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»WHITE PAPER

FIVE KEY ELEMENTS FOR HIGHER CABLE DURABILITY IN DRAG CHAINS

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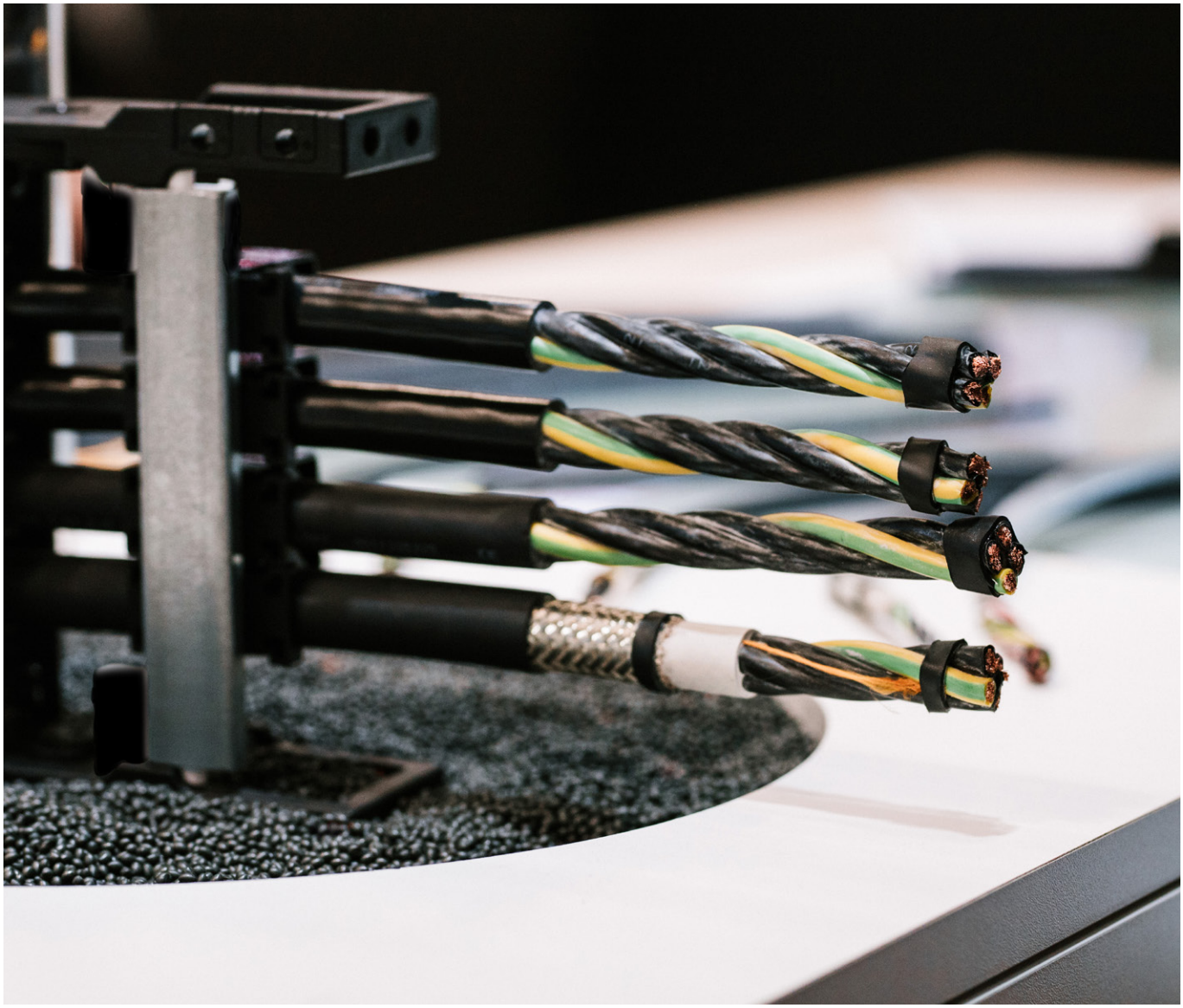
When designing and constructing drag chains, users often ask, „why do I need special cables for this?“ High loads such as bending, abrasion, and millions of motion cycles are quite demanding on cables and call for solutions that are perfectly tailored to each specific application. In this white paper, learn which factors are important for the function and durability of drag chain cables.



