Precautions and Insights When Using SMT Surface Mount Technology

Table of Contents

List of Figures

IHI Brand, IHI Connectors ®/ International Hydraulics Inc. SMT Surface Mount Technology. Precautions before choosing SMT wire terminations. FAQ.

The increase in the use of SMT high density logic “micro” circuits has also increased the use of multi-layer PCB architectures. At the same time, really high currents are now routinely handled on PCBs where high current power can be controlled and switched using semi-conductors for numerous traditional and new applications in renewable energy, energy storage and conversion, and many other commercial and industrial control applications.

There are serious challenges to use of SMT methods for high current, large wire terminations which need to be fully understood by the customer when using SMT in place of THT (Through Hole Technology) to terminate high current wires, on the PCB.

After more than 20 years of experience shipping High Current THT technology, IHI has SMT products which can be carefully evaluated by our customers’ engineers for applicability.

Surface Mount Technology, by definition, excludes mechanical bus pass through to the opposite side of the PCB which reduces mechanical and electrical fortitude versus THT, and consequently requires CAREFUL DERATING, SAFETY REVIEWS, and PRODUCT LIFE REVIEWS for each customer application on its own merits. There is no shortcut for thorough testing by your design team in the assembled form in the worst-case situations, to ensure all of your assumptions are good. Given your obligation to do the due diligence testing on your particular application for durability and safety covering all possible scenarios, we have included some test formats that may be helpful as part of your total design review program.

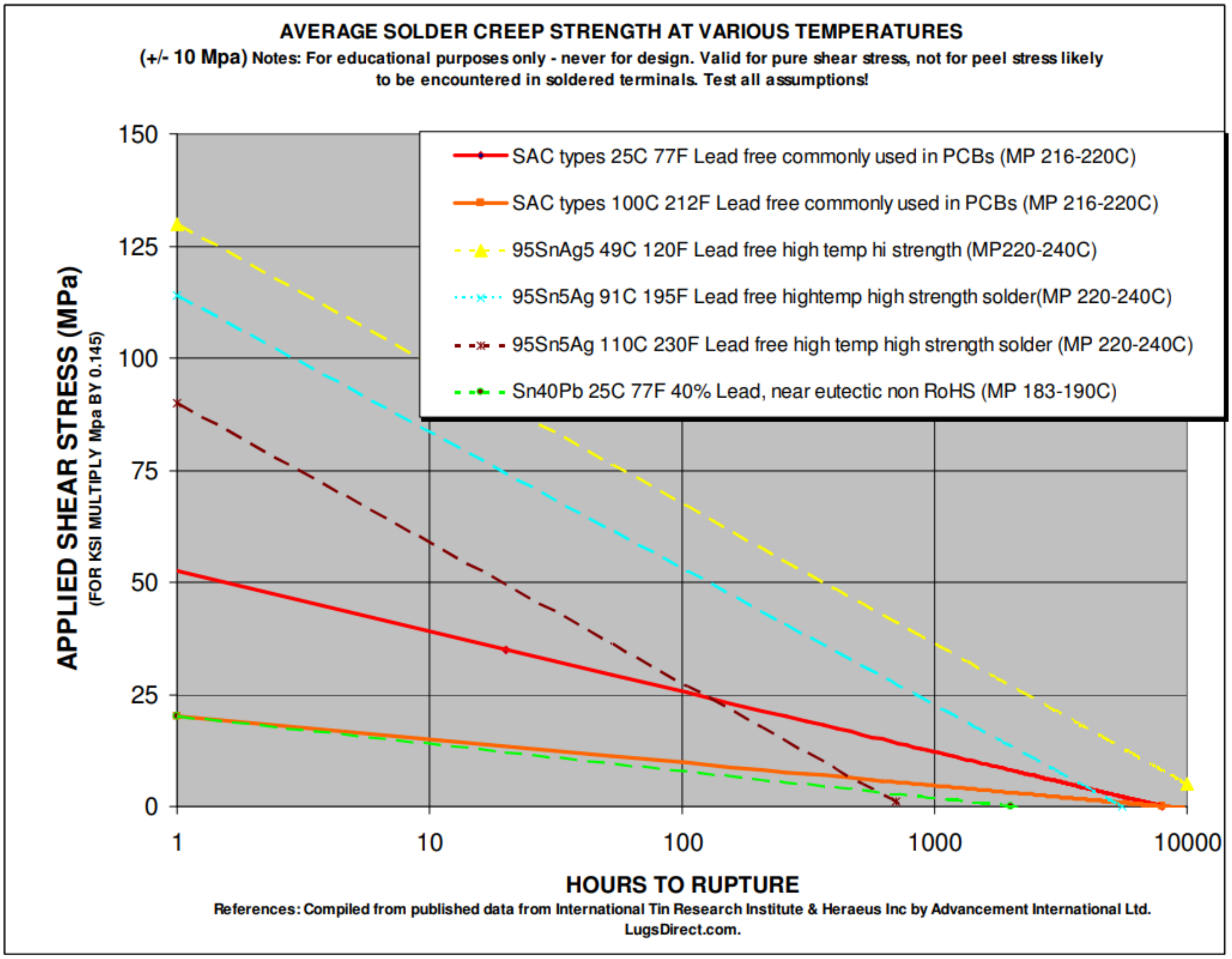
Some guidelines rules for use of SMT (Surface Mount Technology) in place of THT (Through Hole Technology) for PCB terminals. This is not by any means a full listing but a starting point for a complete engineering study developed by your team.

1. Always use THT as the first option. Do not use SMT unless you take responsibility to investigate the increased limitations and fully safeguard for them.

2. For SMT applications, solder alone is a poor mechanical joint – creep (movement) under small constant loads is significant (consult tin creep chart below). So long term loading (pull, push or twist) of soldered SMT terminals is a no-no. No constant loads are to be applied to the SMT terminal – all wires must be separately anchored elsewhere. The weight of wire or other forces hanging on the SMT terminal must be close to zero.

3. Avoid field wiring applications if the anchoring of the wire is up to the end user. You must be to know that the adequate anchoring of the wire is going to happen.

4. Anchor by default, like building the wire anchor into the case or so that the wire is fully clamped on the insulation when re-attaching the cover rather than expecting the end user to use a wire tie and not bothering to do so. Make sure wire anchors meet the wire pull forces that could be encountered.



