Power plant wire management

Wiring | Effective management of cabling in a PV system can greatly impact its lifetime maintenance requirements and thus profitability. Samuel Truthseeker of TECSI Solar looks in detail at the latest developments in wire management and highlights several reliability considerations

Credit: TECSI Solar

Fully integrated wire management devices show great promise for lowering costs and maintenance requirements

Wire management failures can have an unforeseen impact on the continued operation of a solar power plant. If left unmitigated, they can lead to electrical shorts or fires that result in system downtime and unbudgeted O&M. Improper installation and device choice, as well as environmental conditions can drive the premature failure of a wire management system. Ironically, the builder of a power plant, who often chooses the deployed wire management device, isn't the asset manager who has to maintain the system for its 25-year life. However, with proper knowledge, investigation and modelling, an asset manager can advocate for proper O&M funding prior to asset purchase. This could save the organisation hundreds of thousands of dollars in unforeseen costs. This article is intended to help those responsible for building solar power plants to determine the right wire management device for the job. It is also intended to help those responsible for continued O&M to create a more accurate budget based upon the risk factors associated with the deployment of a particular wire management device.

Wire management devices for use in commercial power plants can be categorised by three main classes. Two classes, cable ties and wire clips, are the most widely used. The final class, fully integrated wire management devices, although not yet widely deployed, show the most promise for lowest installed cost and zero maintenance costs over the life of the system. This article explores the advantages and disadvantages to each class as well as the factors that should be considered when choosing a product within a class.

Cable ties

Cable ties continue to be widely used as wire management solutions for solar power plants. Their ease of use, availability, nonconductive nature and low cost have proven to be a winning combination. However, there are several issues that have been identified with this option. Most notable is material quality. Zip ties have been around since the 1960s, but suitable polymeric materials for harsh outdoor environments have not. Most commercially available cable ties labelled "UV resistant" for outdoor use, will not survive long in real-world solar applications. The UV resistant labelling is not a certified or industry defined term [1]. It's just marketing. In fact, at some power plants the entire site had to be rewired because there was a 100% failure rate of their "UV resistant" cable ties after just six months. Cable management is often left to the EPC contractor, who is incentivised to provide the lowest cost solution that meets the contractual obligations. This

Credit: TECSI Solar

Figure 1. Cable ties markings

is where the ambiguous "UV resistant" specification requirement becomes problematic. Instead, developers should stipulate products by manufacturer and part number or through stringent product specifications. Once the correct specification has been created, a quality assurance programme to evaluate the installed ties needs to be defined. For the most part, cable ties all look the same, making verification difficult if not impossible.

Not all cable ties are the same

Several cable tie manufacturers, such as HellermannTyton and Nile Polymers, have added their logo to their products as a way to prove the authenticity, and by association the quality, of the installed tie. See Figure 1. However, since the printable area is extremely small and could easily be hidden from view after installation, the auditing process for inspectors or plant commissioning teams can be difficult and expensive even with a reasonable quality assurance (QA) sampling schedule. To make things even more challenging, a single manufacturer may have several solar ties of various UV resistance that look exactly the same, including their markings. Lack of predictable life expectancy and product verification are two of the main reasons why some plant managers have decided to go with metal ties or clips. However, those options, which we will discuss further on, carry their own set of challenges including the need to be grounded.

Expected cable tie life

Specifying the right cable tie depends upon your project costs and O&M schedule. PV modules typically have a 25-year performance warranty while cable ties don't have any. The lack of warranty is driven by the low margins and unknowns associated with the application and environmental conditions. Structural-specific factors, such as the smoothness of the hole where the tie is installed and environmental conditions such as irradiance, moisture and temperature, all contribute to the life expectancy of a cable tie.

Low temperatures in themselves do not generally degrade polymeric wire ties. However, wire ties can become brittle and break under extremely low temperatures. Therefore, it is critical to ensure your wire management specification takes into account the site's temperature extremes. Notched impact tests measure the toughness of a material by measuring the impact energy it can absorb. If the material becomes brittle when it is cold its ability to absorb energy drops precipitously. A product's material data sheet should include notched impact test results Find a result with a temperature equal to or lower than the lowest recorded temperature at your job site (say -30^{0}F for Minnesota) and ensure that the result is within 10% of the baseline test conducted at 73^{0}F/23^{0}C. If it is, then that material should meet the requirements for cold use approval. If the changes are >10% then the material should undergo greater scrutiny. The material shouldn't necessarily be disqualified out of hand since the decreased strength might be acceptable after taking into account the degradations from all possible contributing factors. Calculating the allowable loss is difficult and should only be done by a qualified engineer.

