ASSEMBLY PROCEDURE FOR S250-PCB, S300-PCB S350-PBC HIGH CURRENT PCB LUGS

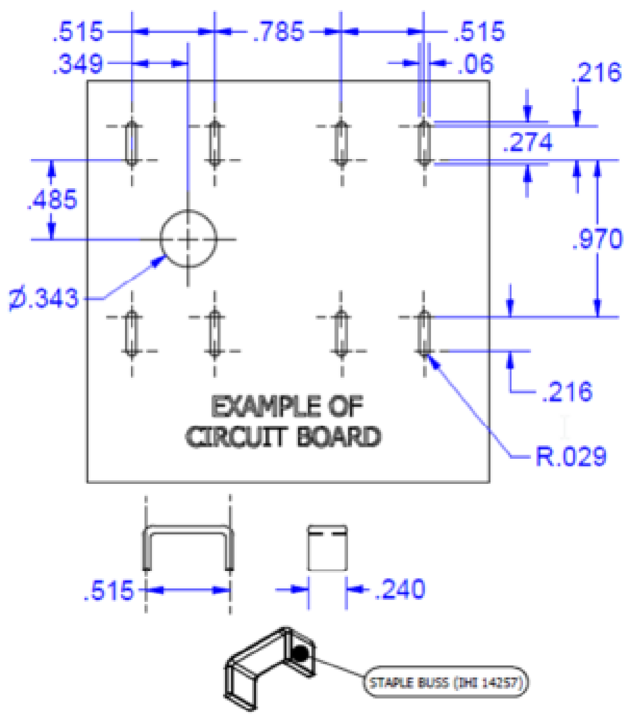
1. Solder the 4 pcs 14257 copper shunt staples into the routed PCB slots per the layout provided. These are wave solderable. These behave as anti-rotation stops for the lug, and current / heat transfer shunts for the lug to foil.

Slots should be plated through to help shunts contact top, bottom, and any intermediate foil layers by being substantially wetted.

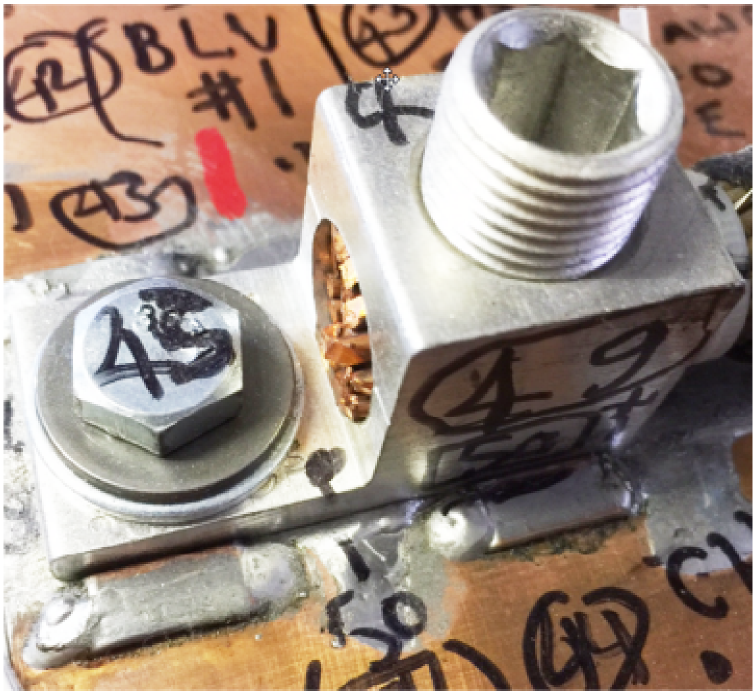
Adjustments may need to be made to ensure the width of the lug will fit comfortably within the staple array. Better to have some extra clearance than interference which could prevent flat seating of the lug bottom.

Layout for S250-PCB and S300-PCB.
Note! For S350-PCB the dimensions 0.485" and 0.970" will be wider at 0.532" and 1.064" respectively.

Final dimensions will depend on the customer construction and soldering pads so to uses as a starting point only.

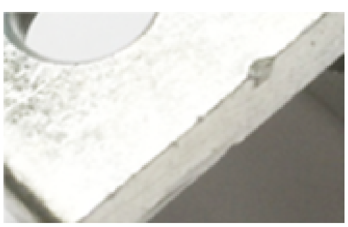


2. The contact pad may be plated with tin, or unplated copper foil, if clean and bright. (IHI has tested both surfaces with the same contact resistance over time).