» Designed for Continuous Movement

Drag chains – also called energy chains – have been an integral component of mechanical and plant engineering since the 1970s. In moving applications, they serve simultaneously as a guide and as protection for electrical cables, as well as pneumatic and hydraulic hoses. In machine components that sometimes move back and forth millions of times, they prevent, for instance, kinking in cables and hoses, and prevent them from becoming entangled or pinched. Drag chain manufacturers offer customers solutions for high speeds, quick accelerations, long and short travel distances, and adverse conditions, all according to the application.

The consistently identical motion and often high number of cycles put a particularly heavy load on the cables used. This spurred manufacturers in the industry to further develop standardised cables. Vendors with the capacity to manufacture and test their own products have a clear advantage. They are capable of directly implementing all sorts of new findings into the manufacturing of their products and optimise them based on valuable experience.

The rubbing that occurs between the individual cables and between cables and the drag chain presents a challenge. It must also be considered that the available installation space for power supplies in modern and compact machines and plants is becoming ever scarcer. This can be seen in the increasingly smaller bending radii of newly constructed drag chains, as well as in the cables that must be suited for such tight bends. Depending on where the drag chain is used, they may also be subjected to extreme temperatures, oils and chemicals, moisture, or UV radiation. The long-term exposure to all of this puts considerable strain on the material and can, sooner or later, lead to damage and expensive downtimes.

The cables installed in drag chains must not only be resistant to bending and abrasion, but also fulfil other widely varied requirements depending on the application. When designing a complete system, it is necessary to select the exact cable to fit each application. When choosing cables, it is recommended to closely consider all factors that could have an impact on cable function. The five key elements here are the cores, the stranding, the screening, the sheathing, and the required standards.

The roles that each of these play, and what should be paid attention to when choosing, will be explained in greater detail in this paper. For a more practical overview, this white paper will deal only with standard materials. Exotic coatings, special braid constructions, or alloys are of course available in specialty cables, but will not be considered for the purposes of this paper.

» 1. Cores

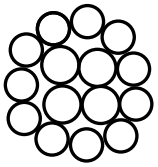
The cores are the essential heart of every electrical cable. According to the function of the cable, the core's job is to transmit energy or data. To do this, a conductive material is need, usually copper, which is surrounded by an insulating layer. For drag chains, the copper cores are braided together. This means that, instead of a single, solid wire, there is a bundle of many fine wires. This is what provides the cable with the flexibility required to function in a drag chain. Usually, drag chain cables feature braids of conductor category 6, which are the most finely stranded. These braids consist of a large number of individual wires and are therefore very flexible, which ensures long durability. For more simple applications, however, braids of conductor category 5 can be used.

The number of the conductor class provides information about the wire diameter and the number of wires that make up the braid. The higher the conductor class, the

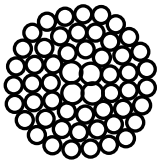
greater the number of wires and therefore the thinner each individual wire is. In practice, this means, for example, that a conductor category 6 core with a nominal diameter of 0.34 mm2 consists of 42 wires, each wire with a diameter of 0.10 mm. Whereas a conductor category 5 core with the same diameter consists of 19 wires, each with a diameter of 0.15 mm. The core's nominal diameter should stay the same, after all.

The exact arrangement of the wires inside the braid depends on the respective manufacturing process. The use of bunched strands for cores with smaller diameters is salable and, from a technical perspective, perfectly adequate. This means that the wires are bunched together without a fixed arrangement. For larger diameters, the most durable solution would be the use of a transmission line conductor. In this construction, each wire has its exact position. This means the cable can withstand and distribute loads very well. This is important because the wires on the outside of the braid must usually endure greater tensile forces, while the wires on the inside are compressed.

The core insulation must be abrasion resistant since it is also constantly in motion and rubbing against other cores, the screening, or other fill materials. Materials are also required to be be elastically resilient. This means that they return to their original form after being subjected to bending or tensile forces. The insulation material should also be temperature resistant. This is due to the fact that cables are heated by the flow of electricity, and the more solid the insulation stays under heating, the less the mechanical durability of the entire cable suffers. This results in greater technical reserves in terms of current carrying capacity and therefore greater safety.



