White paper

A PVC cable for permanent movement in the energy chain - why and when is this an ideal solution?

Contents

Introduction

This white paper deals with the question of whether cables with a PVC outer jacket also work reliably in moving applications in an energy chain and whether this cost-effective material represents an alternative to other materials such as PUR or TPE.

Choosing the right outer jacket is crucial when it comes to the longevity of the cable in the application and the entire system. PVC has become a widely used material for cable jackets. But why is the right PVC cable an excellent choice for moving applications in an energy chain? The white paper addresses this question in detail. We will investigate whether cables with a PVC outer jacket work reliably in a moving application in an energy chain and whether this more cost-effective material is an alternative to other materials such as PUR (polyurethane) or TPE (thermoplastic elastomers). Another important aspect is the cost: PVC is inexpensive to produce and process compared to other materials. Many users therefore ask themselves whether this polymer could also be incorporated in moving applications without having to compromise on reliability.

This white paper is aimed at engineers and purchasers who need to select materials for their specific applications based on informed decisions. We offer you a comprehensive overview of the specifications of PVC, its advantages and disadvantages as well as practical recommendations based on extensive test series. With this knowledge, you can be sure that your energy chain applications function optimally while reducing costs.

Specifications and advantages of PVC cables

PVC - a brief definition

Polyvinyl chloride (PVC) is a thermoplastic polymer and considered the third most important polymer for plastics after polyethylene and polypropylene. PVC plastics are generally divided into rigid and flexible PVC:

Rigid PVC
- Used for producing window profiles or pipes, for example

Flexible PVC
- Typically contains plasticiser
- Used for insulation and cable jackets or for floor coverings

Even though PVC, like many other plastics, has fallen into disrepute at one time or another, it is characterised by many important specifications that we need, especially in electrical engineering. In addition, this material has various other advantages, particularly in the area of cables, and can be produced and processed relatively cost-effectively. Therefore, users wonder whether this polymer might also be suitable in moving applications.

PVC cables offer a variety of specifications that make them an excellent choice for electrical-engineering applications. Here are some of the most important benefits:

Mechanical strength:
PVC is known for its high mechanical strength and durability. These specifications are particularly important in applications where cables and wires are subjected to constant movement or stress.

Flexibility:
Depending on the mixture, PVC can be flexible or rigid, which makes it very versatile. Flexible PVC is particularly adjustable and ideal for moving applications such as energy chains.

Resistance to environmental conditions:
PVC offers good resistance to moisture, chemicals and UV radiation. However, it should be noted that extreme conditions may require special mixtures.

Cost efficiency:
Compared to other materials such as PUR (polyurethane) or TPE (thermoplastic elastomers), producing and processing PVC is relatively cost-effective. This makes it an attractive option for many applications.

Electrical insulation specifications:
PVC has excellent insulating specifications that make it perfect for electrical cables and wires.

Simple processing:
PVC is easy to extrude and mould, which simplifies the production of cables and wires. Subsequent processing, e.g. removing the outer jacket, is also much easier and quicker than with a corresponding PUR outer jacket.

Reaction to fire:
Special PVC compounds can have flame-retardant specifications, which increases safety in certain applications.

Despite all the advantages, it is nevertheless important to note that the particular requirements of the respective application must be taken into account. This is the only way to ensure optimum performance and long cable service life.

Overview of the various PVC cables

The variety of cables is virtually unlimited. From standardised to non-standardised cables, there is a wide range of options, even if these are reduced to the PVC outer jacket. Some of the most common PVC cables are presented below:

NYM cables for domestic installation:
The best-known cables are probably the three- and five-core NYM cables for domestic installation. They are laid over, on, in or under the plaster in dry, damp and also wet rooms and masonry. In some cases, the cables are also laid in concrete, with the exception of direct embedding in vibrated or tamped concrete. They are also suitable for outdoor use. However, it is important to make sure that they are protected from direct sunlight and that they are not buried in the ground.

