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What are the best cables for **robotic applications?**

Choosing the proper cables for your robot arm is essential to avoiding unnecessary damage and downtime. However, this isn't always as simple as it seems. There are a number of considerations that need to be made when choosing robot cables; the biggest of which is whether the chosen cable is designed for linear movement or torsional movement. Read on to learn the difference between "regular" cables and robot cables.

Know Your Cable Types

There are several types of cables used for "moving" applications in the industrial world. You may hear them referred to as flexible, high flex or continuous-flex. They may all have the same electrical characteristics when it comes to gauge and conductor count, but the truth is all of these cables are different.

Flexible cables could simply be referring to how malleable they are and have no mechanical qualities to survive the rigors of a cable carrier. High flex cable is an industry term widely used to describe a continuous-flex cable. But, it could simply mean a cable that is highly flexible, so be careful when choosing a cable specifically referred to as high flex. Continuous-flex, as its name implies, is designed to continuously flex or move. These are the cables that should be specified when it comes to linear motion. True continuous-flex cables have been designed for and tested in cable carrier applications.

Often, these cable types are mistaken for one another and misapplied in high demand dynamic applications. Just because a cable feels flexible doesn't mean it will survive the rigors of a high-duty cycle cable carrier

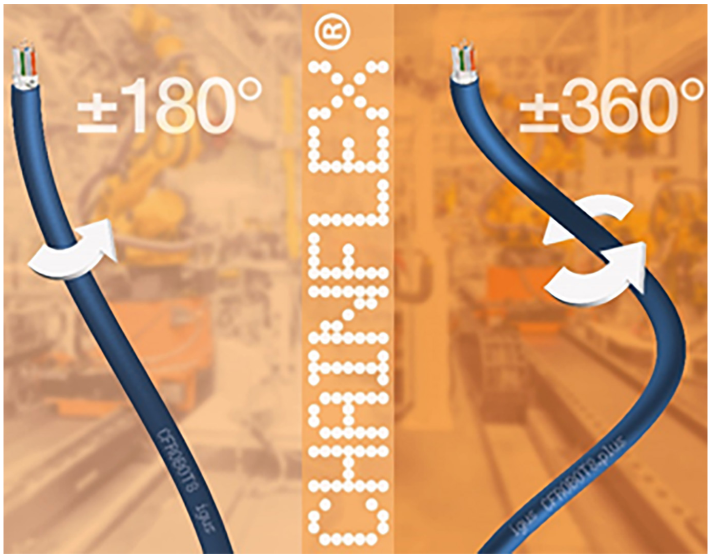
This misapplication can lead to premature failure and extended downtime. The same is true for robotic applications. The majority of the six-axis robots in the field put a high degree of torsional stress on cables. Using a "highly flexible cable" instead of the right cable in an application such as this will most certainly lead to premature failure and increased costs.

Ensuring the cable's compatibility with high demands is essential, as failure of such a cable often means that the entire production must come to a standstill. Downtime/maintenance in automated systems is often the most expensive portion of operational costs, running some companies upwards of $780,000 a year. With costs that high, using the proper cables is essential.

Stress: Linear vs. Torsional

Linear stress occurs in either the X, Y or Z axis. Cables inside a cable carrier, for example, experience linear stress as the carrier moves them back and forth in one direction. In these types of applications, there is very little, if any, "twisting" of the individual cables.