5. Do full maximum current (or better, elevated over full current) heat rise and heat cycle tests to rule out fatigue of the solder joint caused by differential expansion and contraction between copper and aluminum. This phenomenon limits the maximum size of aluminum terminal that can be used with copper foils. The higher the heat range encountered at high cycles the more likely there is to be some stresses develop. All mechanical tests need to be done before AND AFTER a long-term cycle high current stress test.

   Following the format of UL486A-B where the testing method for aluminum wire in wire terminals is comprised of a 500 on, and 500 off, over-current cycles and should be a good starting point.

   If your application is heavily cycled in terms of current and temperature them you must consider that in the evaluation process.

   Typically for small light parts, 30 minutes is adequate to get the part up to full temperature and then another 30 minutes to get back near room temperature. The time for the duration of each cycle has to be sufficient to allow the maximum and ambient stable temperature to be reached with each cycle. If the temperature has not leveled off then use a longer time. A total time commitment of 500 hours or three weeks of 24/7 testing or longer.

Longer term testing should be done if any adverse signs show up or if the product will see rougher service in terms of current, number of cycles, harsh environment and other factors known to the customer. Use of fine stranded (flex) wires can increase chances of joint relaxation, wire oxidation and therefore hotter running over time and cycles. Test Currents: UL486 uses 1.60-1.65 times the continuous NEC 75C rated current for the wire used to carry out 500 cycle tests for COPPER wires.

To achieve NEC 90C current rating the test current is 2-2.5X the user current for copper wires. Bear in mind when attaching a terminal with solder to a PCB, rather than bolting it to full size copper bus, heat rises will likely be higher or much higher. Foil is a lot thinner than a typical electrical bus. Trace widths will not likely make up the deficit.

As a guide to the elevated test currents for industrial type electrical gear these are for 75C and 90C wire insulation (and therefore user current rating) respectively
AWG#10 rated at 30A in use, 500 cycle test at 56A (90C rating test at 75A)
AWG#8 rated at 50A in use, 500 cycle test at 80A (90C rating test at 100A)
AWG#6 rated at 65A in use, 500 cycle test at 105A (90C rating test at 131A)
AWG#4 rated at 85A in use , 500 cycle test at 140A (90C rating test at 175A)
AWG#2 rated at 115A in use, 500 cycle test at 190A (90C rating test at 240A)

Current STABILITY is as important as total heat rise since it speaks for the integrity of the electrical joints over time. The stability factor S_{each} should not exceed + or – 10 based on the
STABILTY formula S_{each} for each of 11 readings $=d_{each}-D_{avg}$
$D_{avg} =(d_{each}1+d_{each}2+d_{each}3+....d_{each}11)/11$.
This test was originally conceived to test the integrity of aluminum wire in wire connectors. It is not required for copper wire only applications but nevertheless is a very good way to shake out issues that involve thermal cycles and the decay of integrity which can occur over time.
Readings are taken at cycle number 25, 50, 75, 100, 125, 175, 225, 275, 350, 425, and 500. For electrical gear (all bolted metal construction, no soldered joints) the 500 cycle test is considered good if the heat rise is under 125C over ambient but clearly this is way, way hotter than any PCB should run and therefore is not a useful pass grade for PCB lugs and particularly SMT lugs.

6. Assuming that end customers do not torque the wire binding screw properly or some long-term relaxation can occur (in particular for aluminum wire for which the 500 cycle test is designed) has lead UL to use a lower than standard user torque for 500 cycle testing. For assigned user torques (not those based on the type and size of driver tool) are lowered to 90% of the user torque for the 500 cycle test. For generic driver type torques (UL charts), the torque reduction can be much larger, say 20-30% (see UL486A-B).

   IHI UL approved parts are shipped with specified (assigned) user torques to ensure that the user has the proper information about the correct UL file torques. No UL approved parts are subject to the development of the correct torque for a given customer application, wire size and class.

7. Static Heat Rise tests are a good place to start testing a design in order to find out what heat is being generated and dissipated in your assembly under the highest loads possible and worst cooling situations including high ambient temperature.

   Heat rise test temperatures are for “bolted” construction industrial bus situations so should be derated for PCB applications where FR4 and thin copper foils are likely to degrade over time (see heat cycle test) leading to higher thermal resistance from foil delamination. It is known that wave soldering (and other heat methods of soldering PCB components cause a lowering of the heat flow through the PCB from a reduction of bond strength in foils and dielectric materials.

   AWG10 user current 30A, heat rise test current 50A
   AWG8 user current 50A, heat rise test current 70A
   AWG6 user current 65A, heat rise test current 95A
   AWG4 user current 85A, heat rise test current 125A
   AWG2 user current 115A, heat rise test current 170A

In industrial electrical applications, the heat rise test is considered satisfactory if the rise in temperature over ambient is less than 50C. However, for a PCB application, especially a SMT one, much lower heat rises would be indicated. A rule of thumb for printed circuits is that every 10 Degrees C increase in working temperature will halve the life of the PCB assembly.

8. By testing the twist off torques before and after the 500 cycles it should be possible to see the degree of strength loss and if that should be a concern for the particular application.
9. Solder has very low strength at modestly higher temperatures. Review yield strength charts for tin at elevated temperatures and in combination with creep load (which should not exist –see #2, #3).

10. Use terminals sized conservatively that will help to keep the joint cooler rather than using a terminal at the maximum current that NEC rates the size of wire and terminal. Say, use an AWG#4 wire and terminal (NEC rated 85A) at #6 current of 65A.

11. Use thicker foil on the PCB. The foil is the ONLY thing conducting current, creating extra local heat (thin sections) and retaining the terminal mechanically so clearly, a thicker foil is superior and the right and adequate thickness is mandatory. Thicker foil helps the mechanical strength of the joint. There has to be some metal structure to do the job of distributing the load and heat and spread the torquing stresses more uniformly to the dielectric substrate.

12. Find out what the largest wire is going to be and then test the screw on wire retention force. IHI can give guidelines on the right area for a good wire connection to the terminal based. That user torque should then be increased by a safety factor and then the terminal should be subjected to that torque multiple times with no damage to the SMT joint. Some solder creep at extremities is not uncommon at high

torques but is not an issue if it does not affect failure torque (negligible loss of joint strength).

13. Have proper and effective means to avoid overheating of the PCB for any and all reasons whatsoever. If the solder joint melts, there is nothing else to hold it in place (other than the wire retaining anchor required for SMT). Design for that.