3. The contact pad may have several plated through vias to help distribute current and heat in the pad zone if the surface remains flat. IHI test boards had none so are worst case, relying on the four shunt staples to transfer all current and some heat.

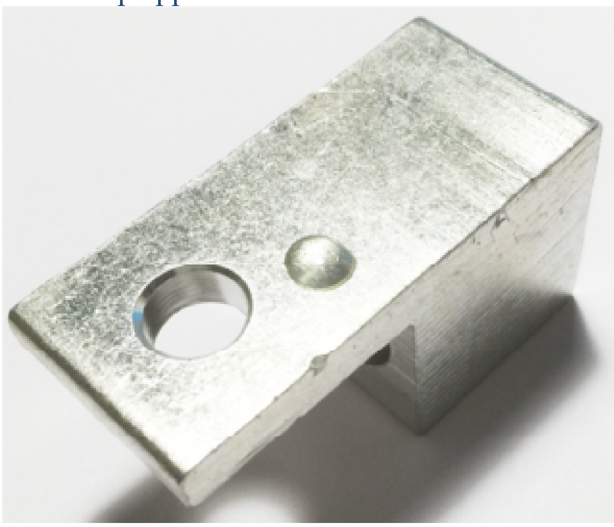
4. When all the PCB processing is complete and PCB is ready for final terminal assembly, confirm pads are 100% bare and clean, flat contact surfaces, no dielectric interference in the contact zone. If there is an unusually prominent handling nick or burr on the critical lug edge surface, remove it.



5. Apply a small amount (one drop is generally all it takes to wet the entire surface) of SANTOVAC-5 pure 5 ring PPE to each surface (pad and lug bottom) and spread to pre-wet each surface 100% of each entire contact surface.

About 0.10 ml of fluid per lug is required (2 small drops or 1 large drop depending on dispensing methods).

With drop applied

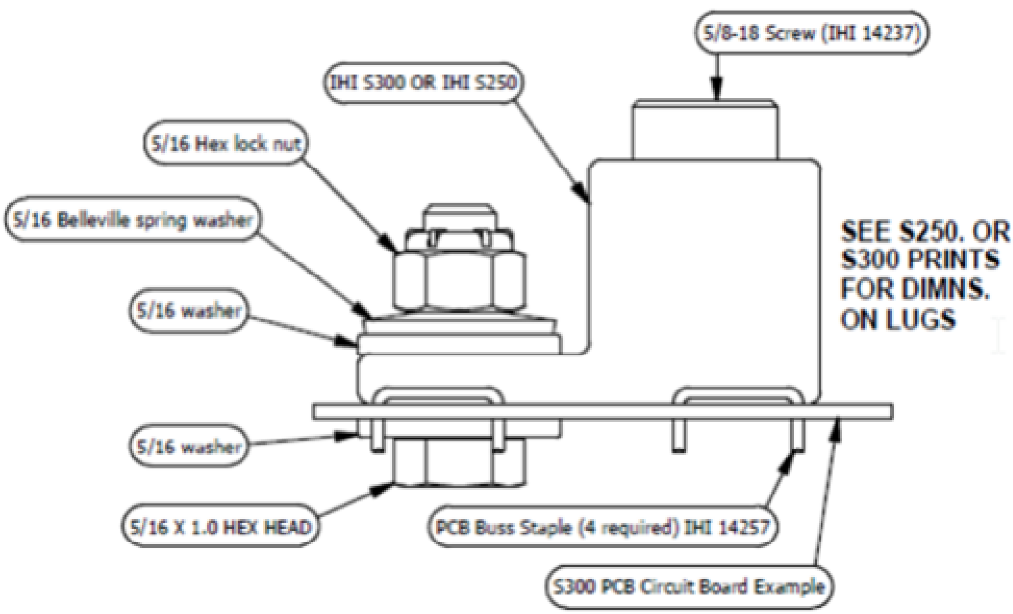


After spreading drop over lug contact surface

6. Some migration (flow) of excess contact lube may occur at higher temperatures. Do not use excessive amounts to avoid that.

7. No grit or dirt contamination of the mating surfaces prior to assembly.

8. Mount the lug with the bolt assembly provided exactly per the print (5 piece hardware assembly plus 1 lug).



9. Tighten to 150 inch-pounds (17 N-M) torque. The nylon shake proof nut will consume about 40 inch-pounds (4.5 N-M) leaving about 110 inch-pounds (12.4 N-M) conventional clamping torque on the bolt.