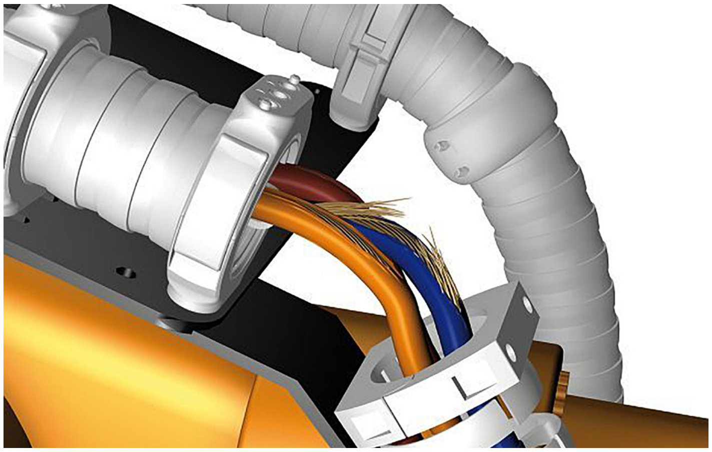
Torsional stress is the twisting of the cable due to the rotation of the robot arm. Six-axis robots can exert a high degree of torsional stress on a cable at multiple points along the robot arm. Axis 4 and 6 can see rotation of over 360° each and sometimes in opposite directions. Meanwhile, axis 5 will provide additional stress in a linear fashion, with more than 200° of motion possible.



5 Key Differences Between a Linear Continuous-flex Cable and a Cable Made for Torsion

Outer Jacket: While PVC is by far the most common outer jacket material for linear applications, PUR and TPE are used on robotic movements because of their high degree of abrasion resistance. With three dimensional motions, abrasion patterns are much less predictable and contact with other materials within the cable management system is nearly impossible to prevent. The jackets of other cables or hoses often can be abrasive to unlike jackets and when routed in a dresspack cannot be separated. Furthermore, the cables will certainly contact the cable management conduit which will have abrasive qualities of its own.

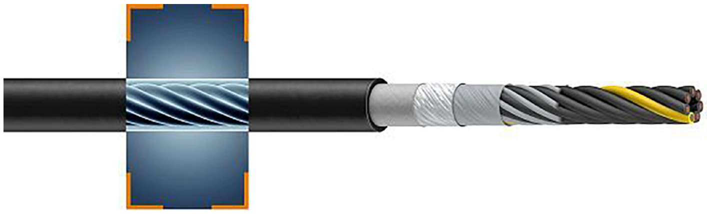
Shielding: Linear applications use a braided shield having up to 95% optical coverage. This tight braid resists the twisting found in robots and can cause the braid ends to break and puncture the outer jacket as well as the inner strain relief elements. This internal carnage can lead to conductor failure due to the lack of positional security. The shielding in a torsional cable uses a different braiding technique that alleviates the issue of torsion resistance, while still maintaining 85% optical coverage. As added protection, a PTFE film is introduced to the shield to help absorb torsional forces.



Buffering Material: In torsional cables, there are materials used between layers known as buffers. These “buffers” absorb the load created when the cable is bending, but more importantly it absorbs the stress on the cable when it is under torsion. Torsion leads to diameter changes in the cable (think of ringing out a wet towel) and without these buffer materials, there would be significant damage to the other elements of the cable due to the compression.

Pitch Length: This refers to the manner in which the individual copper strands are twisted to make a conductor. Conventional high flex cables will use a short or “tight” pitch, to help the cable withstand the stresses created by the constant bending inside a cable carrier (think of a thin wire hanger versus dozens of wires twisted tightly together). A torsional cable requires a much longer pitch for it to withstand the twisting associated with robotic motions.

Conductor Individual Stranding: The copper strand count within individual conductors can vary from one cable to the next. The difference starts with the conductor. A linear flexing cable can have coarser AWG stranding to yield the best linear performance. A torsion cable requires a specially designed conductor, with attention paid to added flexibility and pitch lengths. All the design attributes must allow twisting motion while maintaining the cable’s structure and mechanical strength.