A polymer's strength is typically a function of the length of the polymeric chain. Environmental factors such as UV exposure, elevated temperature, and humidity all contribute to degrading or breaking these chains and reducing the strength and flexibility of the polymer. As exposure times increase, the polymer will become brittle and finally fail under load. And don't forget, just tightening the tie induces a load and stress within the part. Some materials like PVDF (Polyvinylidene Difluoride)-(Kynar) are naturally more resilient to environmental factors than others such as Polyamides (PA)-(Nylon 66). However, using additives such as screeners (carbon black), HALS (Hindered Amine Light Stabilisers), or phenolic antioxidants, the polymeric chains of products such as Nylon 66 can be protected. The impact of using various additives on the weathering performance of a PA material can be significant as shown in Figure 2 for EMS-Grivory's Grilamid TR Polyamides.

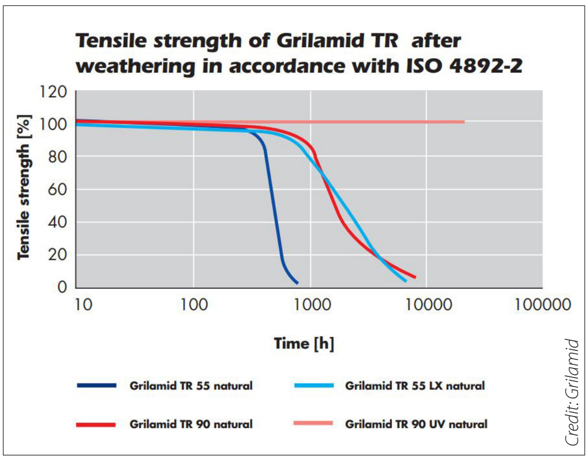


Figure 2. Effects of additives on same PA material

Interpreting and applying test results

Environmental lab testing will not provide direct lifetime estimates due to the inherent complexity of real-world environments. Nonetheless, there is a lot we can learn from it. And, by applying reasonable assumptions, we can make generalised predictions on a cable tie's life expectancy for the purpose of estimating future plant O&M costs. The best approach to predicting life expectancy is to combine indoor and outdoor testing. Indoor testing is used to accelerate exposure, while the outdoor testing is needed to expose the materials to environmental factors more similar to where they are deployed. Typical accelerated UV testing is conducted by xenon arc light exposure in chambers such as the Q-SUN by Q-Labs Corporation. The test procedure is governed by standards such as ASTM D2565 or ISO 4892-2. The xenon arc testing simulates sunlight exposure and can run 24 hours a day at full irradiance. Proper testing includes periods of wetting and humidity to activate potential degradation mechanisms triggered by the availability of additional oxygen from the water. Common xenon arc testing times include 5,000, 10,000, 15,000 and 20,000 hours.

For demonstration purposes, assume an average sunlight exposure of 6kWh a day for a particular site. Then, assume the cable tie is exposed to two-thirds of that solar exposure. The result is 4kWh/day of exposure on the tie. This roughly equates to four hours of light exposure in a 1x concentration xenon arc test apparatus. Taking this into account, the following model could be created:

Xenon Arc Target Exposure Time/ Estimated Years of Outdoor Exposure

- 5,000 hours/3.5 years
- 10,000 hours/7 years
- 15,000 hours/10.5 years
- 20,000 hours/14 years
- 25,0000 hours/17.5 years

Once a target exposure time is reached, some of the samples are removed from the chamber and mechanically tested. Strength reductions <10% from baseline should be acceptable. The accuracy of this model could vary significantly due to the limitations of the exposure mechanisms of the xenon arc chamber compared to all the possible factors (and their intensities) that exist at a job site. To increase the accuracy of the model, these results need to be compared to data from outdoor exposures.

