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WHITEPAPER

Plastic or Metal?

Photo by JJ Ying on Unsplash.com

Plastic or Metal?

With the strong growth of solar photovoltaic (PV) installations in many parts of the world over the past decade, there has been increased focus on how good wire management practices can promote the efficiency, safety, durability and long-term sustainability of installations. A key question here is the choice of materials for cable retainers: metal or plastic? And if we use plastic, which type of plastic is most suitable?

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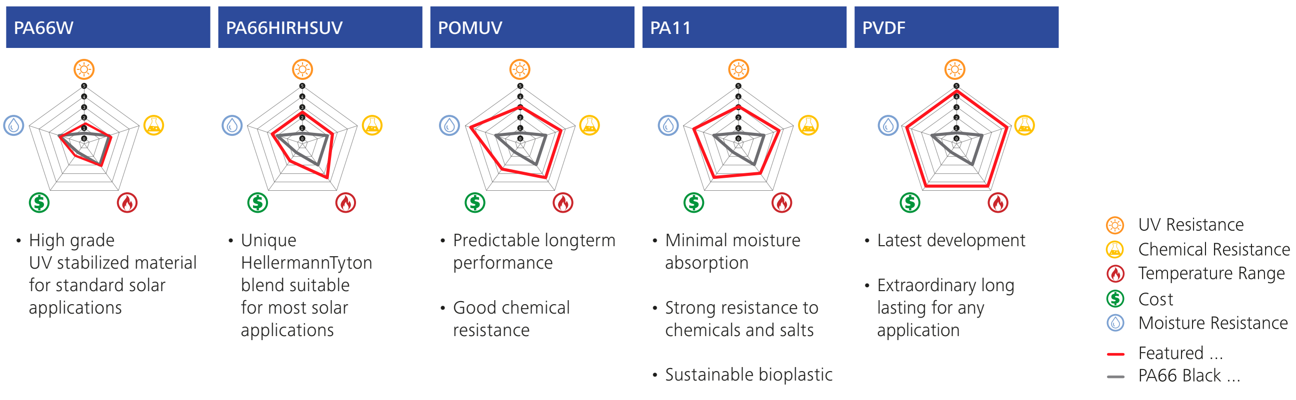
Using the Right Engineered Plastic

Each different application places its own demands on a wire management solution, and solar PV installations are no exception. Although, for instance, an installer may achieve short-term cost savings by using all-purpose "off-the-shelf" cable retainers, the most cost-efficient solution is the one using materials that offer the desired lifetime in harsh solar PV environments, often up to 25 years.

While simple polyamide 6.6 (PA66) non-outdoor grade materials are suitable for many applications, they are generally unsuitable for solar PV installations, which are often subject to extreme climate and site conditions. That means using plastic engineered to meet these environmental extremes. Low-cost all-purpose solutions will invariably be cheaper to purchase, but costs in the long term will be higher due to higher maintenance. Furthermore, cheaper, unsuitable materials can compromise the safety of an installation and personnel, resulting in reduced efficiency and injury or loss of human life. The more often personnel must intervene to replace or repair wiring, the higher the operating costs (especially for installations in remote regions), and the greater the likelihood of errors leading to new faults. A "band aid" approach of this kind is therefore both foolhardy and inefficient, offering a poor return on investment.

HellermannTyton uses a variety of plastics in products for solar PV installations, including materials formulated with UV stabilizers, UV absorbers, and exceptionally strong base plastics with extended life spans, such as our new polyvinylidene fluoride (PVDF) products, which are extraordinarily durable and long-lasting.

Figure 1 Performance of Materials



Compares five different high-performance plastic materials in relation to UV radiation, moisture, temperature, chemicals, and initial cost.