H07V-K cables:
H07V-K is a core cable that is flexible and cannot only be laid rigidly. The H07V-K cable is ideal for pipes, on and under plaster and in closed installation ducts. It is also suitable for the internal wiring of devices, switching and distribution systems.

NYY-J PVC underground cables:
Another example is the J PVC underground cable. This is a power supply cable for use outdoors, in the ground, in water, indoors, in cable ducts, for power stations, industrial plants and switchgears and in local networks where mechanical damage is not to be expected. Please note that the maximum operating temperature is 70°C.

PVC connection cables:
These are probably the cables that we encounter most frequently in our daily routine as they are installed in everyday appliances such as the fridges, toasters or standard lamps. We see these robust cables everywhere and use them every day.

Vehicle cables:
Today, modern cars or other vehicles also contain several kilometres of so-called vehicle cables. Depending on the installation location in the vehicle, appropriate PVC compounds are often used for the outer jackets.

This is only a small part of the PVC cables. However, this overview provides an insight into the wide range of applications and shows how versatile PVC cables can be when the right PVC is used for the jacket.

The right PVC compound makes all the difference

As already mentioned at the beginning, PVC cables are often the most cost-effective solution compared to other jacket materials as PVC can be manufactured quite easily and inexpensively. However, it is also possible to produce very different PVC compounds.

PVC is not always the same

For example, the requirements for the outer jacket in a domestic installation are different to those for applications in permanent motion. Therefore, different PVC compounds are needed to meet the conditions to which an NYM jacketed cable is exposed as well as those to which a permanently moving PVC cable is subjected. As a result, there are special compounds. Some are characterised by a higher resistance to oil while others are suitable for use in soil. In addition, the appropriate compound can also determine its suitability for high or low temperatures and whether it works better during movement or rigid installation.

An important specification of PVC cables is their flexibility or rigidity, which depends on the compound. This specification plays a key role in deciding whether a cable is better suited for moving or rigid applications. Due to the large number of possible compounds, there is no "one solution" for all applications. Instead, cables with optimised PVC compounds have to be selected that are precisely tailored to the specific conditions. This also means that standardised cables are not always sufficient, especially if there is no standard that describes the application's requirements.

All in all, the right compound of the PVC outer jacket contributes significantly to the suitability of a cable for moving applications. An optimal compound can ensure that cables function reliably even under demanding conditions, such as when moving in an energy chain, and achieve a long service life.

Comparison: PUR vs. PVC in energy chains

A common statement made by many suppliers is: "PUR, or polyurethane, is the best material for continuous motion in energy chains." This is a myth! It only applies to certain conditions, but not as a general rule.

Based on this assumption, almost all drive manufacturers and many other suppliers almost exclusively offer moving cables for the energy chain with a jacket made of PUR. Arguments in favour of this thesis are that PUR is resistant to abrasion, notches, tears and cuts and can also be used flexibly at low temperatures. These specifications of PUR are of course true, but do not necessarily apply one-to-one to continuous motion in energy chains. Here, other requirements affect the cable, which affects the choice of jacket material.

To illustrate this, you can look at the assessment of abrasion resistance. This is subjected to standard tests, where a sample of the jacket is analysed and evaluated for abrasion using sandpaper, a razor blade or a needle. However, this test only provides information about how the jacket reacts in one specific position and not how it behaves in an application in an energy chain. In energy chains, there are no such influences as the cable is protected by the chain. It is, however, exposed to a different type of abrasion on the energy chain itself. In the case of energy chain movement, it becomes clear that in dry applications, PUR has significantly poorer abrasion behaviour than good PVC compounds.