The best methods for predicting a polymer's performance is through real world exposure. So, any real world historical data you can get from a manufacturer on their product is highly valuable and should be sought after. Even more valuable is if their materials have been submitted for unaccelerated outdoor testing to third-party test labs such as Q-Lab Corporation. They have test labs in various environments such as: (1) hot and humid Florida, (2) hot and dry Arizona and (3) cold and moderate Ohio. Samples should be removed and mechanically tested every year (or some other reasonable schedule) to provide strength retention data over time. After 25 years they will have collected all the required data on how the material will behave. However, material manufacturers don't usually have 25 years to wait to sell their product. By coupling the limited outdoor testing with the accelerated indoor exposure from the xenon arc chamber, useful models can be created without having to wait 25 years.

For our example problem of 4kWh of exposure per day, one can compare the outdoor test results at 3.5 years with the xenon arc test results at 5,000 hours. If the results correspond, you can begin to feel confident in the equivalences of the xenon arc exposure times to real world performance. However, if the xenon arc results are different than the degradation found through outdoor exposure, then adjustments need to be made to create a more accurate model. For the fictitious example shown in Figure 3, the xenon arc results represented by the blue triangles overestimate the degradation compared

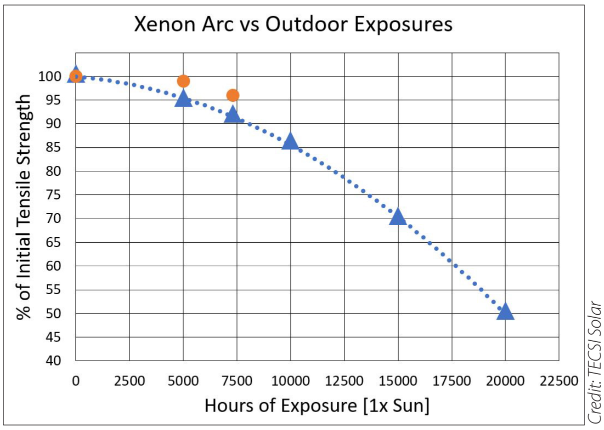


Figure 3. Xenon arc versus outdoor exposures

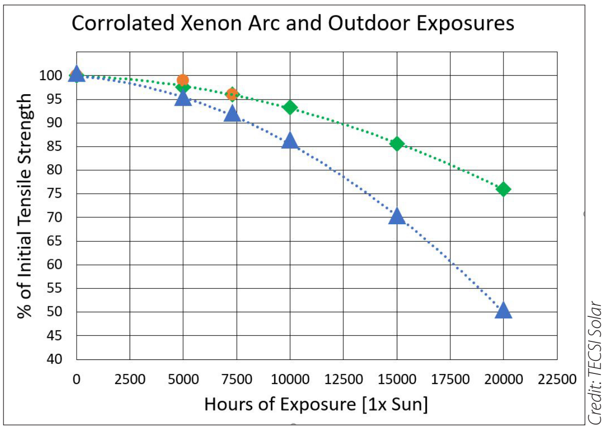


Figure 4. Correlated xenon arc and outdoor exposures

to the outdoor exposure data represented by the orange circles. After five years (7,300kWh) of exposure outdoors, the samples lost 4% of their tensile strength. On the other hand, samples exposed to the xenon arc testing lost 8.3% of their tensile strength. By comparing the results, an adjustment factor (4/8.3=.48) can be applied to the xenon arc data to produce the more accurate prediction curve shown in Figure 4 by the green diamonds. The 10% allowable strength reduction limit previously identified can then be applied to the data. The adjusted prediction curve (green diamonds) shows that 90% of the strength is expected to occur around 12,500 hours. This equates to 8.5 years of outdoor exposure which is significantly more than the 5.5 years initially predicted by the blue triangle curve from the original xenon arc test data.

It should be noted that this methodology assumes a constant difference between the xenon arc and outdoor testing when extrapolating the data into the future. However, this might not hold true. There are many factors that bring uncertainty to this approach including the differences between, (1) sample thickness versus tie thickness, (2) actual exposures versus the lab exposures, and (3) tie installation strength requirement versus allowable strength reduction limit. And there are always discrepancies that can arise from improper installation leading to premature failure such as the installation of cable ties across sharp edges of mounting holes. Nonetheless, this methodology can be used to create a budgetary model for comparing the total cost of system ownership for cable ties of varying quality.

Metal wire clips

Metal wire clips were developed as a way to bring predictability to the otherwise unpredictable life expectancy of polymeric cable ties. Most clips are made from stainless steel and come with the expectation that they will last the life of the system. In addition, metal clips are designed to be installed directly to a structural mounting flange (such as a module's frame wall), removing the need for the predetermined attachment hole required by cable ties. Wire clips might seem to be the simple solution. However, these devices have their own issues that need to be addressed through proper design and installation practices. Failure to do so could lead to electrical shorts, attachment failures and plant downtime.