10. Check that the Belleville (cone spring washer) is substantially or completely flattened allowing maximum creep take up stroke.

11. Note that optimum PCB creep “loss of FR4 thickness” in the cone washer after compression is about .005” (0.127mm) and total active residual stroke of about 0.01” (0.26mm).

12. The wire mounted in the lug should have a strain relief separate from the PCB and should have enough flexibility in the wire to avoid applying forces to the lug that could interfered with the floating of the lug contact surfaces or damage the PCB.

13. The assembly would be expected to pass pull out testing to meet the pull out force tables in UL486A-B or UL486E for qualifying factory wiring. The strength of the PCB itself and its mounting is entirely up to the user to determine.

14. Current in the lug should never exceed the 75°C current table amperage per NEC recommended ampacity, using the appropriate wire rated cable gauge in the chart.

15. Copper or aluminum cable may be used. Use the appropriate 75°C column derating for aluminum per the NEC ampacity chart.

16. Aluminum wire should be wire brushed and coated with an approved De-Ox anti-oxidant dielectric grease in accordance with wire manufacturers’ instructions.

17. The temperature of the lug should never exceed 75°C

18. A conservative design would keep the heat rise to about 30°C over ambient.

19. A rule of thumb is that the life of PCB assemblies is cut it by 50% for every 10°C increase in operating temperature.

20. As with all power PCB designs, current limiting (fold back) based on excess temperatures are essential. No extended period overcurrent may be permitted.

21. Temperature rise Time Constant of a 300kcmil copper wire at 305 Amps is about 1 hour

22. Since IHI or Advancement International Ltd., does not approve any particular application or design, even if giving some general guidance. 100% of all customer design assumptions must be tested by the customer under all of the conditions that may be encountered and for extended periods of time including high cycle testing and failure mode testing. The validation of the design for the purpose intended and its reliability is entirely the purchaser’s responsibility.

23. IHI and Advancement International Ltd do not give any warranty or make any fitness for purpose claims.

TESTING DATA:

1. All testing of these PCB lug assemblies has been using 3 ounce copper double sided and .06 inch (1.5mm) thick FR4. Large foil areas were provided to take current from one end of the PCB to the other. The contact surface should not be less than 3 ounces or current derating will be required.

2. Horizontal orientation of the PCB, no forced air cooling. Ambient temperatures of 18°C-24°C were typical.

3. The total copper foil should not be less than 6 ounces (2 x 3 oz. copper) or current derating will be required.

4. Current in the lug should never exceed the 75°C current table for NEC recommended ampacity.

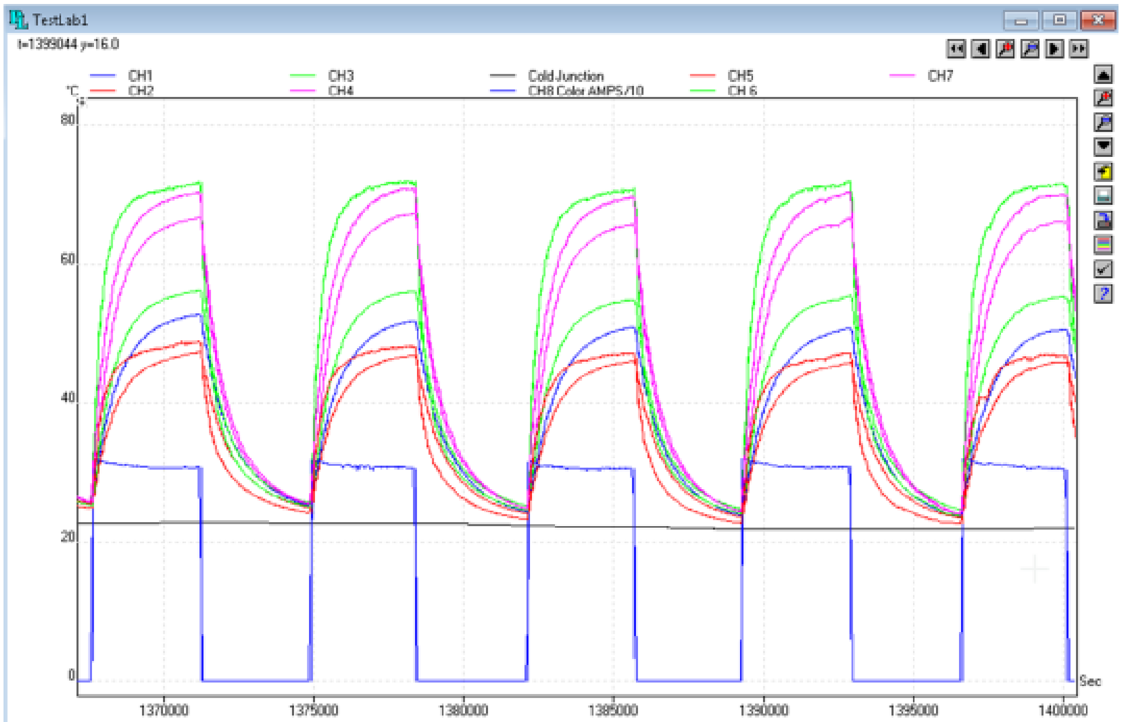
5. 8000+ cycle test on the double sided version at 305 amps shows no decline in voltage drop between the wire and copper foils (drop across the connection including wire to lug connection and lug to PCB foils connection.