Copper wire of conductor class 5



Conductor class 6 wire with same cross-section

» 2. Stranding Element

It is important to ensure that drag chain cables have the appropriate stranding during their construction, meaning the arrangement of the individual cable components. There is often an empty space in the middle of cables with large core diameters or a large number of cores. In cables that are not subjected to mechanical loads, this empty space is often filled with dummy cores or simple fill material. If the cable must withstand accelerations, a tension-resistant core element will instead be used, which both fills the empty space and helps the cable withstand tensile forces.

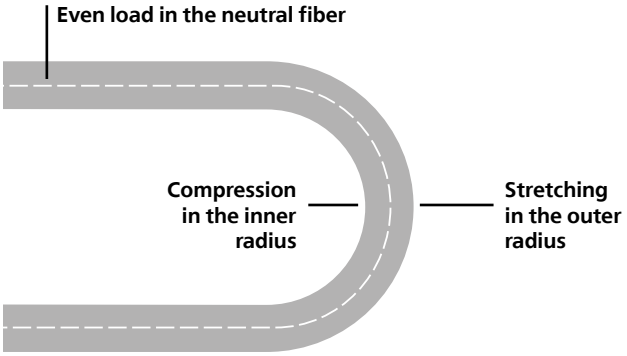
The cores are stranded around this central component with short lay lengths so that the core changes position in the stranding of the cable over a very short cable length. This allows the tensile and shear forces, which act differently on the core in the inner and outer radius, to be well balanced. These forces are caused by the stretching of the outer radius of the cable and the simultaneous compression of the inner radius. In most cases, these forces are equalised by stranding in layers. This means that the cores or entire components are laid in a single layer around the central component. They form a sort of layer around the central component.

If there are multiple cores, these can be assembled in bundles and are then stranded around the central component. Viewed from the outside, this resembles a steel cable. Stranding in bundles gives the individual cores an additional means of compensating for bending forces and increases the cable's lifespan in permanently moving applications. The disadvantage of this method is the additional space these stranded bundles require, which give such cables a somewhat larger diameter. It is pos-

sible to construct the stranding with a reverse twist. This reverse twisting of the cores means that the stranding is preloaded, holding them together.

Stranding the cores causes many small valleys to form inside the cable which must be filled. The highest-quality solution for this is an inner sheath extruded under pressure, which holds the cable together lengthwise exceptionally well. This also serves as a very good foundation for screening that can be tightly woven directly on top. Cables that are not subjected to the highest loads can also go without an inner sheath. Instead, during the manufacturing process, individual fillers are built into the stranding that also ensure the cable has a rounded structure.

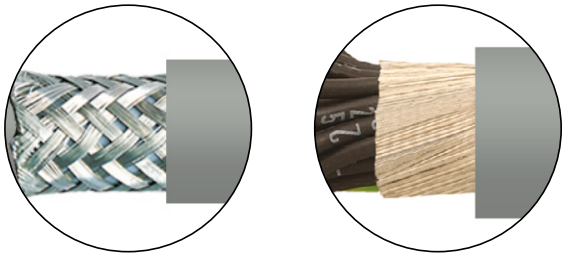
Bending stress on drag chain cables



» 3. Screen

Screening prevents electromagnetic disruptions and interactions with other cables and ensures reliable signal transmission. This is especially important in modern, industrial applications where ever more electrical components, machines, and plants are being installed in the tightest of spaces, and can only operate if they are not constantly influencing one another. Even within a single cable, there are sometimes different signals, such as in hybrid drive systems, where even internal screening elements are necessary. Screening can't hurt. However, due to how laborious it is to manufacture, screening isn't cheap. It also takes up space, which is why it is important to verify its application. In a mechanical sense, screening functions like an additional corset around the cable, which can improve its mechanical durability.

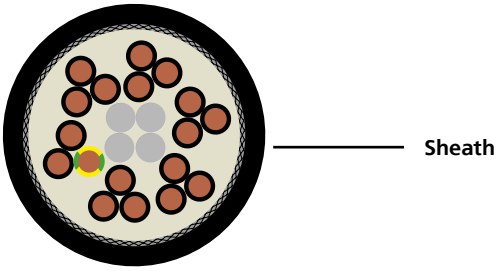
Screening is made of metal and can be constructed using various methods. For high-quality drag chain cables, a so-called c-screen has been proven effective, which is a mesh of metal wires that is wrapped around the strands. This construction is especially resilient against bending loads. For this, the braid angle must be as flat as possible in order to compensate for compression and stretching. For screening inside cables, a „D-Screen" or twisted screen can also be used, which involves the wires being wrapped around the stranded element without crossing over one another. Foils can theoretically achieve the highest coverage and therefore the best electrical properties. These, however, are very fragile causing the effectiveness of the screening to diminish quickly. This is why foils are only used as a complement in special cases such as in bus technology where it is important for the screening to have a uniform surface.