Most clips are punched from stainless sheet steel and then formed by progressive die processes. The punch process can produce sharp edges that can cut or otherwise damage the wire's sheathing, leading to ground faults. Many manufacturers include edge detailing to mitigate this issue. For example, Wiley's ACC-FPV1 clip shown in Figure 5 uses a flare detail to keep the sharp edges away from the wire. Heyco wire clips are produced using a coining punch process which naturally rounds the punched edges.

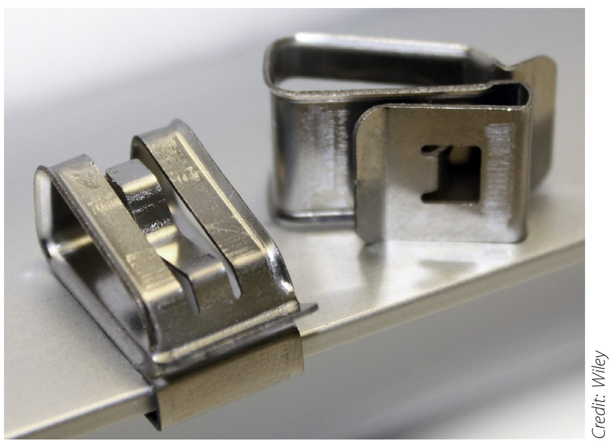


Figure 5. Wiley wire clip with flared edges to help prevent wire damage

Per code, metal wire clips need to be bonded to the ground path to provide system safety in the event of a short. Meeting this requirement on galvanised steel structures isn't difficult if the clips are made of stainless steel since both metals conduct electricity when they are in contact. However, this is not the case with stainless steel clips against anodised aluminum structures. Anodisation is a surface treatment that protects the base aluminum from corrosion. However, it is also a dielectric, meaning it does not conduct electricity. (Anodisation also occurs naturally, but is more robust and has better aesthetics when driven by industrial processes.) Most clip designs include sharp teeth that penetrate the anodisation layer connecting the clip to the system's ground path. Atmospheric corrosion over time at this critical connection could lead to failure of the ground path resulting in shock hazards and possibly fires. Perhaps even more concerning is galvanic corrosion driven by the dissimilar metals. To prevent this, the clips would need to be made of aluminum to match the aluminum substructure. However, aluminum clips are not practical since they would be highly susceptible to galvanic corrosion on galvanised steel structures and they would not reliably penetrate the anodisation layer of aluminum structures. In addition, due to their greater flexibility they would not have the same clamping force as similar stainless designs.

Corrosion testing

A properly designed clip can make the difference between zero maintenance and a complete plant retrofit. Besides historical data, the best way to evaluate the quality of a clip is through testing. Salt fog testing such as ASTM B117 can be used to evaluate material compatibility and corrosion resistance. Galvanic corrosion occurs when moisture acts as an electrical conductor between two dissimilar metals with different electrode (galvanic) potentials. The greater the potential between the materials the faster they will corrode. For solar wire clip applications, we are typically concerned with the stainless steel of the clip and the aluminum of the substructure (module frame wall). The ASTM B117 salt fog test can be used for accelerating galvanic corrosion between metals and is considered highly aggressive. Since aluminum has a lower electrode potential, it sacrifices itself producing aluminum oxide. Runaway galvanic corrosion can eventually consume enough of the base aluminum that the clip completely falls off. However, before that happens, the aluminum oxide buildup, which is a dielectric, will inhibit the clip's ability to transfer current from the wire to the safety ground path. If the wire insulation becomes compromised and the clip no longer has its current-carrying capacity then it could become energised resulting in shock hazards or arcing. The aluminum oxide produced from the galvanic corrosion has a chalky white appearance that looks very similar to the salt deposits left behind by the salt fog. Therefore, after the salt fog testing in complete, the samples should be thoroughly rinsed to dissolve away the salts. Any white powdery residue left behind at the clip/aluminum interface is a result of galvanic corrosion. By reviewing corrosion residue results from various manufacturers, one can choose the better performing wire clip. Similar to the cable tie manufacturers, many wire clip manufacturers are including identification markings to their clips so auditors can verify the installed product and thus its quality.

