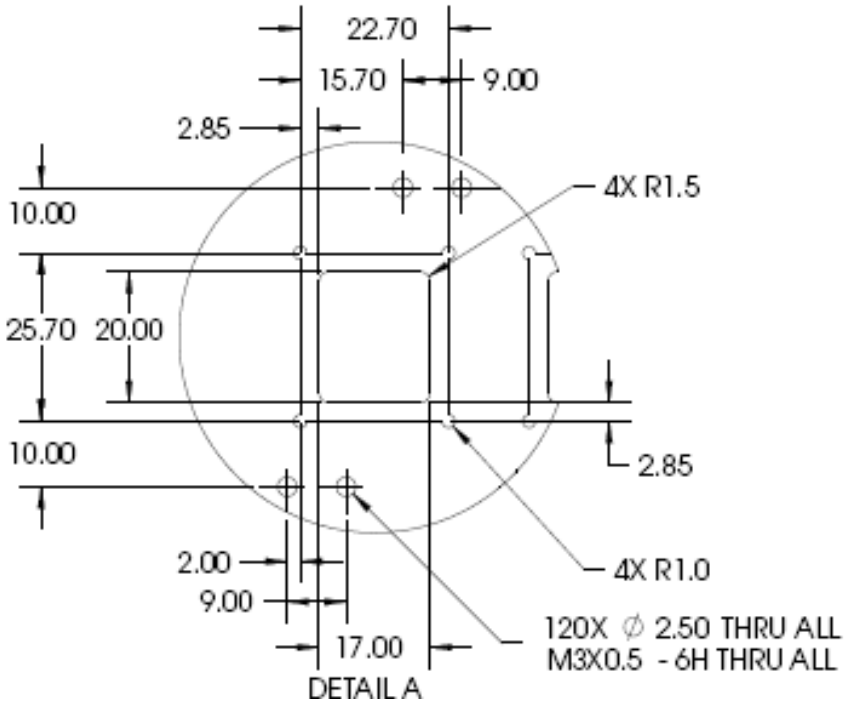

Figure A8b: Rectangular LED Array solder reflow fixture bottom plate drawing detail
(Drawing not to scale, all dimensions are in millimeters)

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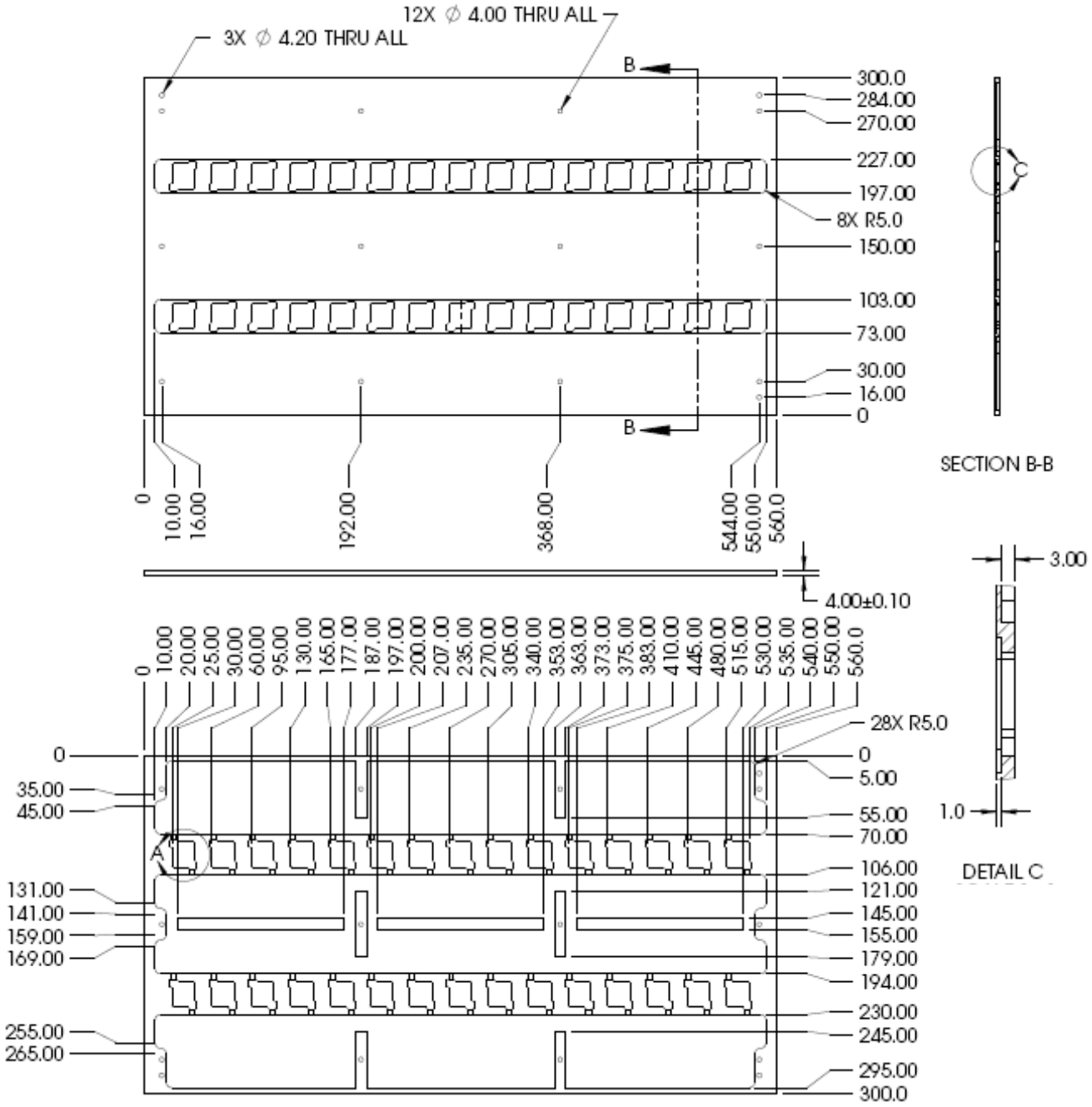