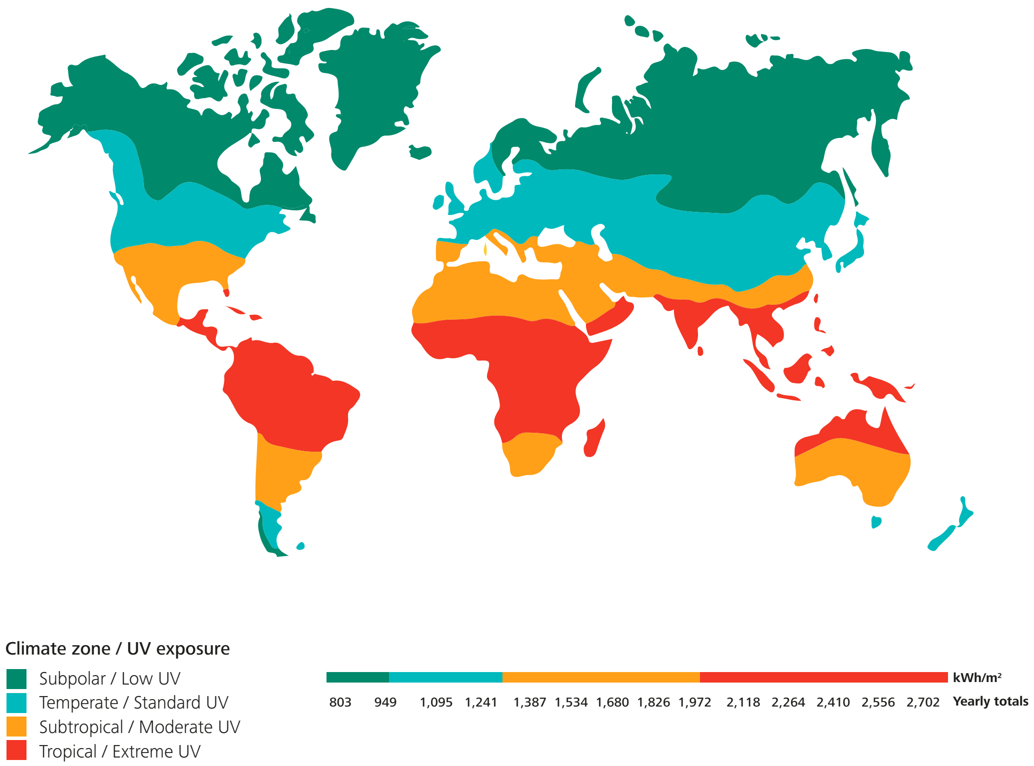
Climate Zones and UV Radiation

Although many different factors influence the amount of UV radiation an installation receives (e.g. pollution, shading by other structures, orientation and albedo reflection), climate and weather patterns are by far the greatest influence. This includes local topographical features that affect climate patterns. For obvious reasons, most UV radiation is received by the photovoltaic front surface of panels, but the backs of panels are also exposed to significant amounts of UV radiation – where most of the wires and cables are located. According to research conducted by Fraunhofer Institute for Solar Energy Systems (ISE), reflectance from the ground onto the back of panels (measured in albedos) accounts for some *15 % to 30 %* of UV radiation on installations.

HellermannTyton provides a range of plastics for wire management in solar PV installations (formulated with UV stabilizers, UV absorbers, especially durable plastics) to meet the needs of different UV exposure levels in installations.

The map below (Figure 2.) shows climate zones / light exposure worldwide. Figure 3. depicts the performance of plastic materials when exposed to radiation.