Another characteristic of PUR that one should consider carefully is its cold flexibility. Here, too, you must bear in mind that the usual cold tests cannot simply be transferred to the use of the cable in an energy chain. According to the specified standard, the so-called cold winding test stipulates that, depending on the diameter, the cable is wound around a corresponding mandrel and then stored for a certain period of time at a predefined temperature. Once this period is over, the sample is taken out, the cable unwound and the outer jacket inspected for cracks and other damage. If the outer jacket is in good condition, the cable is approved for movement at the tested temperature.

This is a good comparative material test. However, here too, no account is taken of how a cable behaves at the corresponding temperature in a permanently moving energy chain. Separate tests are essential to obtain a meaningful result. Tests carried out directly in the moving energy chain have shown that PUR behaves significantly worse here in the cold than in the standard cold winding test.

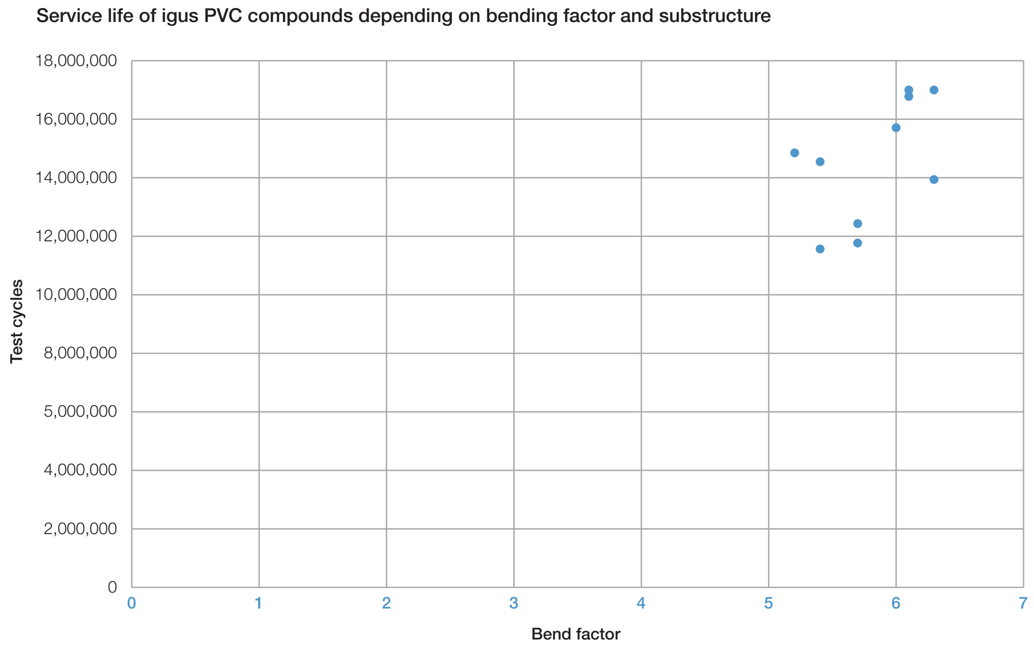
Still, the same applies here as with PVC: there are also different PUR compounds and qualities, which can also have very different specifications. In general, only a few PUR compounds are suitable for continuous movement in energy chains.

Therefore, it is important to consider the conditions under which the cable is used in continuous motion and in the energy chain. PUR should not be favoured over PVC as a general rule, but the individual parameters and suitable tests should be taken into account.