Figure A9a: Rectangular LED Array solder reflow fixture top plate drawings
(Drawings not to scale, all dimensions are in millimeters)

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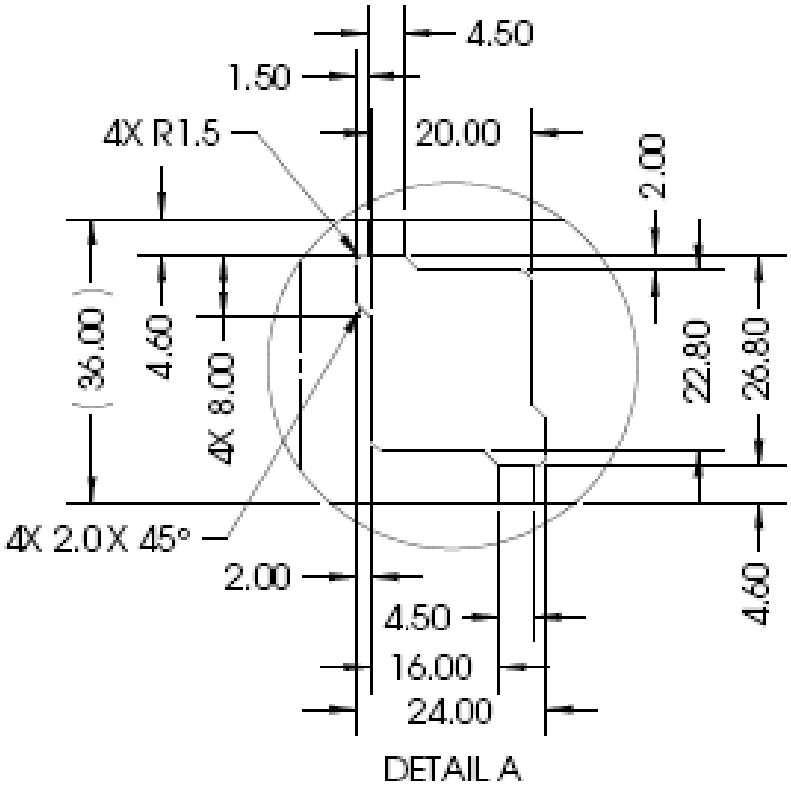

Figure A9b: Rectangular LED Array solder reflow fixture top plate drawing detail
(Drawing not to scale, all dimensions are in millimeters)