14. Solder joints must be checked for integrity by torque testing the terminal to failure. A minimum twist off failure torque must be established by the user of the SMT terminal and it must be controlled by the manufacturing facility that makes the PCB assemblies. A minimum wetted area and porosity (gas bubbles or localized spot dewetting from normal plating variations) of the sheared solder interface should be established along with the minimum shear off twist torque. These allowances may have to be liberal to account for normal variations in soldering in real world production conditions. A design which relies on 100% coverage on every joint is not realistic for production and indicates a marginal design doomed to poor yields and quality issues along with high hidden production costs. Production plating of the connector is also subject to normal variations in bonding strength of barrier plating

15. Take full account of the fact that with SMT (not with THT) you lose the mechanical through-joint of the foot or feet that pass through the entire thickness of the PCB and also the current path enabling top and bottom foils to share the current and dissipate heat to air. Over sizing the SMT terminal and wire size for mechanical and current path and heat rise reasons is much more important on SMT than THT.

16. Porosity of solder joints in lead free solder is quite possible and will weaken the twist off torque considerably with no external evidence (nicely wetted joint externally but reduced metal content internally from gas bubbles, spot dewetting and other voids).

17. Develop the right solder/flux paste recipe and process for your application proven by adequate testing. As will all soldering, process control is vital to consistent results. Make use of solder paste application methods that allow flux gases to escape to reduce voids in the final solder joint.

18. Do tear off tests by leaning the SMT terminal over with a torque wrench and a crow's foot wrench to see at what force the copper foil peels away. This is especially important for SMT near the edge of the PCB where separation of the foil is more likely. The peel force must be adequate for the application and safety. Do it in both axes but look for lowest number in the shortest axis or one near the edge of the foil.

19. Position SMT terminal inboard to avoid the weaker and hotter running edge area of the PCB

20. Do pull UP tests to ensure that no weakness exists in that (less likely) fourth upward force plane.

21. PCB foil adhesion strength is known to fall after soldering due to the high temperatures of the soldering process (especially lead free) and stress on the organic dielectric plastic substrate.

22. Do what-if analysis for safety – if the SMT terminal "fell off" due to poor implementation of the joint, what would the consequences be? Must be fail safe – grounded, no person ever in danger, etc. never use in life support, vehicle braking systems, or any other human-in-danger scenario, meets all applicable

safety codes and electrical codes.

23. Realize that you will need to hold the SMT terminal in place while soldering as it will float around on the melted solder otherwise. The correct size pad will assist in this.

24. The means to hold the SMT terminal in place must not cause movement during the solder solidification process which will seriously weaken any soldered joint. Typically, a solder mask border will control the part from floating off location, but it must be level and without shock, movement, or vibration while solidifying.

25. IHI solderable body (one piece) SMT PCB terminals have limited solderability life at high temperatures due to high temperature migration of substrate metals causing a loss of wetability of the tin coating. While the high temperature time is adequate for wave soldering and flux paste soldering (or hand soldering with solder wire) it may not be for some high temperature, long duration, processes like reflow operations or some slow rework operations. These parts should be considered single use parts and not reused in rework situations.

26. IHI will reject all warranty claims caused by poor application design, inadequate failure mode analysis inadequate customer testing and inadequate process controls to maintain integrity and inadequate quality control to eliminate suspect SMT joints. If the joint fails in any way – the implementation was inadequate! In short all, (all) aspects of the connection integrity of the terminal to the PCB are the customer's responsibility to confirm before using!

27. Happy testing! A thorough test program and conservative design will help you make you customers happy with your products.

SMT Power Wire Connector Insights – What You Might Wish You Had Known

The point of this article is to inform customers about aspects of SMT (Surface Mount Technology) parts, particularly from a mechanical engineering point of view, where some of the mechanics of SMT soldered parts may not be well understood.

When using the horizontal screw tear off peeling SMT mode 100% inspection of production is required.

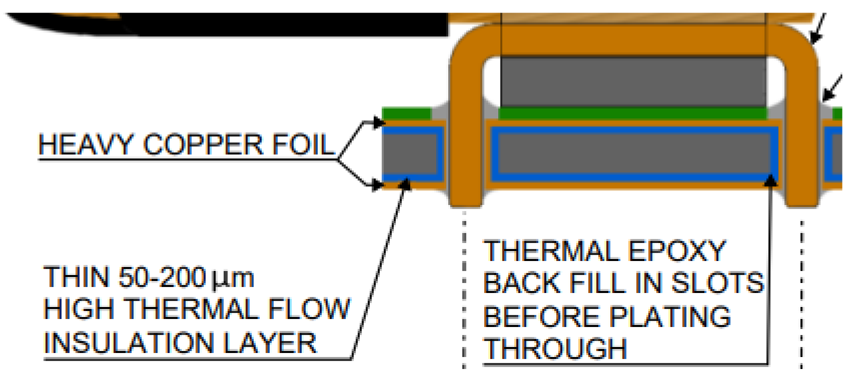
Generally, in vertical screw twisting mode SMT, much higher torques are achievable, and the tighter distribution curves may enable a customer to sample torque test each lot, versus test every single part for a secure attachment, if the customer data supports that in the given application.

If you are thinking about using Surface Mount Wire Technology (SMT/SMD) Wire Connectors on your new High Current PCB project, here are some mechanical engineering insights to help make good choices.

Rule #1 – do everything you can to use a THT wire connector (Through Hole Technology with one or more soldered-through the PCB bus legs) since you will save yourself some potential headaches associated with Surface Mounted components.

THT mounted connectors tend to be intrinsically rugged mechanically, and electrically, for a long life and reliable performance. Screw torque on IHI's THT PCB connectors is resisted by stiff conductive legs or staples using mainly <u>favorable</u> <u>compressive</u> stresses with less reliance on shearing, tearing, and peeling stresses.

THT wire connectors can be used on IMS metal core aluminum backed Double Sided PCB
https://lugsdirect.com/PDF%20Documents/tht-high-power-wire-connector-with-bottom-cooled-ims-metal-core-pcb.pdf



<u>Figure 1.</u>* *Dual layer IMS metal core with relieved metal and epoxy back fill, plated through slots creates optimum sharing of current and heat flow with excellent mechanical properties for a sturdy wire connector

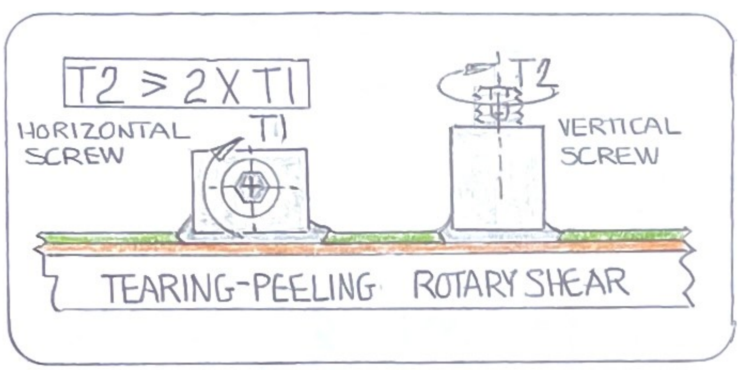
Rule #2 – Look long and hard at the best way to handle <u>both</u> current and mechanical demands of a wire connector on a PCB as well as long term heat flow.