Results from the igus test laboratory

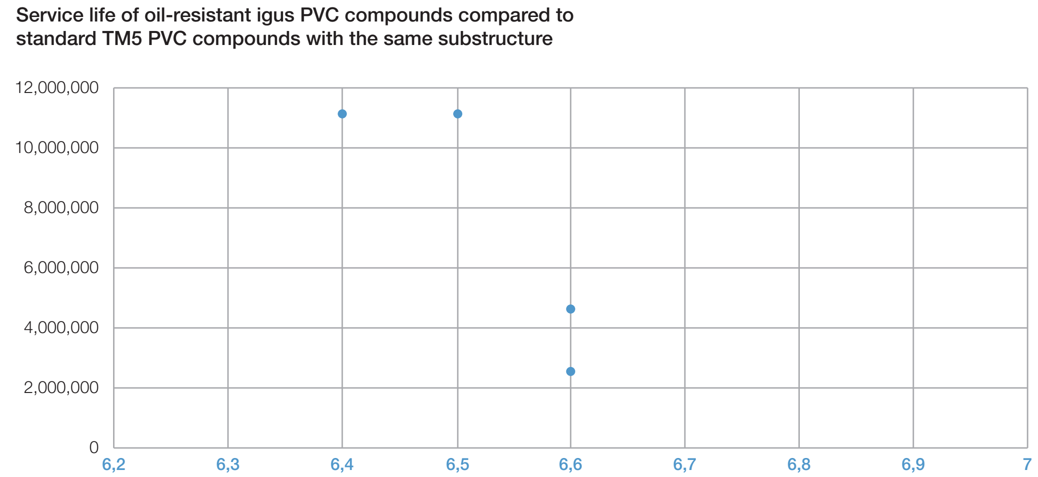
In its 4,000m² test laboratory, igus has analysed PVC cables with different braided structures in hundreds of test series, especially for use in continuous movement in energy chains. The results show that the quality of the PVC compound, the type of processing and the design of the substructure have a significant influence on durability in the energy chain.

The following graph shows the distribution of durability depending on the braided structure and bend factor: the values vary to a certain degree.

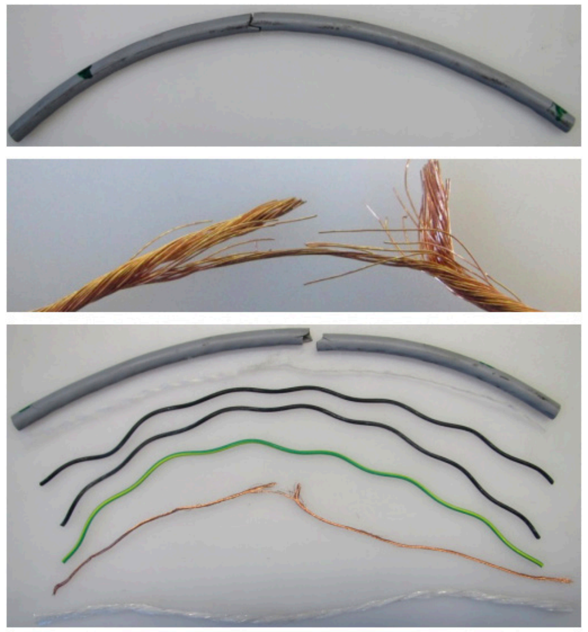


PVC compounds in endurance tests with different test radii and substructures in comparison, source: igus

Even with relatively small bend radii, cables can have a service life of well over 10 million double strokes in an e-chain and with an optimised PVC compound. Comparative tests were carried out in many other test series. They showed that the weaknesses of "e-chain-compatible" PVC cables available on the market can be clearly explained with non-optimised PVC mixtures. Below is a comparison of two different substructures. An igus PVC compound is contrasted with an "e-chain-compatible" PVC cable from the competitor:

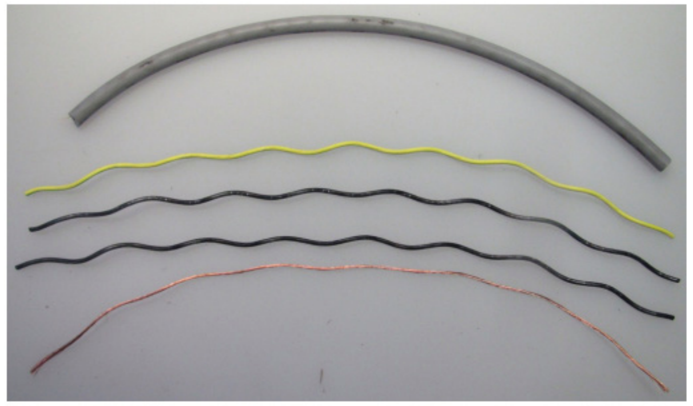


PVC compounds in an endurance test compared with e-chain-compatible PVC cables available on the market, source: igus