6. Resistance (Kelvin dual lead process) based on volts drop at 305 Amps is 15-30 micro Ohms. (15-30 x10-6 Ohms). This has held for two years at 4000+ cycles per year for a total of 8,000+ cycles.

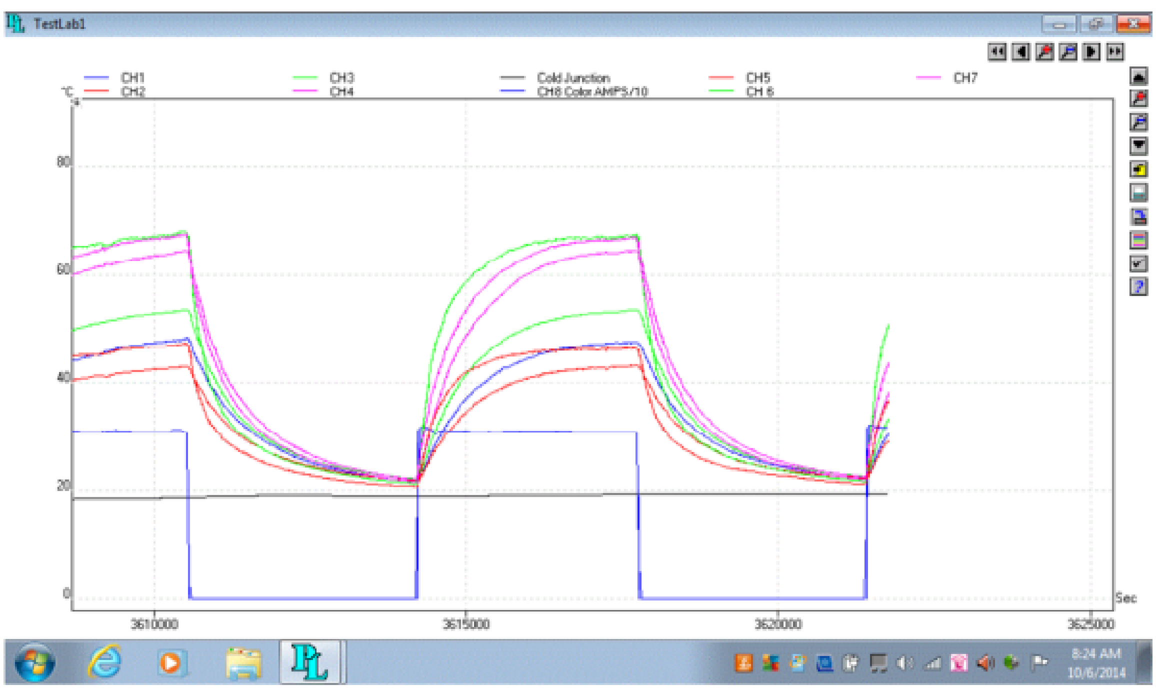
7. Power loss: About 2 watts consumed per lug at 305 Amps using 300 kcmil copper wire.