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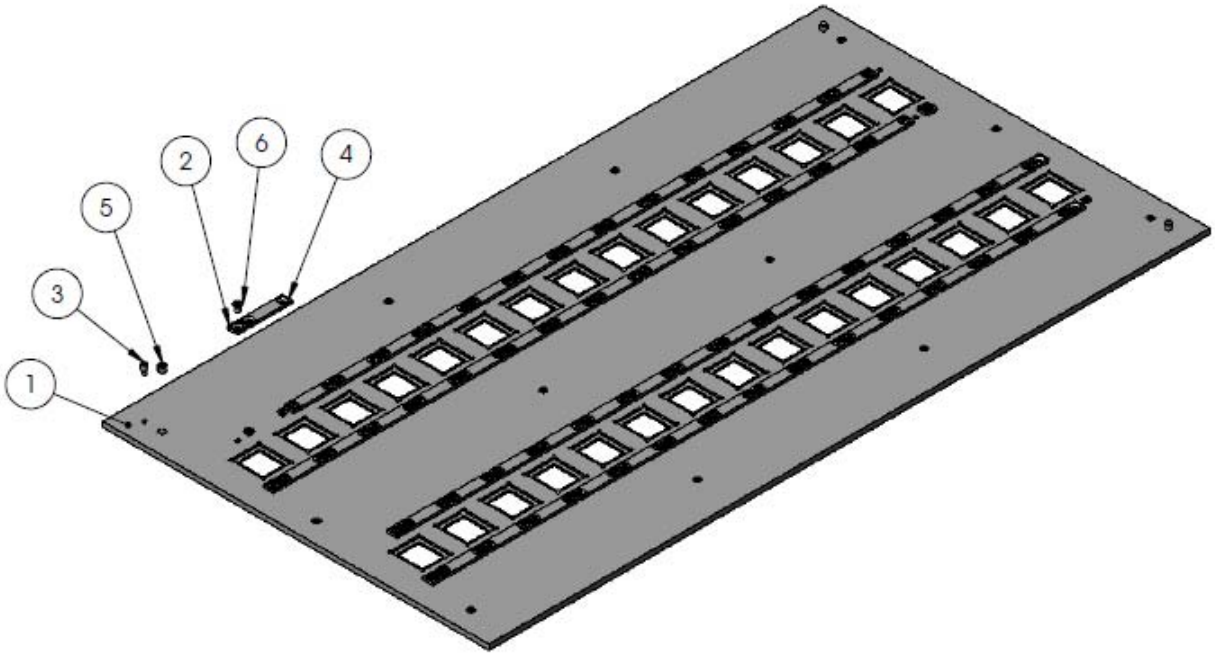

ITEM NO.	PART NUMBER	DESCRIPTION	Exploded/ QTY.
6	B18.6.7M - M3 x 0.5 x 5 Type I Cross Recessed FHMS --5N		120
5	STKB-M3-4_PEM	Thru-Threaded, Knurled - Types STKB, STKC	12
4	110581	BLOCK, FIXTURE, REFLOW, RECT,	56
3	HFP BA 3 - P4 - L3.5 - B4	PIN, GUIDE, 304 SST (MiSUMi) OR EQUIV.	3
2	110580	BLOCK, FIXTURE, REFLOW, SQ.,	10
1	110576	PLATE, FIXTURE, REFLOW, RECT, BOT	1

Figure A10: Rectangular LED Array solder reflow fixture bottom plate assembly drawing
See figures 11 and 12 for item numbers 2 and 4 in parts list above
(Drawing not to scale, all dimensions are in millimeters)

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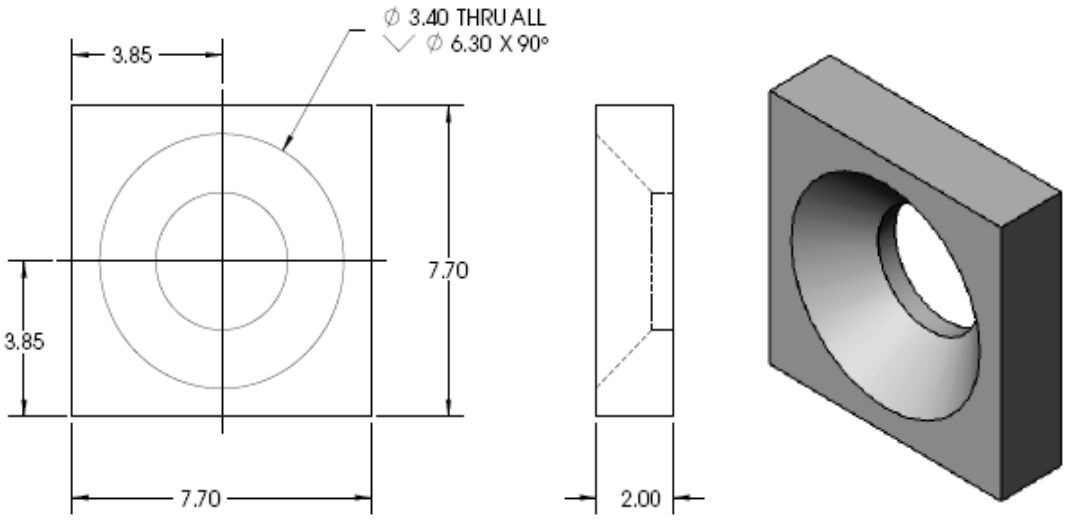