"Asset managers should research the deployed or planned wire management method. Not doing so could easily cost hundreds of thousands of dollars"

The amount of galvanic corrosion that would prevent a wire clip from performing its bonding or conductivity requirement isn't typically tested. This is unfortunate since maintaining conductivity could be critical to the safety and continued operation of a power plant. Bonding performance of a clip to the aluminum structure is dependent upon several factors including the clip's base material, coating, the size and shape of its teeth, the number of teeth, and its clamping force. While straight salt fog testing is useful, a modified version that includes bonding path resistance testing such as the one in Section 13 of UL 2701 would be more applicable. By adding the conductivity testing, a more relevant evaluation is created which can produce results that are both different and more useful than the salt fog testing alone.

ASTM B117 salt fog testing is good for comparing products. However, it is not good at predicting life expectancy. As a rule of thumb, one can say that a moderately aggressive salt spray exposure time is around 500 hours while a more robust timeframe is 1,000 hours or more. Results cannot be used to predict real-world performance. The extreme nature of the test as well as the actual variability of the environmental conditions at the job site makes performance predictions from B117 impractical. A better method for predicting life expectancy of a connection is the standard GMW 14872 – Cyclic Corrosion Laboratory Test. This standard has been defined and refined by the automotive industry to qualify materials for use on automobiles. The standard provides guidance on test protocols and pass/fail criteria for a part's particular location on the vehicle such as under body, under hood, or general exterior locations. The GMW testing includes a more complicated salt solution than B117 and uses a salt spray instead of the fog. Salt exposure is coupled with varying periods of humidity and dryness at controlled ramps to simulate more realistic conditions to which the galvanic corrosion would actually occur in the environment. Over the years, they have tweaked the tests to map with results the auto industry has seen in their fleet of cars. Entire test chambers, like the Q-lab's Q-FOG CRH, have been developed specifically to conduct these tests. The only significant modification that would need to be employed for solar applications is the inclusion of the bonding path resistance testing. One hurdle to overcome with this approach is the expected cost increase of 1.5 to 2 times over the standard B117 testing. However, this approach would allow for predictive modelling, which currently isn't provided by the salt fog testing.

It should be noted that not all stainless steels perform the same. The less corrosion resistant steels such as 410 can begin to rust after just 48 hours of exposure to the 5% salt (NaCl) solution of ASTM B117 [2]. Highly corrosion-resistant steels such as 316 stainless can be exposed for over 1,000 hours before showing signs of rusting. Rust alone does not mean that a clip can't function as intended. However, as rust builds up the likelihood that it will inhibit conductivity between the clip and the base material increases. Also, rust is generally associated with poor product performance and could trigger warranty claims. Interestingly, theoretical analysis shows that 18-8 stainless steels (304 and 302) which are less corrosion resistant than 316, might be better at reducing galvanic corrosion when in contact with aluminum since they are closer to aluminum on galvanic charts. 410 stainless steel is typically not recommended for use with aluminum due to galvanic issues and should generally be avoided [3]. Passivating stainless can further reduce atmospheric and galvanic corrosion. However, passivation increases cost and often isn't required. This is probably why we don't see passivated stainless wire clips being offered in the marketplace.

18-8 and 316 stainless steel fasteners are typically approved for use in aluminum applications so long as they are not exposed to chloride (i.e. salt). However, the unique requirements of wire clips make them more susceptible to failure by atmospheric and galvanic corrosion. The fact is, at this time, we don't have a good understanding of the life expectancy of the electrical connection of stainless steel wire clips on aluminum. And, until we have more field and chamber test data we will not be able to predict how nor when failures might occur. One needs to account for this added risk of variability when developing an O&M budget.