"A chain is only as strong as its weakest link"

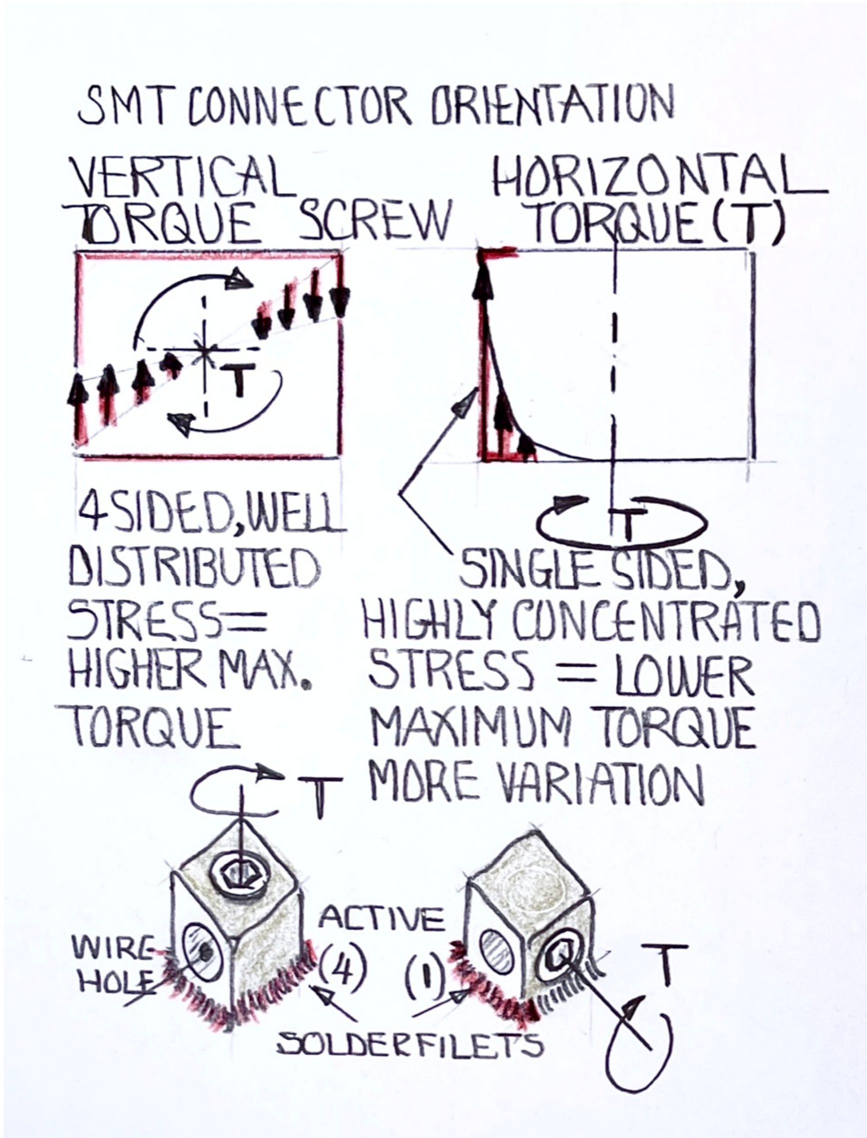
Rule #3 – If you must use SMT then let's be fully aware; look at the caveats and minimize them.

1. **Limit the size and power for SMT connectors. Use moderate temperature rises. SMT connectors are more limited on maximum wire size and maximum current, whereas THT connectors go all the way to the largest wires and highest currents used on PCB. THT designs are more scalable than SMT designs as current increases.**
   These size limits are based on differential CTE (Coefficient of Thermal Expansion) and fatigue life of the SMT solder joint, as well as limited mechanical strength for clamping and holding large wires.
   Very high temperatures and high cycles are harder on SMT soldered parts then THT ones.
2. **Consider <u>upsizing</u> the SMT lug – so you might use an AWG 6-14 lug for a # 10 wire if in horizontal screw torsion.**
3. **SMT connectors can be better suited to factory wiring (in house) than field wiring (end users).**
   Factory wiring can control the applied forces and torques and monitor and audit the actual outcomes of the SMT process and wire termination activity.
4. **Single "face and trace" contact of SMT wire connectors does not help to pass current (or heat) into the underside of the PCB as efficiently as a through bus THT part.**
   Of course, with metal core substrates IMS, this can be moderated for heat flow, though not for current flow which, unless double sided, IMS is used is limited to the top foil(s).
   The elimination of multiple trace layers and Single Sided PCB is a backward step for sharing current density distribution.
   Higher resistance current in limited foil paths create more I^2*R watts of wasted heat.
   SMT focusses all of the connector-to-foil power transmission as well as the mechanical strength to a single interface surface of low strength materials.
5. **Orientation of SMT connector screw = <u>vertical</u> = good. Use the optimum orientation for the maximum strength of the soldered joint which heavily <u>favors a vertical axis wire binding screw</u>**

   A rule of thumb is that the vertical torsional shear strength will be 2 times or more of the horizontal axis tearing / peeling separation strength for the same parts and soldered face size.
   This 2X + tends to bring the strength of the SMT joint in the decent range needed for tightening screws on larger wires but can fall short of targets in horizontal screw torque modes.



***<u>Figure 2.</u>* Vertical screw orientation increases torque shear greatly over horizontal screw axis.**
This works well since the soldered interface is in rotary shear which is strong.
Essentially all of the solder at the periphery of the interface is collectively resisting shearing and quite high numbers are possible.