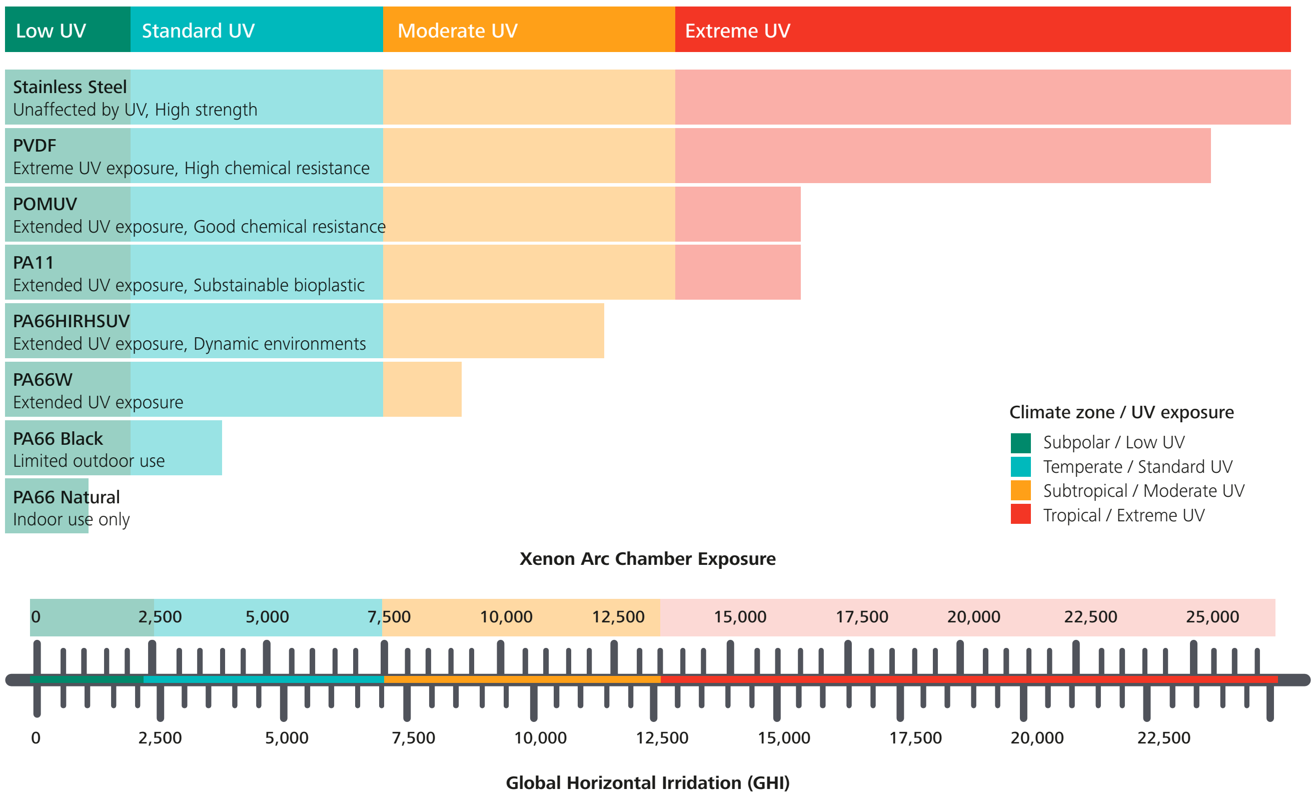
Figure 2 Climate zones and yearly totals of full spectrum light radiation



Note that humidity, salt in the air at coastal locations, and altitude all affect the performance of materials. Our product engineers advise you on the best combination for local requirements The world map shows annual total kilowatt hours per square metre (kWh/m²).
We can now match this to materials, taking into account light radiation levels.

Recent Facts about Photovoltaics in Germany, Harry Wirth, Fraunhofer ISE, download from *https://www.ise.fraunhofer.de/en/publications/studies/recent-facts-about-pv-ingermany.html*, version of March 11, 2021

Figure 3 Plastic materials and their approximate performance under UV exposure



In addition to GHI represented in this diagram, other microclimatic factors will affect the choice of material.
See Figure 6. later in this paper for the suitability of materials for specific climate zones.

FACTS AND FIGURES

Montpellier, France

Example Based on Light Irradiation Estimates

Let's take the example of the city of Montpellier in southern France. Montpellier has approximately **1.541 kWh/m² global horizontal irradiation (GHI) per year** (source: https://solargis.com).