Figure A11: Wire guide, item number 2 from assembly drawings
(Drawing not to scale, all dimensions are in millimeters)

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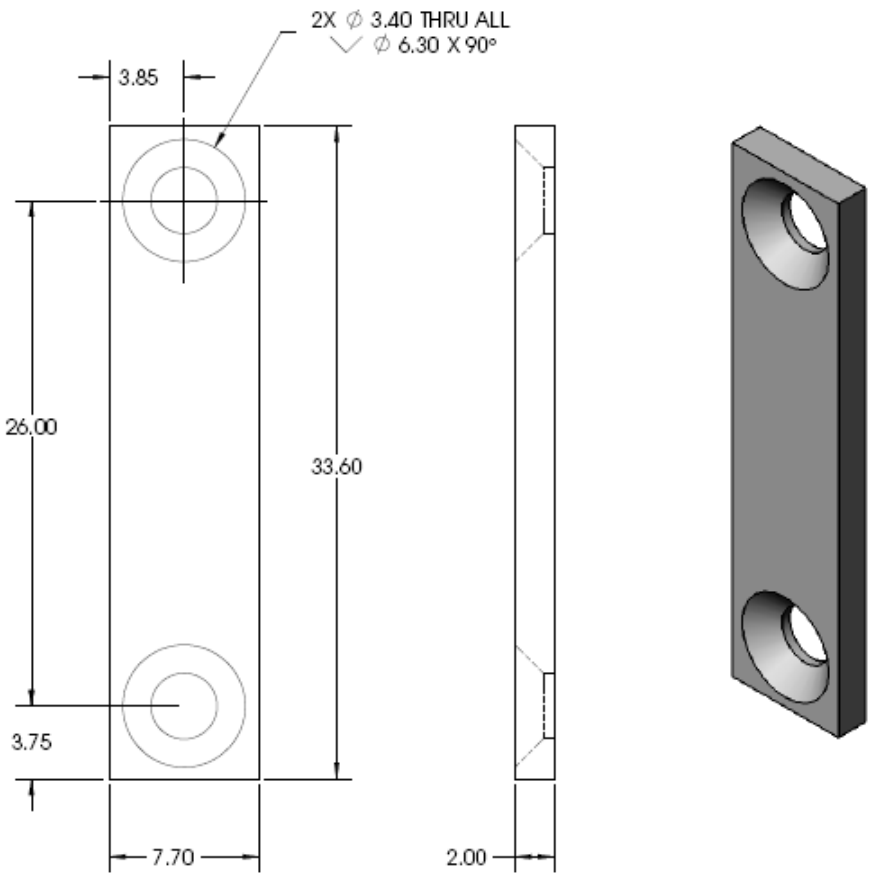

Figure A12: Wire guide, item number 4 from assembly drawings
(Drawing not to scale, all dimensions are in millimeters)