TEMPERATURE AND CURRENT CHARTING USING PICO-08 THERMOCOUPLE LOGGING UNIT

February 2014



October 2014



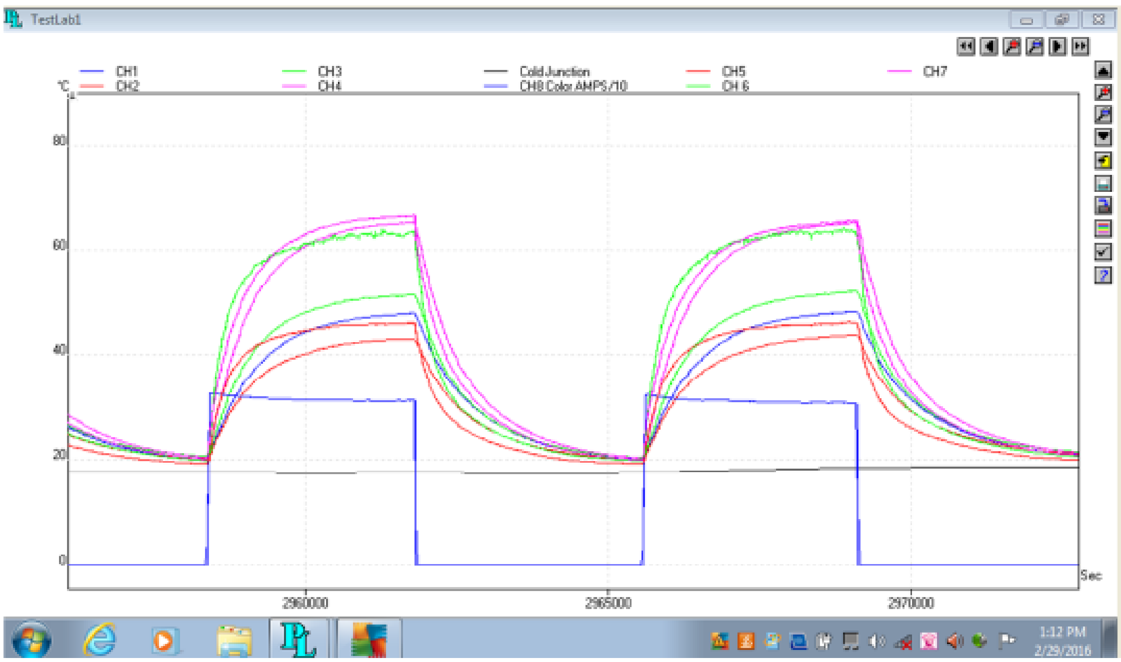
After 2500 cycles. Double sided attachment to PCB with staples-Lugs temperatures CH1 (blue) and CH2 (lower red). Blue square wave is current divided by 10.

Single sided attachment to PCB with NO staples (Finding the limits) lug temperatures CH3 (lower green) and CH4 (high magenta)

Testing started February 16-2014 and continues to current date, February 29-2016.

No noticeable changes after more than 8,000 2 hours cycles, 1 hour on 1 hour off.

February 2016



After 2 years 24/7, 8,000+ cycles x 2 hours 1 hour on 1 hour off, still going strong.

FAILURE MODE ANALYSIS

Failure mode analysis test of "let's design it to break" non-suggested PCB design, NOT used as suggested. Short term current overload stress testing of this terminal arrangement using only ONE side of the dual sides 3 ounce copper, NO staples to bus current and heat to bottom foil (steel bolt would pass little current at 12-15% IACS) and at 500 Amps (+ 64% over suggested) stress test. Comprises a completely inappropriate construction and current ampacity level.

Result: Much higher temperatures caused adhesive foil delamination under lugs that were not supported with shunt staples and dual foil. No increase in volts drop or resistance of connection was seen so power loss was the same but an increase in temperature due to poor foil contact with FR4 substrate was seen. In spite of this, the “let’s design it to break” test has also exceeded 8000 two hour cycles at 305 Amps 300kcmil copper wire, with no volts drop degradation. Delaminated foil is not desirable since lug temperatures increase due to poor conductivity to the FR4. Foil delamination under customer tests should be a “fail”.

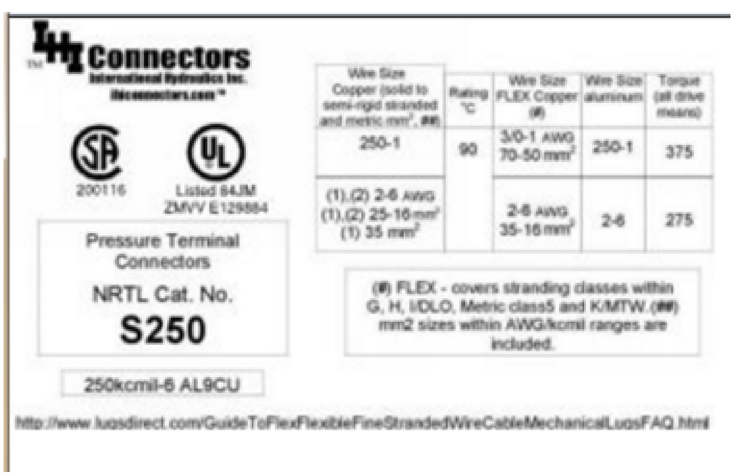
No permanent damage to any part of the construction should occur during product testing and be considered acceptable.