Cable retainer manufactured from PA66W
Type of plastic

8,000 kWh/m²
Expected performance under light exposure (see Figure 3)

8,000 : 1,541 ~ 5 years
Estimated lifetime with permanent exposure to the sun

In practice, we would expect the cable tie made from PA66W to last longer than five years, as it would not be exposed to UV radiation permanently. Furthermore, this type of plastic might be installed underneath the panels, where UV levels are lower. Both of these factors would extend longevity. On the other hand, its longevity will also be affected by heat, salt and other chemical influences, and other possible stress factors (e.g. movement from wind).

In this example, a PA66W retainer would be unsuitable, and we recommend a material with higher UV stability, if a lifetime of more than 5 years is desired.

Moisture Resistance

We rarely think of plastic as a material that absorbs and releases moisture. However, moisture is absolutely essential for the manufacturing process, including moulding. Furthermore, it is integral to the physical properties of the wire management retainer, especially to its flexibility and tensile strength. Of all plastics components dealt with in this paper, base PA66 is the most sensitive plastic material in regard to moisture. When talking about moisture, we refer to base materials being either hygroscopic and nonhygroscopic. Hygroscopic materials absorb or adsorb moisture. The thermoplastics polyamide 11 (nylon 11 or PA 11), polyoxymethylene (POM) and polyvinylidene difluoride (PVDF) are affected far less by moisture, making them more suitable for arid regions (desert or semi-desert), or in applications where humidity is high (e.g. floating solar PV installations, or agrivoltaic installations).

Temperature and Heat

Solar PV systems are installed in some of the hottest regions of the world, testing the strength and longevity of wire management solutions. Furthermore, it is not uncommon for a rooftop solar installation to reach temperatures of over +80° C. Unsuitable materials or incorrect installation (e.g. due to insufficient knowledge of material properties, or incorrect tension) can lead to material failure within months, even for some plastic components with life expectancies generally considered to be long. It is therefore important to seek the advice of a knowledgeable partner. Wire management solutions from HellermannTyton are rated for different environments and conditions, which includes temperature – one of the most common causes of components becoming brittle and failing.

Georg Neureiter
Market Manager Renewable Energies EMEA

"Our HellermannTyton wire management solutions are used by leading companies worldwide and to date (Q1 2021) have been installed on solar PV energy systems amounting to 20 gigawatts. Our record speaks for itself."

Chemical Resistance

Chemical resistance is another key factor in the choice of whether to use metal or plastic, and the type of plastic to be used. Contact with chemicals can take many different forms, including pesticides and herbicides to suppress vegetation or pests in agrivoltaic systems. An often underestimated chemical reaction can occur on coastal solar sites in combination with popular zinc-galavanized solar substructures. Here, salt in the air in combination with water forms a solution of zinc-chloride, which can lead to extreme corrosion on base polyamide 6.6.

Furthermore, galvanic corrosion as a result of salt and moisture may occur in some metal wire management systems – a concern we often hear from operators and installers of solar PV systems – reducing the strength of metal components. This disadvantage of metal can be avoided by using a suitable plastic, and a further advantage is being able to avoid the risk of dissimilar metals that might react chemically with each other to weaken an array.

Plastic in Summary

Plastic offers the advantage of being less likely to splice wire and cable insulation, as well as resistance to specific chemical processes. Selecting the most suitable plastic material allows installation of plastic wire management systems cost-efficiently with long lifetimes in extreme environments. Plastic is also an insulating material and therefore can provide optimum protection of cable insulation in critical situations, such as movement on trackers or during the motion of floating PV arrays. Thermal cycling (i.e. temperature extremes in the course of a day) must also be taken into account, as this also causes movement.

In terms of initial cost, the following table summarizes the cost ratios for various types of plastic. We should stress, however, that these are initial costs, and that special plastics such as PA11 or PVDF, although involving a higher initial investment, will provide greater efficiency and return on investment in the longer term in harsh conditions. The motto is therefore: talk to our experts and we will help you choose the most suitable material for your installation.

Figure 4 Investment Ratios

Material	PA66 Black	PA66W	PA66HIRHSUV	POM	PA11	PVDF
Initial investment (ratio)	1	1.2	1.5	1.8	2	10

Using PA66 Black as the basis of initial outlay, the cost ratio increases from left to right.
The initial investment for PVDF is ten times that of PA66 Black, but offers a higher return on investment in terms of longevity.