C-Screen **D-Screen**

4. Sheath

The sheath is the outer-most layer of the cable and is responsible for protecting the cable from external influences. In drag chains, they protect against abrasion with the stays. Plastic mixtures such as PVC, PUR, or TPE are used, with TPE having the highest abrasion resistance. TPE is also available in flame-resistant designs. The plastic is liquefied and applied to the stranded elements using an extruder. This is ideally done under pressure so that the liquid plastic flows into and fills all gaps. For cables that are stranded in bundles, this process is also called gusset-filling pressure extrusion. This prevents the individual cores inside the cable from moving, which makes them more robust for longer travel distances.



A gusset-filling, extruded sheath, however, has the disadvantage of being less easily stripped. Mechanical stripping typically does not work, and manual stripping requires a certain level of precision to not cut into the cores by mistake. HELUKABEL has developed a clever solution for this in their special rip cord which allows the cable to be quickly, easily, and safely sripped.

The sheath material contributes to many other properties of a cable, such as in temperature resistance. PVC has the lowest temperature range, where as TPE cables are suitable for extremely high or low temperatures. However it should be noted that all other cable components must be designed to withstand the most prevalent conditions of the application. Even resistance to chemicals differs between individual materials. It is recommended that materials being considered for a specific application should first be tested to avoid complications down the line. As a fire prevention measure, more and more applications are requiring halogen-free cables, which is a factor that must also be considered when choosing a sheath material.

5. Standards

Last but not least, the cables must fulfil all relevant standards depending on the specific application, whether it be the European DIN VDE and EN requirements or the American UL standards. These serve to establish comparable reference values for technical applications. Manufacturers and users alike orient themselves according to these values.

Standards, as the name implies, deal of course with standardised applications. Special requirements, such as those presented by drag chains, are typically not explicitly defined. The construction of a drag chain cable, for example, is not regulated by a standard. Even common standards dealing with cables' current carrying capacity, the installation type „drag chain" is not included as other types are. This is why cable manufacturers have committed themselves to produce cables according to high standards that are based on the existing set of standards. In this regard, it is advantageous to test cables under realistic conditions. This ensures that the customer's expectations of a safe and functional system are met.

There are other areas where further standards for cables and wires apply, such as the DNV for on and offshore applications. Many companies also have their own factory standards for certain applications. These further elevate technical requirements. It may also be the case that multiple provisions contradict one another and lead to confusion. This is why it is important that the user and manufacturer work closely together to ensure that all relevant specifications are met, and that the customer receives a quality cable.

» Take Away

Drag chain cables are complex, high-performance products. Their reliability is thanks to the perfect interplay between their individual components — from copper wires to sheath materials. Each of these parts can be affected by different factors, which makes it that much more important to keep these factors in mind when selecting suitable cables for an application. At the same time, the chosen solution must also be an economical one. This means that the cable should not fulfil any further requirements than those actually presented by the application. To this end, manufacturers offer multiple different cable qualities for the same electrical assembly.

It is incredibly advantageous for customers when all drag chain components exhibit optimum compatibility. This helps avoid complications and malfunctions that in turn can cause interruptions and expensive downtime. It is all the better when, such as with HELUKABEL, the drag chain and the cables used within all stem from a single source. The specialist for electrical connection technology has steel, stainless steel, and plastic drag chains, as well as a large selection of specially designed, high-quality drag chain cables in its portfolio. Thanks to their expertise in manufacturing, they are able to directly implement improvements and current trends into products and ensure their compatibility.

The different, individual components can also be combined into complete, pre-assembled, and installation-ready system solutions upon request. All products are put through their paces under realistic conditions in an in-house testing laboratory. This ensures that all components being used exhibit optimum compatibility and that the entire drag chain system reliably meets the stringent requirements of harsh, daily use over the long term.

» CONTACT

We look forward to your request and remain available for any further questions.

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