Conclusion

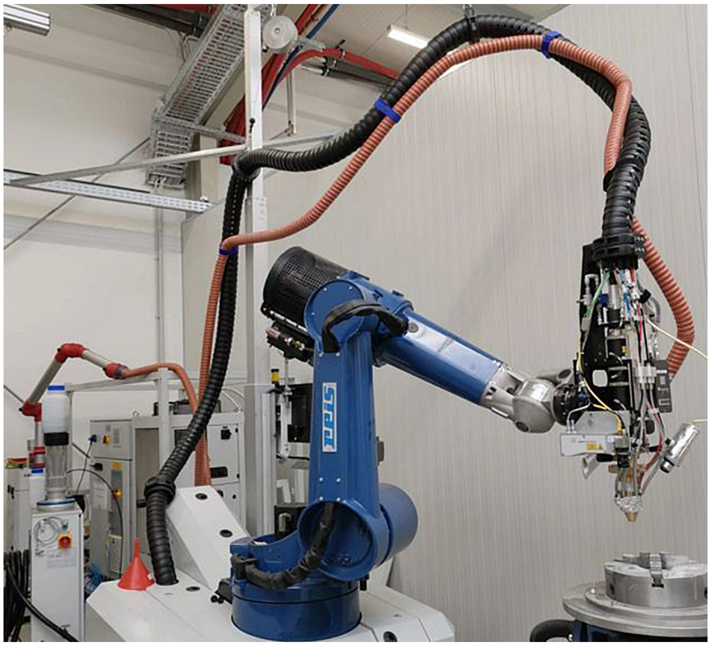
By selecting the proper cables for your robot, you can achieve a service life of millions of cycles without the need for maintenance or cable replacement. Alternatively, choosing improper cables can cost hundreds of thousands of dollars a year in downtime alone, nevermind the cost of replacement cables. This should make it clear: cable selection is one of, if not the, most important aspects when designing your robot, and requires careful consideration and proper knowledge of the types of cables available.

Robotic cable management **made easy**

Though robotic cables have been designed to withstand the unique strains a six-axis robot can put on them, a cable management system is crucial to ensuring these cables work for as long as possible. When improperly housed, cables will wear prematurely or fail in other ways, causing costly downtime. Unhoused, cables can sag and fall into the work area, or become tangled within the moving parts of the machinery. Housing the cable bundle properly around a robot is critical in maintaining proper performance and avoiding machinery downtime.

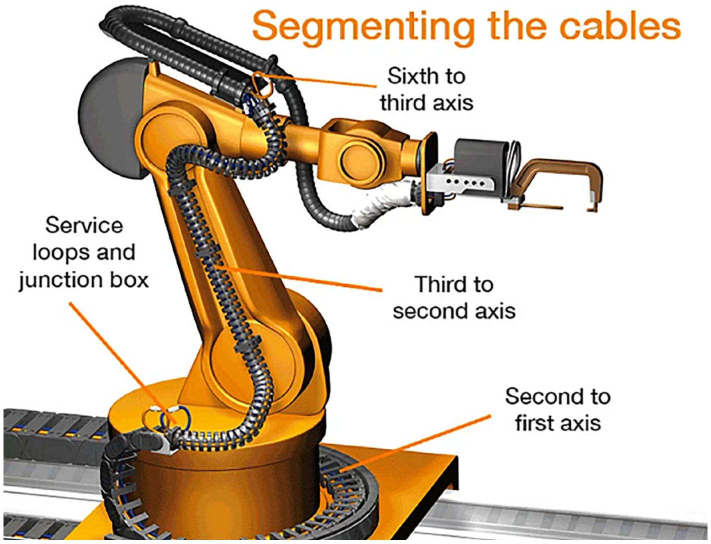
Basics of Robotic Cable Management

In the field of multi-axis robots, industrial integrators are faced with the unique challenge of selecting and managing cables to be run on the outside of a moving six-axis platform. The complex movements made by six-axis robots require special consideration when deciding on how to manage their cable systems.



Traditional cable management systems attempt to keep cables static, while operations surrounding them are dynamic. Restricting the movement of the cables can create points of stress, accelerating cable failure. Today, new intricate movements carried out by robots — especially the sixth-axis rotation — have created a need for a more modern way of thinking about cable management.