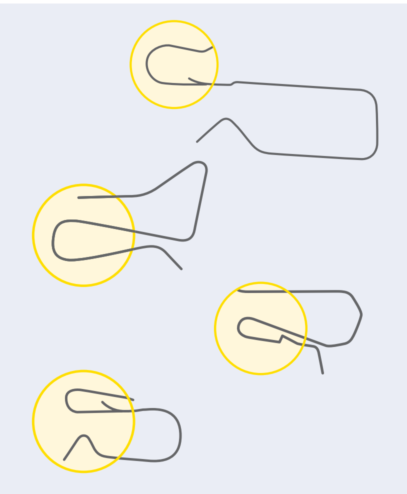
Metal Wire Management Design

Apart from certain regulatory requirements, the long service life of metal components is the primary reason why many installers prefer metal components. Yet, apart from disadvantages of corrosion and chemical reaction, metal retainers often have sharp edges that can splice or otherwise damage cable insulation, resulting in possible arcing or inverter grounding faults. This will cause failure and result in reduced efficiency, require additional maintenance, and endanger personnel.

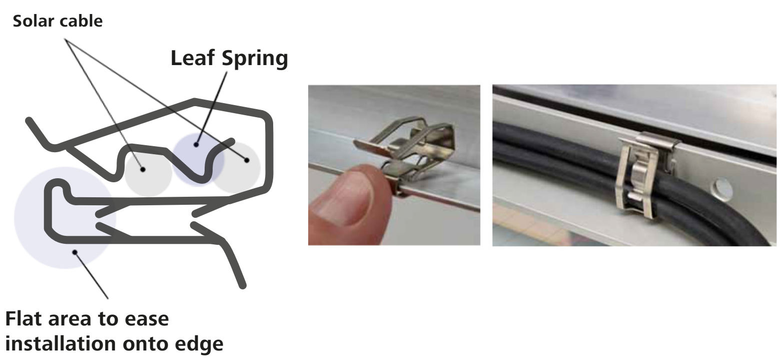
Whenever there is motion, the potential for cable damage increases. Movement may occur due to wind, daytime/night-time temperature extremes (thermocycling), tracker motion or floating PV motion. Potential damage caused by motion is further exacerbated if the cable is installed too tightly or cable is bent at an inappropriate angle. Motion and cable tension are therefore aspects that installers must be especially mindful of whenever working with metal retainers.

Furthermore, metal clips are not particularly installer-friendly, and installers are only too keenly aware of the strain of installing metal clips. Wire management for solar PV systems may involve hundreds of thousands of edge clips with small push points, resulting in thumb pain from repetition. Recognizing this, HellermannTyton has engineered edge clips that require little force to insert but have very high resistance to extraction. Compared to competitor clips, this can save hundreds of hours in labour and strain-related downtime. What's more, with cable protection in mind, our metal edge clips have been engineered with a leaf spring that produces less metal-to-wire contact, and edges have been rounded in critical areas, reducing the risk of wire and cable damage. In contrast, most competitor edge clips are simply deburred. The use of rolled steel in our edge clips also means that the edge clip is much less likely to nick, splice or otherwise damage the cable or wire either during installation or as a result of motion throughout the lifetime of the system.It is critical to remember, however, that metal is a conductive material, and retainers are often used in high-voltage applications. Arc faults or short circuits are an ever-present risk.

Figure 5 Competitors' Metal Edge Clips



HellermannTyton's Metal Edge Clips



Intelligent engineering design reduces strain for installers, and reduces downtime during installation.

Are Plastic Coated Metals an Option?

"We don't recommend using plastic coated metal materials. In the most severe instances we've seen, a clamp at the end of a row on a single axis tracker system was used to hold a bundle in place against the constant motion of the tracker and other motion-inducing forces (e.g. UV, wind, thermocycling). This was effective in the short term, but if the coating peels off or the cushion slips out of the clamp, the bundle moves against a narrow metal edge, producing a dangerous situation."