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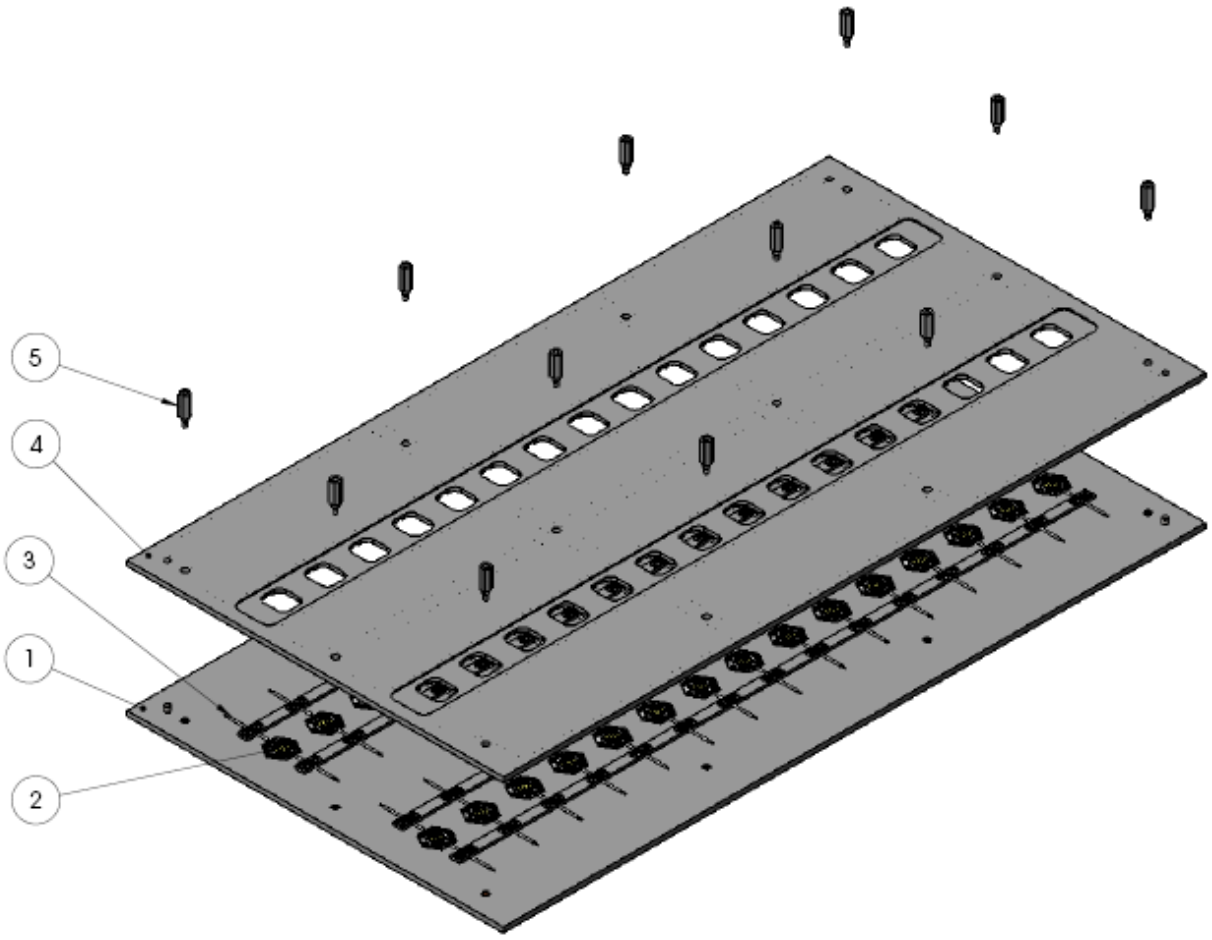

ITEM NO.	PART NUMBER	DESCRIPTION	Exploded/ QTY.
5	Standoff_Modified		12
4	110579	PLATE, FIXTURE, REFLOW, STAR, TOP	1
3	Fixture_Plate_Reflow_Wire		60
2	BL_Star_Final	LAYOUT, STAR, MFG	30
1	550040	ASSY, FIXTURE, REFLOW, STAR, BOT	1

Figure A13: Star LED Array solder reflow top and bottom plate assembly drawing
(Drawing not to scale, all dimensions are in millimeters)