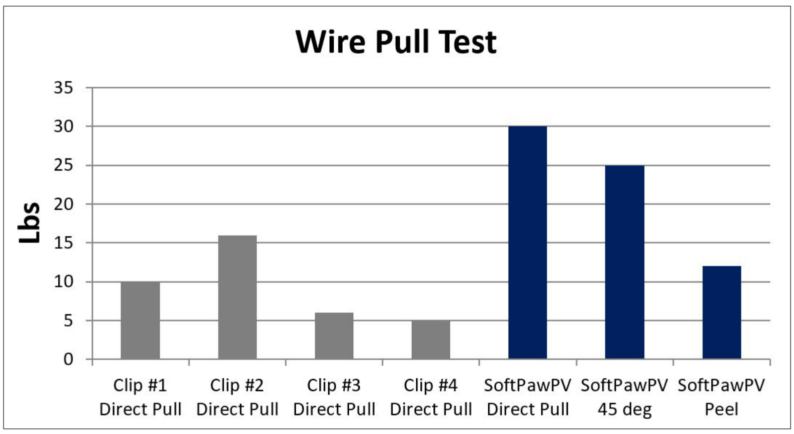
Credit: TECSI Solar

Figure 6. Wire clip mechanical load test

Mechanical load testing

Cycle testing is important to ensure that a clip will not walk off its supporting structure. The most common test procedure for evaluating this is the UL 2703 temperature cycling test. This test protocol cycles samples 200 times from -40°C to +90°C. A minimum of 1lb should be applied to the clip in the most vulnerable orientation at all times during the test to simulate field-applied loads. This target weight is based upon two 72-cell module pigtail wires weighing 4oz each (the target cable and another cable crossing or braided into it) and a safety factor of 2.

Insertion and removal forces should be evaluated for both the clip to the structure and the wire to the clip. A perfect clip would create a strong electrical and physical bond to the structure yet be easy to push on and take off for all types of flange thicknesses. As installers will tell you, pushing on just a few of these clips can leave fingers blistered at best and bleeding at worst. Installers can use gloves, but they lose the dexterity required to pick up, hold and align the clips. Inevitably, a creative and somewhat finger-abused installer will look for alternative ways to install the clips. This can include using the pigtail wires or tools such as hammers or pliers to push the clips onto the structure. These approaches can damage the module's cables or the backsheet. This damage could lead to shorts or module corrosion which might not show up for months or even years after the installation is complete. Some clip manufacturers such as HellermanTyton have tried to address this issue by increasing the push-on zone for the installer's fingers. Nonetheless, the issues persist. Most clips utilise retention teeth that are orientated away from the insertion direction to allow for lower attachment forces. However, this can greatly increase the required removal force during O&M operations, exacerbating the same issues encountered at installation.



Credit: TECSI Solar

Figure 7. Results from mechanical load testing

Mechanical load testing by a universal test machine is typically used to evaluate both the clip and wire securement capacities as shown in Figure 6. Testing by TECSI Solar engineers has shown that the forces required to remove wires from a clip range from 5 to 16lbs, with the average around 9lbs. See Figure 7. Results are from four different styles of clips from three different manufacturers. By pulling on the wire, both the wire capture strength and the clip attachment strength were evaluated. Multiple tests were conducted on each clip. All except one test resulted in the wire evacuating from the clip instead of the clip evacuating from the aluminum mounting plate. Wire removal at a moderate force is preferred since the higher clip attachment loads could lead to wire damage in the event a wire gets pulled unexpectedly. The lower end 5lb force was found acceptable by a cross functional team of engineers and installers. Clips with pull out forces less than this may require greater scrutiny, or possibly be rejected outright.

The right clip for the application

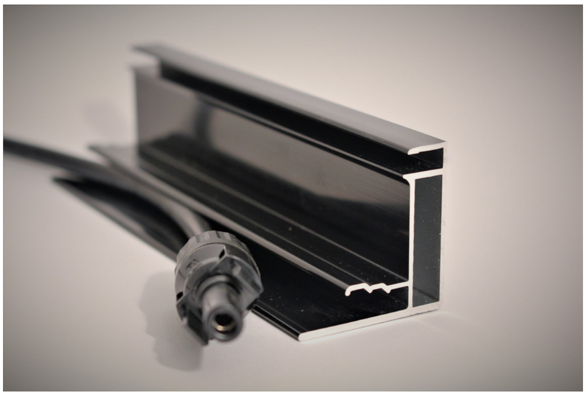
Before you choose a wire clip for your project, look for proper material callouts, testing, and edge treatments as discussed in the previous sections to reduce your risk of corrosion and ground faults. Then address the "Goldilocks" issue naturally associated with clips. Even though the clips are designed for various sizes they don't have the acceptance range of cable ties. First, you need to compare the clip's flange thickness spec to your module's mounting flange thickness. A mounting flange larger than the design range of the clip can make clip securement and removal challenging, leading to hand injuries and product damage. Conversely, mounting flanges smaller than the design range can result in clips falling off from