<u>Figure 3.</u> Illustration of the stress levels on the SMT joint between <u>vertical</u> (favorable) and <u>horizontal</u> wire screw torque axis (less favorable)

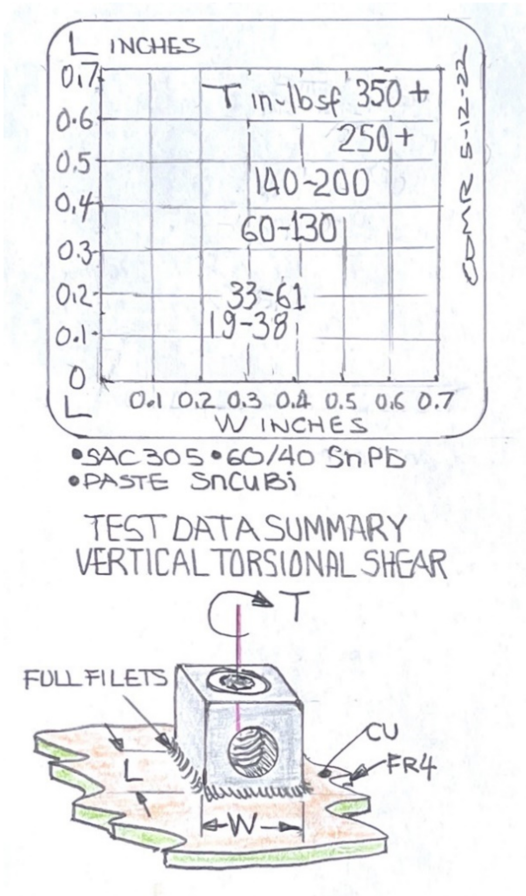


Figure 4. ***Scatter graph of typical range for the more favorable <u>vertical</u> <u>torsional shear strength</u> with full filets for different sizes of the soldered face. Parts with full filets properly soldered tend to have very useful torque numbers enabling larger wires at higher torques to be tightened without compromising the SMT joint.***

6. **Orientation of SMT connector screw = <u>horizontal</u> = not nearly so good. If you use a <u>horizontal wire binding screw</u>, only the solder along one edge of one side of the soldered interface is active in retainment. This creates a complex mix of peeling stresses, crack propagation, and minimal active area of the soldered interface contributing to the tensile retention strength.**

   In other words, the type of stress is not shear stress that acts on a large known fixed area but a type of peeling stress, or tear off stress, which reduces the torque to failure by a factor of 2 or much more and introduces indeterminate stress concentrations avalanche crack propagation.

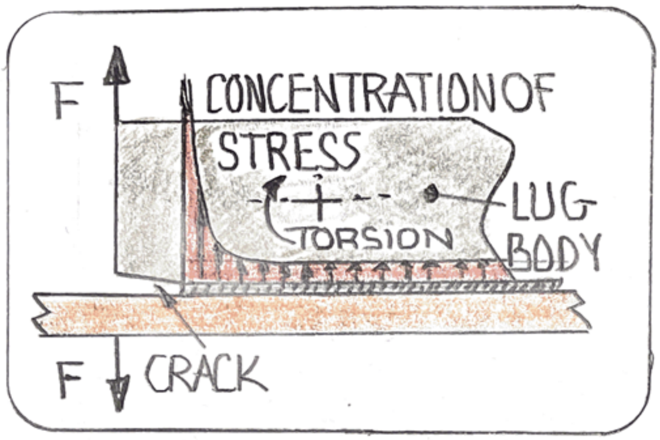


Figure 5. ***Stress concentrations at the lateral peel-tear edge locations creates lower tear off torque.***

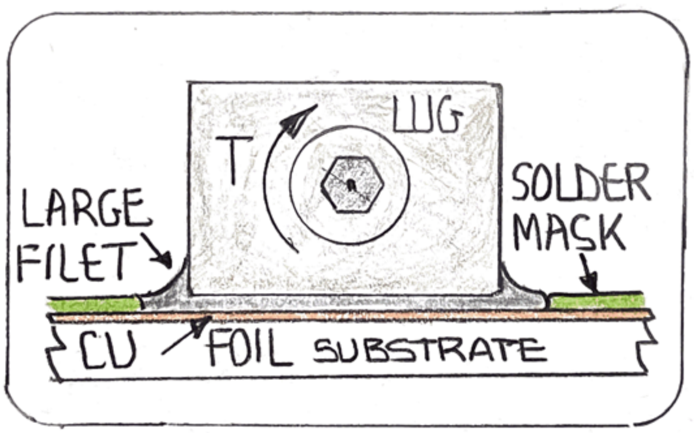


Figure 6. ***Use solder mask dam to add a large filet radius to the lateral side subject to peel-tear stresses. Large filets are essential for best screw torque performance of both horizontal and vertical SMT wire connector orientation.***

With reflow solder paste processes, pre-fluxing the sides of the connector may be needed to assist with full wetting strength and an optimal wet-up height of the full filet radius which acts as a stress crack blocker and stress spreader in front of a boundary which presents crack-like edges of a multilayer sandwich stack.

Filets are required by IPC standards and do offer a large boost in mechanical performance for both vertical and horizontal twist modes.

Filets tend to have less gas bubbles in them compared to the trapped flux gasses in the main interface layer.

The filets also act as an augmented length of the “torque arm” that increases favorable resistance to the applied separating torque.

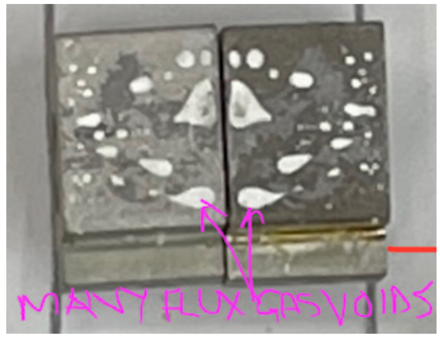


Figure 7. ***"Wet" low viscosity solder paste may have more flux gas voids. Voids nearer the outer edge can reduce torsion or tear of strength randomly. External filets tend to have less gas bubbles trapped due to increased ease of flux gas release.***

7. **Solder paste flux may not clean tin plating as effectively as it spreads up the sides of the connector. Fluxing effectiveness would be stronger under the connector, though traps more flux gas bubbles in a confined location.**