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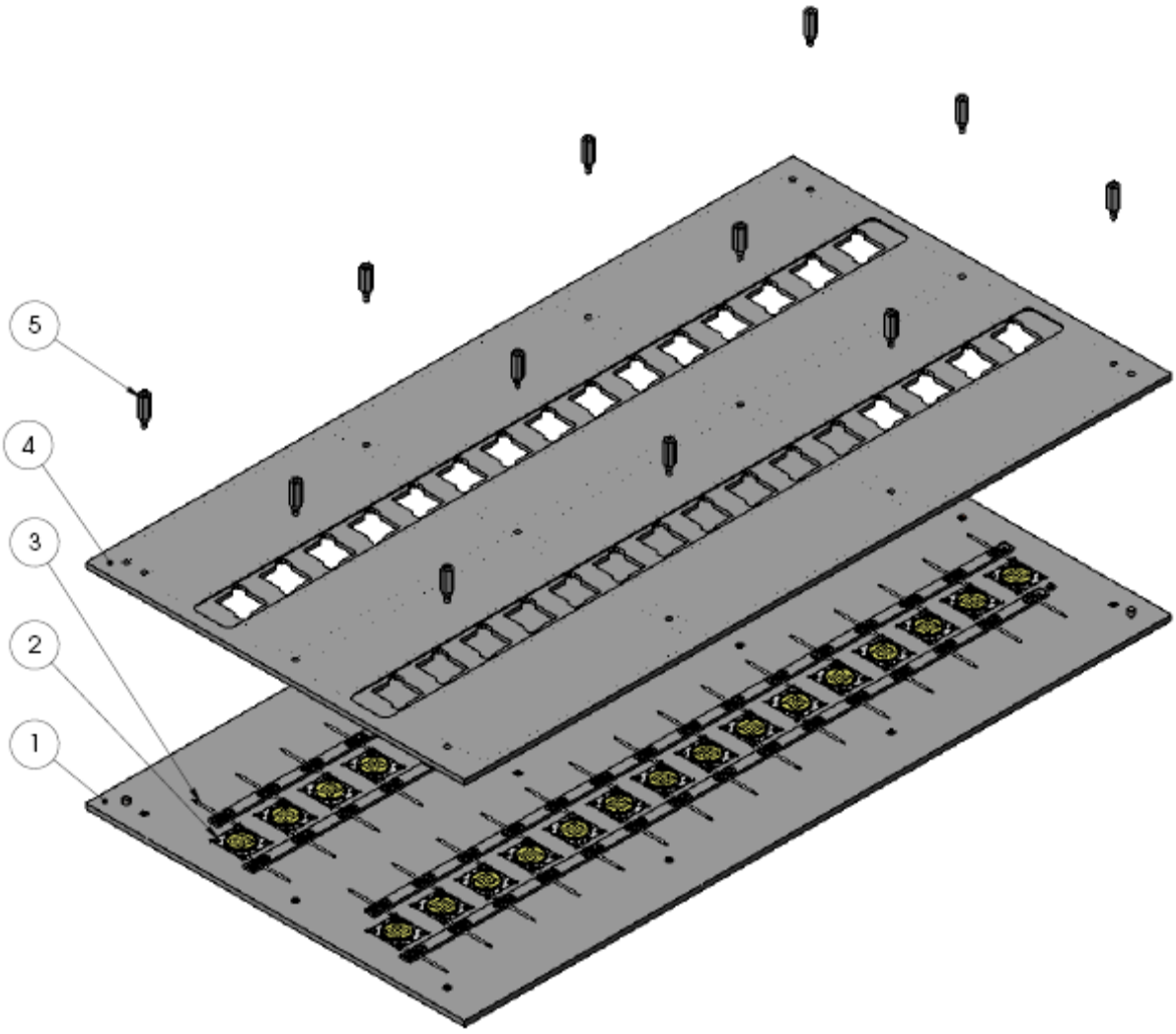

ITEM NO.	PART NUMBER	DESCRIPTION	Exploded/ QTY.
5	Standoff_Modified		12
4	110578	PLATE, FIXTURE, REFLOW, RECT, TOP	1
3	Fixture_Plate_Reflow_Wire		60
2	BL_Rect_Final	LAYOUT, RECT., MFG	30
1	550039	ASSY, FIXTURE, REFLOW, RECT, BOT	1

Figure A14: Rectangular LED Array solder reflow top and bottom plate assembly drawing
(Drawing not to scale, all dimensions are in millimeters)

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Resources

Electronic Assembly Standard Information

www.ipc.org

IPC Task Group of the Product Assurance Subcommittee, IPC-A-610D Acceptability of Electronic Assemblies, Curran Associates Inc, 2005

Acknowledgements

Nexlogic Technologies and Bridgelux worked collaboratively to develop this reflow process. Nexlogic Technologies may be reached at:

Nexlogic Technologies
2075 Zanker Road
San Jose, CA 95131
+1 (866) 845-1197
+1 (408) 436-8150
www.nexlogic.com

About Bridgelux

Focused on bringing innovation to light, Bridgelux is a leading provider of high-power, cost-effective and energy-efficient light-emitting diode (LED) solutions. The company's proprietary epitaxy technology, innovative chip designs and leading-edge LED packaging technology have enabled the company to develop advanced solid-state lighting (SSL) products that offer superior quality, are lower in cost and environmentally friendly—all without compromising performance. In addition to LED chips, the company delivers a range of SSL light sources that customers can easily integrate into a variety of lighting applications that will open up new markets in solid-state lighting. Founded in 2002, Bridgelux is headquartered in Sunnyvale, California. For more information about the company, please visit www.bridgelux.com

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