Credit: TECSI Solar

Figure 8. Esdec racking integrated wire management

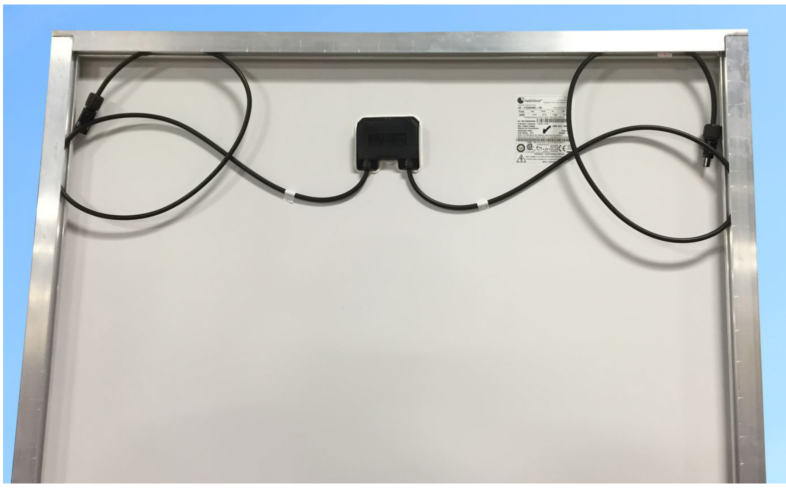
Credit: TECSI Solar

Figure 9. SolarCleat perlin integrated wire management



Credit: TECSI Solar

Figure 10. SoftPawPV module-integrated wire management



Credit: TECSI Solar

Figure 11. SoftPawPV ready to install factory wiring

Credit: TECSI Solar

Figure 12. Removing standard factory installed wire ties

installed stresses or thermal cycling. Next, test out the clip's compatibility with the project's module pigtail wires and homerun cables. Research by TECSI Solar has shown that PV module j-box wires have diameters varying from 5 to 7mm. Most wire retention devices have a limited acceptance range and even if your cable fits within their stated range the fit should be verified. Too tight a fit along with wire tension can damage the cable resulting in sheathing failure and ground faults. Conversely, a loose fit can allow motion from thermal expansion or wind to chafe the wire, which can result in similar failures.

Structure-integrated wire management devices

One of the most promising innovations in wire management is the integrated solution. These solutions fully integrate the wire management into the modules or structure. They don't require additional consumables and come installed on the structure ready to accept wires. Since this approach relies upon the product's existing material, there are no compatibility or corrosion issues as with wire clips or questions about UV and weathering resistance as with cable ties. All of the testing associated with corrosion and weathering is no longer applicable. The wire management features are guaranteed to last the life of the system since they are made of the same material. ESDEC's FlatFix product shown in Figure 8 is representative of such a device. Wire management devices can also be formed right into the structures. The licensable SolarCleat technology shown in Figure 9 is a feature that can be punched out of metal purlins or formed into polymeric products. This single feature can accept several wires at a time and since there are no consumables each one is virtually free, after the initial investment in tooling, of course. As with wire clips, the cut edges of the SolarCleat are treated by coining punch processes or flaring to prevent wire chafing or damage.

Module-integrated wire management devices

Perhaps the most promising integrated wiring management device is the licenceable SoftPawPV flange, shown in Figure 10. This device adds wire management to the frame wall of a PV module. Previous module-integrated wire management devices utilised features on the junction box to hold either the connectors during shipping or the wires at installation. However, the drawback to those designs was their limited use range. The SoftPawPV flange extends all the way around the PV module, providing the full range and flexibility for wire attachment that the industry has grown to expect through the use of wire clips. In addition, since it is integral to the module's frame wall, there are no weathering, UV, or galvanic corrosion issues typically associated with consumable devices, and thus, by definition, the device will last the life of the module.

The SoftPawPV device makes it possible to completely remove the use of clips or zip ties within the array since it can also manage the home run cables. While the j-box pigtails run along the top of the module near the j-box,

Credit: TECSI Solar

Figure 13. SoftPawPV temperature cycling testing

the homerun cables can run along the bottom of the module. In addition, due to the continuous nature of the device, it can handle multiple wires by skipping their attachment along the length of the frame. If circumstances arise where clips are required, they can easily be included as with any other module.