While current systems utilize a more restrictive cable package that will run cables from the robot case to the end effector, designers should consider a new, dynamic approach: treat a six-axis robot as three separate segments: the sixth to the third axis, the third to the second axis, and the second to the first axis. Segmenting the dress pack into three shorter sections prevents it from wrapping, catching, or snagging on machines and minimizes stress on cables and hoses. This breakdown of segments is imperative to having maximum cable control while allowing cables to function properly for their manufacturer-determined service life.



Ideally, each segment should feature a minimal dresspack, strain relief with service loops, and a junction box that contains and protects electrical connectors joining the cables. Strain relief cables specially designed to handle torsional movement are crucial to avoid cable failure and keeping machines up and running for as long as possible.

Why use Strain Relief

The motion of a six-axis robot is very dynamic, with multiple axes working simultaneously. This symphony of motion puts a great deal of stress on your cables. The job of the cable management system is to protect the cables from getting caught and damaged along the robot arm. This level of protection stops at the end bracket, and it's at that point that the cables must fend for themselves.

The last line of defense is strain relief. When a cable is not properly strain relieved, its tendency is to try to move back and forth inside the dresspack. This leads to shortening of the service loop near the tool and can result in cable damage and connector failure. Understanding these two failure modes is vital.

Cable Damage: There are two ways the cable can be damaged in this instance. The first is outer jacket wear. Quite often, we see preventable wear on the outer jacket of a cable due to a "sawing" motion of the cable as it is pushed back into the dresspack and pulled out again. This constant sawing shaves the jacket material down to the inner elements and leads to premature failure.

This sawing also leads to another form of cable damage: conductor breakage. If the cable is "too" free to move, it is at the mercy of the robot joints and end effector. The motions of a six-axis robot can be violent and the constant pulling on the cable at high acceleration can lead to the copper strands fracturing and in time, complete conductor failure.

Connector Failure: Perhaps you have specified a super strong cable and it is able to withstand the rigors of high duty cycles and violent motions. You still may experience failures at the connector. These connections can be very delicate and easily damaged under stress. Maybe you use an over molded connector specifically to avoid this problem — over molded connectors do reduce the failure rate at the point of connection between the cable and connector. But they can still fail.

Styles of Strain Relief

Grommet: Most corrugated hose systems come equipped with a "grommet". This grommet is a rubber disc with holes drilled into it, specifically to the diameters of your particular cable package. The grommet does a great job holding the cables in place and restraining them from unnecessary movement. But if you need to add or subtract a cable, it can be very difficult and time consuming.

Tie Wrap: Another style of cable management comes with a type of tie wrap plate. If you have used cable carriers before, you should be familiar with this style of strain relief. When using tie wrap plates, it is important to tie wrap each cable or hose to an individual tie wrap finger. A good rule of thumb is to put two tie wraps at each position, one zipped in one direction and the second in the opposite direction. This greatly reduces the chance of the cable coming loose.

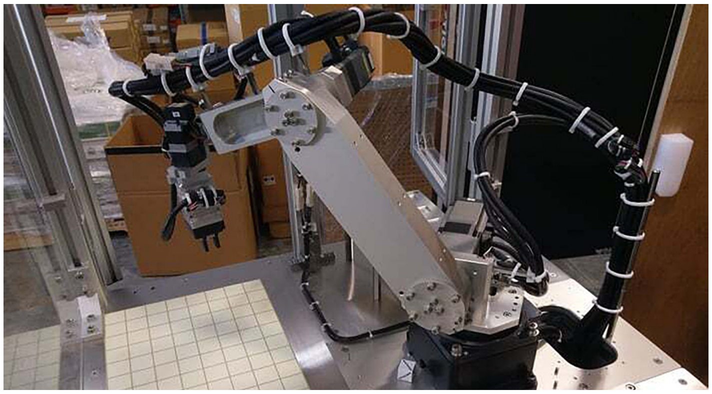
Clamping: The last style commonly used with robot cable management is a compression clamp. The cable sits in a fixed lower saddle while a set screw pushes the upper saddle down into the cable and holds it in place. This is by far the most secure way to relieve cables of strain and offers the lowest wear factor of the three options available. The limitations of this style of strain relief are space and the outside diameter (OD) of the cable. It requires more real estate at the end effector, and very large OD cables and hoses may not fit in the available clamps.