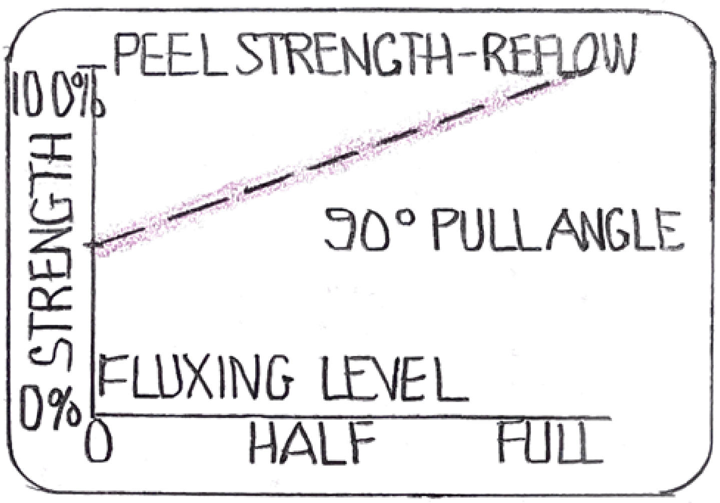


Figure 8. ***Peel strength of solder is directly affected by fluxing level of that surface. No fluxing can result in 50% or less peeling strength of solder or non-wetting. (4)***

8. **Peeling-tearing type of failure mode is much less predictable than rotary shear since it is a form of tearing along a single edge line, or at best, a thin linear minimal area zone in tension. It can easily behave in a crack propagation mode and is associated with much lower thin film peeling stress numbers that apply to the solder and plated layers.**
   Intermetallic diffused bonding layers also play an important role in plated and soldered metal interfaces with regard to peeling strength, but are hard to quantify on a given part due to variations at the subatomic quantum physics level.
   IHI has developed a process that enhances peeling bonding strength of the solderable plating which reduces low fliers in the distribution curve.
   As a practical matter for higher stress SMT mounting configurations, especially horizontal screw axis only 100% testing of the final soldered bond can give the needed measure of proof that all is withing the customer desired standard.

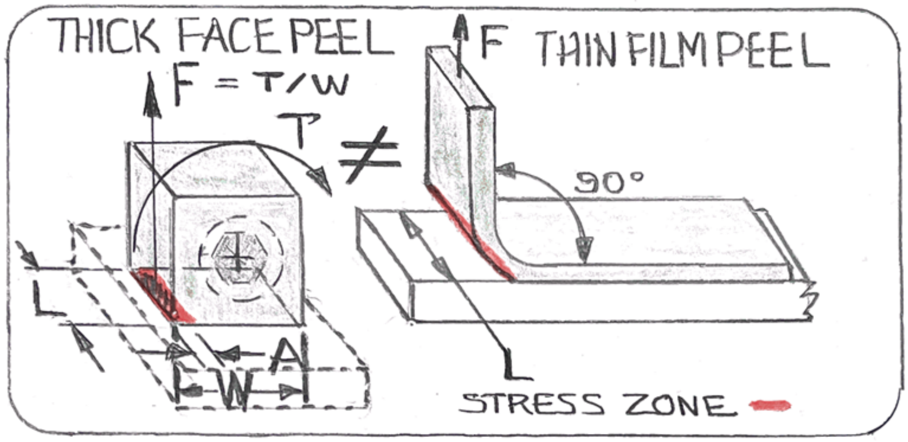


Figure 9. ***Thick objects do not behave as weakly as thin film peeling initially, but can become more so when separation (crack) starts.***

Testing indicates that some indeterminate tensile <u>area</u> = L*A (red zone) under the SMT connector "thick face", as well as the filet, is behaving like a favorable tensile stress zone, until it peels. As the crack moves inward the peak stresses rise, since the force F = Torque T / W width, F moves inward and becomes F= T/(W-A) and propagates the crack under load like in Figure 5.
The filet (if there is one) and the soldered bond along the lateral edge lines L, have the peak counter torque leverage initially, then falls rapidly.

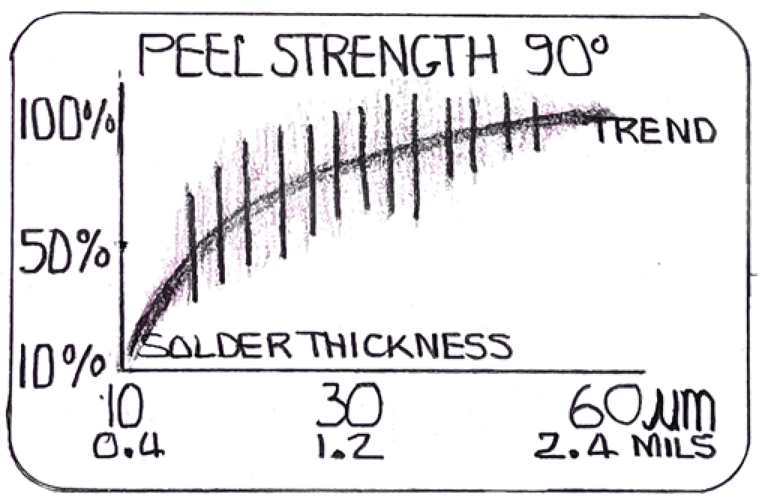
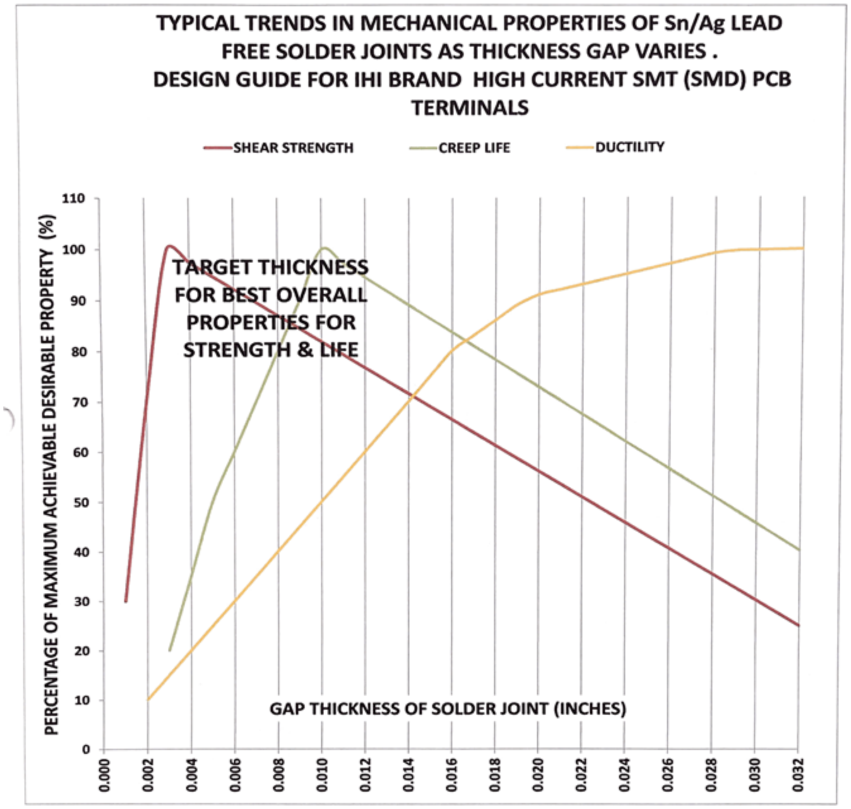
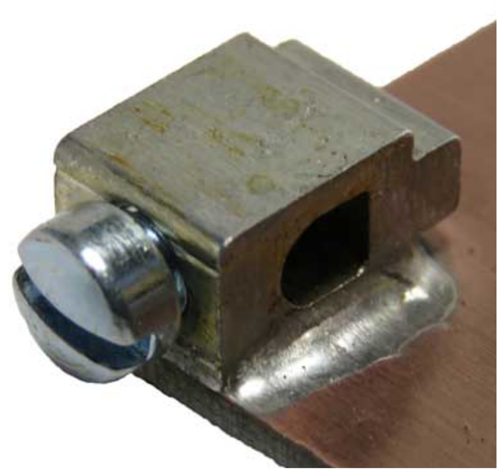