In addition to field wiring, a module with integrated wire management can come from the factory in a prewired "ready-to-connect" position. See Figure 11. Field wiring of the module is essentially removed from the installation process all together. Prewiring also eliminates the need for wire cutters and the installation step of cutting off two or more manufacture applied zip ties that bundle the coiled wires to the j-box. See Figure 12. By removing this step, the installers save prep time and reduce the possibility of damaging the back side of the module. In addition, prewired integrated modules remove the need for managing thousands of scrap plastic pieces across an entire job site. Also, the cable ties that bundle the wires on the module are often cut prior to wiring up the string. This leaves the pigtails dangling from the j-box where they are vulnerable to damage and contamination. As installers have learned, if a connector's contacts get dirty it can lead to dangerous situations including melted connectors and arcing.

O&M is also greatly simplified with module integrated wiring. When a module needs to be replaced there are no clips to remove, cable ties to cut, or replacement parts to bring. The affected module can simply be removed, replaced, and rewired. In addition, module integrated wiring can dramatically reduce the required preplanning normally associated with servicing a failed module.

A module integrated device can be optimised to the junction box's wire size because it is part of the module and can be defined at the bill of materials level. Nonetheless, it needs to be tested for mechanical strength like any other device. Relevant testing includes the mechanical load test and temperature cycle test previously outlined for wire clips. Variants of the SoftPawPV flange with different grip features were tested by temperature cycling as shown in Figure 13. Most of the designs passed the 200 cycle test requirement but some fell out prior to test completion. The designs that passed were further evaluated by standard mechanical pull testing. And to even further define their performance they were tested at three different pull angles. The results from the current design are shown in Figure 7. It should be noted, that at no time during testing were the wires or their sheathing damaged by the SoftPawPV device – hence its name.

Determining lifetime costs

The variabilities that exist in the application of cable ties and wire clips make predetermining lifetime costs difficult. Cost modelling by TECSI Solar engineers has shown a significant volatility in the predictions driven by a number of factors and their potential severity. The TECSI Wire Management Cost Estimation Tool for commercial systems attempts to take these factors into account. This tool is available on the resources page of our website (www.TECSIsolar.com/Resources). Please note, there are limitations to this modelling. For example, if a project deployed a high-quality tie and they were installed such that there were stress concentrations leading to failures at a rate equivalent to lower quality ties, then the cost savings estimated by the tool would not be realised. However, barring any installation issues, the TECSI modelling reveals that the more robust solutions result in lower overall cost of ownership due to lower O&M costs. It all depends upon the reliability of the deployed device to actually meet the target life span. This is where integrated devices have the greatest advantage. Due to their general resilience from weathering and galvanic corrosion, they have the lowest risk of not lasting the design life of the system.

Final thoughts

No wire management manufacturer currently provides a warranty on life expectancy due to installation parameters, site variances and the small profits associated with their devices. So for now, it is up to the asset manager to decide the risk level associated with a given wire management approach. Before one purchases an asset, they should research the deployed or planned wire management method. Not doing so could easily cost hundreds of thousands of dollars over the lifetime of the system. Insist that product manufacturers supply their test data. Specifically, ask them for test to failure information. Often data sheets show only the positive results. However, all products have their limitations. The goal is to understand the failure modes and whether they happen suddenly or predictably over time. Additionally, deploy integrated devices whenever possible. They have the potential to significantly decrease overall costs and take the risks out of wire management. Finally, use a tool like TECSI's Wire Management Cost Estimation Tool to estimate life time system costs and then ensure those costs are included in the plant's operating budget. ■

The TECSI Wire Management Cost Estimation Tool is available at www.TECSIsolar.com/Resources

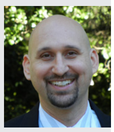
References

[1] Pickerel, K. 2016, "Not all 'UV rated' cable ties have long lifespans on solar projects", Solar Power World.

[3] "Corrosion and Corrosion Resistance", Fastenal Engineering and Design Support Rev3-4 2009.

[2] "General Corrosion Data for Fastener Finished", Triangle Fastener Corporation Corrosion Information Testing MD 251.

Author



Samuel Truthseeker is the principal engineer at TECSI Solar Inc and a professional mechanical engineer. He has over 15 years of experience designing, developing, and deploying all types of residential, commercial, and utility solar products including, modules, racking, trackers and BOS. TECSI Solar is a full services engineering organisation with a sole focus on the solar industry. With PE stamps in all relevant disciplines, TECSI Solar engineers help manufacturers create and deploy better products at lower cost.