Conclusion: use of only one active layer of 3 ounce copper and no shunt staples bussing heat / current transfer and 64% over current causes overheating (t = >75°C) and foil delamination. But no immediate failure or increase of contact resistance other than temperature coefficient related. Result of delamination under lug is increase of temperature of lug due to poor thermal conduction to FR4 and the other side of PCB (air cooling).

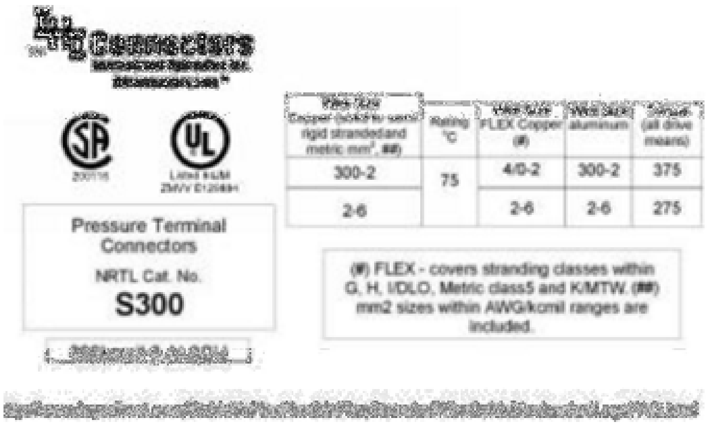
A single time, 1 hour long 500A overcurrent stress test on the properly constructed, dual sided PCB, with four shunt staples, showed no detriment whatsoever.

Both versions went on to complete 8,000 cycles at 305Amps.

WIRE RANGES AND TIGHTENING TORQUES FOR S250 AND S300 LUGS



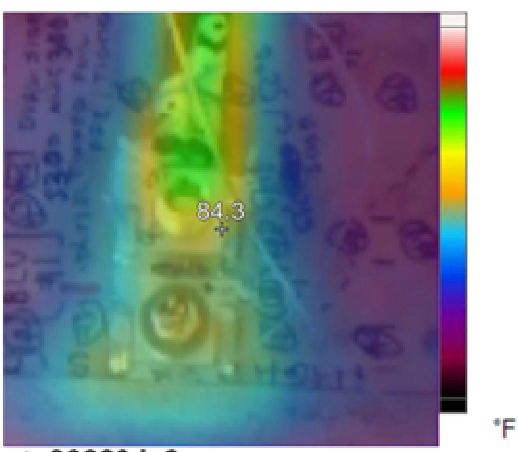
Wire Size Copper (solid to semi-rigid stranded and metric mm², ##)	Rating °C	Wire Size FLEX Copper (#)	Wire Size aluminum	Torque (all drive means)
250-1	90	3/0-1 AWG 70-50 mm²	250-1	375
(1),(2) 2-6 AWG (1),(2) 25-16 mm² (1) 35 mm²		2-6 AWG 35-16 mm²	2-6	275



THERMOGRAPHIC ANALYSIS (SEE NOTES BELOW)

Inspected By:

Inspection Date:	1/16/2015 9:21:47 AM	Location	
Equipment		Equipment Name:	
Ambient Air Temp:		Wind Speed	
Load (%)		Max Rated Load:	
Exception Temperature:		Potential Problem	
Recommended Action		Repair Priority:	
Emissivity:	0.95	Reflected Temperature:	68.0 °F
Camera Manufacturer	Fluke Thermography	Camera:	13062647



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Visible Light Image

Fluke Thermography of S300-PCB lug at 305 Amps showing the 300 kcmil copper wire and head of the lug containing the wire, were running within normal heat rise expectations for the NEC ampacity tables, but more importantly, the mounting tang to PCB interface was running cooler than the wire indicating: 1. Low resistance of the contact connection (low I^2R Watts) 2. Ample conduction of heat carried away by large foil area.