Figure 10. ***0.003" (80 micrometers) <u>minimum</u> solder thickness is a widely established number for strong solder joints. Excessive solder thickness reduces capillary penetration action and increases internal voids. (4)***



<u>Figure 11.</u> ***Optimum solder thickness for balancing strength and fatigue life of the soldered joint.***

https://lugsdirect.com/PDF%20Documents/Precautions-when-using-SMT.pdf



<u>Figure 12.</u> ***Shows a strong filet on the counterclockwise torque lateral edge line.***

Blooper alert, the Part in Figure 12 could be too close the edge of the PCB on the LHS. While there is a full filet both sides, the PCB foil could be the weakest link in "adhesive" thin film peeling mode which for PCB foil/FR4 is only 10 lbsf (pounds force) per inch of width using widely published numbers. After soldering, heat seasoning of adhesive copper foil / FR4 peel strength can be as low as 6-7 lbsf/inch. These things need to be settled in exhaustive testing in the particular end application after normal production processing.

Use of a hex socket screw can allow the part to move inboard having no large head to interfere or foul on the PCB.

Generally Agreed Peel Strength Numbers (1) (2) (3) (5)

FR4 and copper foils (epoxy adhesive)

Thin film peeling ……………………….………. As made 1.5 N/mm, [10 lbsf/inch]

Thin film peeling ……………………….………. After thermal stress of soldering 1-1.2 N/mm, [6-7 lbsf/inch

Solder (SnPbAg), nickel, and aluminum bonded surfaces

Thin film peeling ……………………………….. 5.7 N/mm, [32.6 lbf/inch] (5)

Solder and copper surfaces

Thin film peeling……………………………… 7 -8 N/mm, [40-45.7 lbsf/inch]

Thin film peeling ……………………………. 3.5-5.3 N/mm, [20-30 lbsf/inch

The thin film peeling mode is intrinsically weak.

It is also clear that inboard from the edges, the foil of PCB can act much stronger than its edge peeling mode.

Staying away of the outer edges of the PCB, is therefore wise.

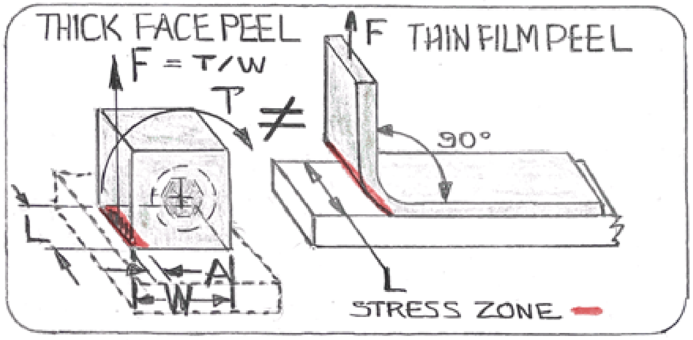
The low thin film peeling strength of plating is best accomplished by avoiding soldering connectors in the tearing – peeling orientation that generates tearing peeling stresses.

Avoid horizontal screw orientation or if used be ready to downrate the size of wire and so moderating the torque needed.

SMT connectors need to be 100% tested for adequate bonding strength since the number of variables are extensive and not all easily controlled.

Figure 13

Example calculations comparing some sample torque breakage numbers with those provided "thin film peeling" numbers from published sources.



THICK FACE PEELING Vs THIN FILM PEELING

Probable strength boost from tensile action of A*L

It is clear that while both modes share the same 90 degree tear off direction, the thicker blocky connector achieves much higher 'peel' strength numbers than is possible with thin films. Nevertheless the behavior of the thick face is somewhat bipolar with a very wide distribution curve. It is likely that the edge conditions along L and assisting zone A*L are subject to some of the same thin film peeling and crack propagation modes.

Tensile PSI <-- moderate estimate for solders

3000 lbsf/inch

B10-PCB EXAMPLE

					Reference	Reference	L*A area assists	
In-lbsf	Inch	Inch	lbsf	F lbsf/inch L	F lbsf/inch L	F lbsf/inch L	Assumed A	Actual Breakage torque
T	W	L	F	P thick	P thin Sn/Ni/Al	P thin Cu/Sn	inches wide	Distribution typ Trend
5	0.34	0.39	14.7	38	33	42	0.013	
10	0.34	0.39	29.4	75	33	42	0.025	
15	0.34	0.39	44.1	113	33	42	0.038	
20	0.34	0.39	58.8	151	33	42	0.050	
25	0.34	0.39	73.5	189	33	42	0.063	
30	0.34	0.39	88.2	226	33	42	0.075	
35	0.34	0.39	102.9	264	33	42	0.088	
40	0.34	0.39	117.6	302	33	42	0.101	
50	0.34	0.39	147.1	377	33	42	0.126	