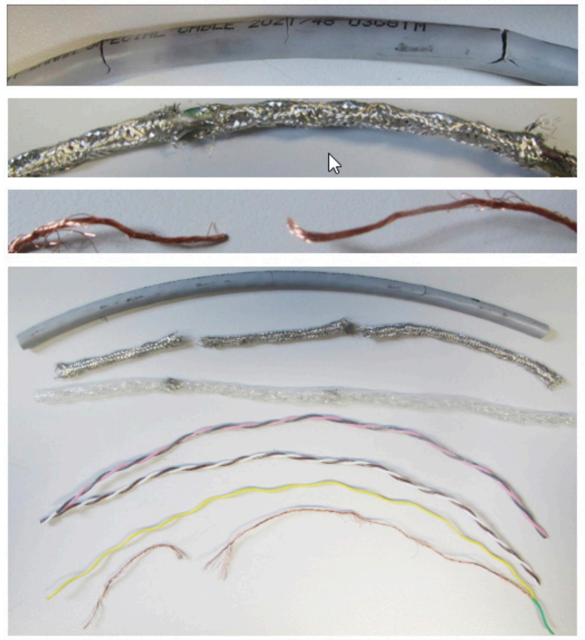


4G0.5mm2 cable broken after less than 4.5 million double strokes, source: igus

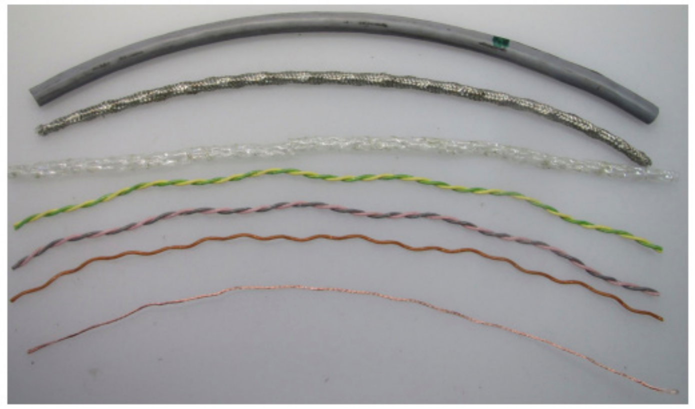
Under the same conditions and with the same bend factor, the differences in the durability of chainflex PVC cables compared with similar cables with a different PVC compound are evident.



CF130.05.04 without damage after over 10 million double strokes, source: igus



(3x2x025)C cable broken after less than 3.1 million double strokes, source: igus



CF211.02.03.02 cable without damageafter more than 10 million double strokes, source: igus

These tests clearly demonstrate that igus PVC cables with optimised compounds and processing methods can last considerably longer than many other "energy-chain-compatible" cables available on the market.

In summary: with the right PVC compound, cables for continuously moving applications in energy chains are often an excellent choice. The material has very good, long-lasting flexural strength and can guarantee a service life of over 10 million double strokes in an energy chain. igus has proven these figures, the quality of the PVC compounds and thus the durability of the chainflex cables in numerous series of tests in its own laboratory over the last 30 years.

When does it make sense to use PVC cables in an energy chain and when not?

A good idea

PVC jacket compounds are ideal in applications with moving energy chains if certain conditions and requirements are met. Here are the most important criteria for PVC cables in energy chains:

Indoors, at room temperature:

PVC cables are ideal for applications in energy chains that are operated indoors at room temperature. Temperatures typically range from +5°C to +70°C.

Outdoors, protected from direct sunlight:

If the energy chain is used outdoors, it should be protected from direct sunlight. PVC cables can work reliably under these conditions as long as the ambient temperatures do not fall below +5°C.