– Georg Neureiter

On paper, plastic coated metal appear to combine the best of both worlds: the durability of metal with the insulating properties of plastic. However, our experience is that plastic coated metals have design and application flaws.

First and foremost, coatings adhere poorly to steel, and we have seen very many instances of this in the field, especially with stainless steel cable retainers after just a few years service on installations. Adding to risk is that many vinyl-coated components – e.g. P-straps and cushion clamps– have coatings that are entirely unsuitable for use outdoors in exposed environments. We have also seen many instances of damage to protective coatings as a result of sharp metal edges, especially in mounting holes, where most often damage occurs. Once the coating is damaged, wire conductors can come in direct contact with metal, with the associated risk of failure and harm to personnel.

And finally, use of plastic coated metal can increase the cost of detecting faults. Whereas it is a simple step to detect and correct a faulty plastic part, the damage to conductors may not always be obvious when a fault occurs in the coating of a metal. The result may be costly arc issues.

Source PVPROS Photo of the Week by Rick Ivins: Wire Management Practices

A vinyl coated, stainless steel tie tightened so tight that it cut through the wire.

Photo source: PVPROS

Protective coat is gone, exposing the metal parts.

Conclusion

There are very specific reasons for choosing either a metal or a plastic wire management solution. In some cases this is regulatory – as in Australia, where electrical codes demand metal on solar PV installations – but generally the decision is made based on the factors of long-term cost-efficiency, long-term operating efficiency, safety and ease of installation, and climate and environmental conditions. If not installed correctly, metal retainers will be unforgiving, punishing an installation in terms of subsequent costs. Great care is therefore required to avoid damage. Plastic wire management solutions require care to instal but are more forgiving if an error occurs as they are gentler on insulation.

Reference Tables

Figure 6 Approximate suitability of materials

Product base material	UV irradiation resistance	Humidity tolerance	Temperature range	Climatic zone
PA66W	☼	💧	-40 °C to +85 °C, (+105 °C, 500 h)	Subpolar/Temperate
PA66HIRHSUV	☼☼	💧💧	-40 °C to +110 °C	Temperate
PA11	☼☼☼	💧💧💧 (~)	-40 °C to +85 °C, (+105 °C, 500 h)	Subtropical
POMUV (Polyacetal)	☼☼☼	💧💧💧💧 (~)	-40 °C to +90 °C, (+105 °C, 500 h)	Subtropical
PVDF	☼☼☼☼	💧💧💧💧 (~)	-55 °C to +175 °C	Tropical
Metal (Stainless Steel)	☼☼☼☼	💧💧💧💧 (~)	-80 °C to +538 °C	Tropical

Gives an overview of plastic and metal wire management options according to the key factors of material, UV irradiation resistance, humidity tolerance, temperature and climatic zone.

Figure 7 Impact on Cable Protection and Corrosion

Material	Cable protection	Chemical	Galvanic corrosion
PA66W	OK	*	No
PA66HIRHSUV	OK	*	No
PA11	OK	***	No
POMUV (Polyacetal)	OK	***	No
PVDF	OK	****	No
Coated Metal	Not recommended	*/***(a)	No
Metal (Stainless Steel and other metals)	Attention to design	*/***(a)	*/***(a)

(~) Also recommended for floating and agrivoltaic installations (a) Depending on steel quality and corrosion protective coating.
Please note: the figure above is provided for information purposes only and is not a substitute for validation tests.

With well over 20 gigawatts of experience in solar PV installations, HellermannTyton is the partner at your side to ensure long-term efficiency and sustainability in solar PV installations. We will help you to develop a wire management strategy and accompany you at every step along the way – from wire management design and choice of components through to installation and start-up. Regardless of whether you are an installer or designing and administering a solar PV installation, our experts are always on-hand to advise you.

Contact

If you have any questions on specific solutions or would just like to receive more information, we are happy to help – with all our experience and with technical know-how.

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