B6A-PCB EXAMPLE

In-lbsf	Inch	Inch	lbsf	F lbsf/inch L	F lbsf/inch L	F lbsf/inch L	Assumed A	Actual Breakage torque
T	W	L	F	P thick	P thin Sn/Ni/Al	P thin Cu/Sn	inches wide	Distribution typ Trend
5	0.34	0.42	14.7	35	33	42	0.012	
10	0.34	0.42	29.4	70	33	42	0.023	
15	0.34	0.42	44.1	105	33	42	0.035	
20	0.34	0.42	58.8	140	33	42	0.047	
30	0.34	0.42	88.2	210	33	42	0.070	
40	0.34	0.42	117.6	280	33	42	0.093	
50	0.34	0.42	147.1	350	33	42	0.117	
60	0.34	0.42	176.5	420	33	42	0.140	

THICK FACE PEELING Vs THIN FILM PEELING

Probable strength boost from tensile action of A*L

It is clear that while both modes share the same 90 degree tear off direction, the thicker blocky connector achieves much higher 'peel' strength numbers than is possible with thin films. Nevertheless, the behavior of the thick face is somewhat bipolar with a very wide distribution curve. It is likely that the edge conditions along L and assisting zone A*L are subject to some of the same thin film peeling and crack propagation modes.

Supporting Test Data for SMT Vertical, SMT horizontal & THT Foot Mounted

The good news. In spite of challenges for SMT high current wire connectors, there is a strong test record. IHI has tested SMT connectors of the B4A-45 configuration with AWG 4 copper wire for 32,885 cycles current during 4 years between July 2015 and July 2019. The parts performed with no issues. The test was stopped to use the test equipment for other parts.

That is rather like doing the UL486 "500 cycle" stability test, 65 times in a row, so quite the longevity test for SMT wire connection with a soldered face PCB attachment.

Testing was done with 30 minutes on, 30 minutes off, at 120-130 Amps. Both vertical screw and horizontal screw orientation were used. The parts are rated for 85A assuming a 75C CU7 NEC current rating.

.062" thick Double Sided FR4 with 3 Ounce/ Ft^2 copper with 8 square inches (roughly 2"x 4") of PCB per connector.

Results are expected to be similar for Sn/Pb Eutectic and SAC305 solders. Extensive Japanese studies showed these two solder types to have very similar mechanical and electrical properties, though SAC305 certainly takes much more heat input to achieve higher temperatures for proper wetting and has more contraction artifacts and surface finish frosting.

Typical heat rise was 40C-50C over ambient of 20C-25C for peak temperatures in the low seventies Celsius.

Free air cooled.

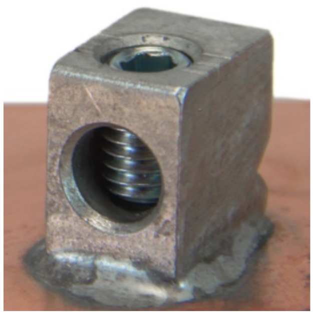
That is an impressive amount of elapsed time and cycles count and builds considerable confidence in these parts in SMT mode if working temperatures are moderate.

A similar test on the same THT monolithic PCB lug body, in "yin yang" pairs, with through wiring, foot to foot, using a simplified UL 500 cycle at 135A test has been running since July 2019 to current May 2022 so about 24,000 stable cycles or about 48 continuous "500 cycle" tests.

The point of this article is to inform customers about aspects of SMT parts particularly from a mechanical engineering point of view where some of the mechanics of SMT soldered parts may not be well understood.

When using the horizontal screw tear off peeling SMT mode 100% inspection of production is required.

Generally, in vertical screw twisting mode SMT, much high torques are achievable and the tighter distribution curves can enable a customer choice to sample torque test each lot versus testing every part for a secure attachment if the statistics of that given application support that.

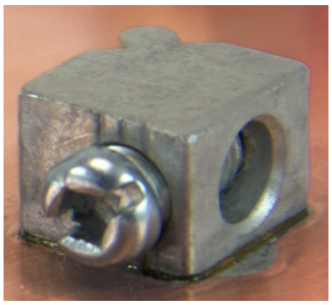


B6A-PCB-45(-HEX) SMT mode vertical screw axis AWG 6-14 65A 75C (0.34" wide)
B4A-PCB -45 SMT mode vertical screw axis AWG 4-14 85A 75C (.375" wide)

https://lugsdirect.com/B4A-PCB-45.html

https://lugsdirect.com/B6A-PCB-45.htm

For SMT connector for larger AWG 4, 6, 8 the IHI B6A-PCB-45 has shown itself to be sturdy both in the upright vertical axis SMT mode and in the horizontal SMT orientation where is gains significant area of contact on its side which improves the



B6A-PCB-45(-RS) SMT mode horizontal screw axis AWG 6-14 65A 75C (0.50" X 0.53" contact surface)
B4A-PCB -45 SMT mode horizontal screw axis AWG 4-14 85A 75C (0.50" X 0.53" contact surface)
https://lugsdirect.com/B4A-PCB-45.html

https://lugsdirect.com/B6A-PCB-45.htm

SMT parts screw torquing precautions

When torquing the wire binding screw to the proper amount for the size of wire, all SMT mounted versions must be protected against "prying" forces when driving the screw. Tearing detachment of the SMT soldered joint can occur due to its inherent weakness in some axes.

A universal jointed bit holder, universal joint coupling or universal "wobble" ended extension driver must always be used to apply pure rotational torque and no lateral prying torque moments.

SEE ALSO IHI GUIDE TO SMT COMPONENTS BEFORE USING SMT COMPONENTS IN DESIGNS

FOR FURTHER INFORMATION ON THE PROPER USE OF THIS PRODUCT IN SPECIFIC APPLICATIONS SEE

https://ihiconnectors.com/GuideToFlexFlexibleFineStrandedWireCableMechanicalLugsFAQ.html

https://ihiconnectors.com/Precautions-when-using-SMT.pdf

https://ihiconnectors.com/FAQ_SMT_SMD_High_CurrentPCB_Terminal_LugsSolderCreep.htm

https://ihiconnectors.com/NOTESonPCBFootPrintLayouts(SMT-SMD-Mode).pdf

https://ihiconnectors.com/High_Amp_Wide_Trace_PCB_Wire_Connection.html

https://ihiconnectors.com/Technical-Data-Installation.htm

References:

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(2) **Copper and copper alloys, Google books**
(3) **SMT soldering Handbook, R. Strauss**
(4) **MicroJoining Solutions Selective Reflow soldering, D. Steinmeier**
(5) **Adhesion Improvement for Solder Interconnection of Wet Chemically Coated Aluminum Surfaces A. De Rose, et al**