Dry environments:

In dry environments, PVC has clear advantages over PUR materials as PUR tends to be more abrasive in dry applications than corresponding PVC compounds. PVC is therefore an excellent choice, especially in such circumstances.

Low to moderate oil load:

PVC cables are also suitable for applications with low to moderate oil loads. When the cables are subjected to a lot of oil, however, special compounds or alternative materials such as PUR should be considered.

These criteria help users decide when to use PVC cables in energy chains. The specific customisability of the PVC compounds makes it possible to develop cables that are precisely tailored to the requirements of the respective application, ensuring high reliability and a long service life.

Not a good idea

Using PVC in moving applications in energy chains is unwise if certain conditions and requirements are not met. Here are the main restrictions and limitations of using PVC cables in moving applications:

Continuous temperature below +5°C:

PVC cables should not be used in environments in which the continuous temperature during movement in an energy chain is below +5°C. At lower temperatures, PVC loses its flexibility and can become brittle, which can result in breakage and failure.

High oil load:

PVC cables are less suitable for applications that involve a lot of oil, such as in the unprotected machining area of a machine tool. Contact with oil can affect the material, which considerably shortens the cable's service life.

High UV exposure:

PVC cables should not be used in environments with high UV radiation. Strong sunlight can degrade the material and make it brittle, which can also result in premature failure.

High chemical load:

If there is a high chemical load according to chemical tables, special compounds or alternative materials are required. Standard PVC can be attacked by aggressive chemicals and lose its mechanical specifications.

This categorisation is based on the assumption that the corresponding cable is intended to function safely for several million double strokes without failure. We recommend avoiding PVC cables under the above-mentioned circumstances and instead considering suitable alternatives such as PUR or other specialised materials.

Conclusion

To sum up, PVC is a cost-effective and high-performance alternative to more expensive materials such as PUR under the right conditions. With the appropriate mixture and processing, PVC can deliver excellent results in a wide range of energy chain applications and save costs at the same time.

Polyvinyl chloride (PVC) as a jacket material for cables in energy chains has a number of advantages and is an excellent choice under certain conditions. The cost-effective production and processing in addition to the mechanical stability, which make PVC a robust and durable material, are particularly noteworthy.

Summary of the most important points:

Cost efficiency:
Compared to other materials such as polyurethane (PUR) or thermoplastic elastomers (TPE), producing and processing PVC is significantly more cost-effective.

Mechanical properties:
PVC offers excellent mechanical stability and flexibility, which makes it ideal for applications in energy chains where manoeuvrability and durability are crucial.

Adaptability:
Different PVC compounds can be used to develop cables that are precisely tailored to the requirements of the respective application. This ensures high reliability and long cable service life in a wide range of applications.

Test series and validation:
Extensive tests, particularly in the igus test laboratory, have shown that high-quality PVC cables in energy chains can withstand over 10 million double strokes. These results confirm the suitability of PVC for permanently moving applications.

Recommendations for technicians and purchasers:

Application areas:
PVC cables are ideal for indoor use at normal room temperatures and for outdoor when protected from direct sunlight.
In dry environments, PVC often proves to be more favourable than PUR due to its lower abrasion. PVC cables also show low to moderate oil resistance.

Restrictions:
PVC should not be used in environments that contain a high level of oil or chemicals or where the continuous temperature is below +5°C.
Alternative materials should also be considered for high UV exposure.

Contact
Please do not hesitate to contact us for further information.

Rainer Rössel
Head of chainflex® Cables
Phone: +49 2203 9649-278
Fax: +49 2203 9649-7691
E-mail: rroessel@igus.net

igus® GmbH
Phone +49 2203 9649-0
info@igus.net
www.igus.eu

▶ To contact page

You can find more information in the following white papers:

▶ White paper: Life cycle costs

▶ White paper: 10 tips

Date: 03/2025