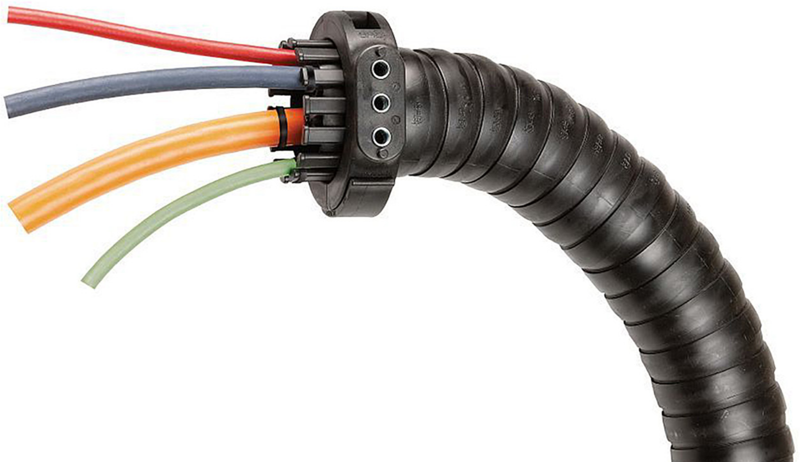
Robotic Cable Management Options

Corrugated tubing is one of the options for cable management used in these robots, but it has its limitations. These are mainly limited torsion resistance and ability to stretch along with the robot's movements. These failings cause strain on the cables, leading to downtime.

A second option is enclosed dresspacks, mounted directly on the robot. This method consists of corrugated tubing housed in reinforced plastic. This adds strength, but its non-modular design makes cable maintenance difficult and requires the replacement of the entire system if one component were to break.

A third option for cable management is a robotic cable carrier, which is mounted directly to the robot and can be tailored to the customer's exact specifications. Similar to an enclosed dresspack, the spring loaded design is equipped with strain relief options, extending the service life of the cables, as well as the ability to quickly add or remove cables without dismantling the entire system, allowing for minimal downtime. Most importantly, the defined bend radius of these systems ensures that cables are protected from exceeding their maximum bend radii.





A Tested System That Integrates Seamlessly

One option for robotic cable carriers is Triflex® R from igus®, a modular, multi-axis cable carrier system designed to guide and protect cables and hoses in robotic applications. Triflex® R ships and installs as one piece and has an integrated fiber rod that returns cables to a home position after the robot completes a cycle. The system includes mounting plates and brackets, protection links, and a pre-engineered fiber-rod assembly. It is a modular, compact system, but with only one piece to install for complete end-of-arm tooling guidance. The lightweight plastic 3D robotic cable management system is made up of one-piece links that require no additional items such as steel cables or spring mechanisms for support. Triflex® R is highly flexible due to its ball-and-socket design, enabling movements in all axes. Its small bending radii and short pitch make it an ideal space saving installation. The modular design also simplifies maintenance; individual links can be replaced as needed, reducing costs, and cables are easily accessed, saving time.

Conclusion

Making the change from corrugated tubing or unprotected cables to a 3-dimensional robotic cable carrier may seem like an unnecessary and complicated task, but experts in the field agree that proper cables and cable management can make or break a robotic system. While the initial savings may sway a potential customer away from purchasing robotic cables and a suitable carrier, costly repairs and loss of productivity from unplanned machine downtime could convince even the most tentative of engineers and designers. These new, specifically designed systems can make maintaining six-axis robots a much simpler task.