Basics of Cable Carriers

Choosing the right carrier extends the life of cables and hoses, enhances machine safety, and reduces operating costs.

Many industrial cables and hoses transmit energy, data, and fluid from fixed sources to moving mechanisms. They usually need to be guided and protected from external stresses common to the manufacturing environment. Cable and hose carriers can do this job.

The carrier is a structure which surrounds the cables and hoses and facilitates travel while maximizing the life of these conduits. Cable carriers can take many forms, from open-style chains to fully enclosed tubes, and they are available in a variety of materials. Individual manufacturers refer to this product with a number of different terms, including cable carrier, drag chain, CAT track, cable track, energy chain, and so on.

Regardless of the name, carriers provide an easy way to keep electric, hydraulic, pneumatic, and other lines in the proper position on equipment and to protect them from abrasion, snagging, entanglement, and overbending during machine movement. Closed-type carriers provide further protection from weld spatter, hot metal chips from machining, and abrasive debris. The result: enhanced operator safety, less downtime and maintenance, lower operating costs, and longer life.

Cable carriers are used on everything from small desktop printers to offshore oil rigs. Yet cable-management is often an afterthought for equipment manufacturers, typically, addressed late in the product-development cycle. And carriers are sometimes low-priority items, with price and delivery the main selection criteria.

However, an inappropriate carrier can quickly cost more than its initial price if it unexpectedly fails or if the conduit wears out prematurely. Here are some tips on selecting a well thought-out cable-carrier design that can significantly reduce operating costs over the life of a machine.

Designs and materials

Cable carrier construction varies, but the most basic design consists of parallel side links jointed by parallel cross bars on the bottom and top. Additional components can include items such as pivot pins, external rollers, and internal separators and...
Fully enclosed carriers protect cables from debris and contaminants like machining chips and cutting oil.

shelves. Some link-type designs are completely enclosed, while others are open between the links. Another variety is the conduit-type design, which is completely enclosed with removable lids for cable access.

Most carriers on the market are either all plastic, all metal, or hybrids that combine advantages of both materials (usually polymer side plates with steel or aluminum crossbars.) An overriding concern in many applications today is the carrier weight, because heavier systems require more power to move them back and forth. Lightweight plastic carriers are often preferred for energy-efficiency reasons.

Relatively low-cost units are made of nylon or glass-reinforced nylon, and they’re generally suitable for moderate loads and speeds. But the materials become brittle at cold temperatures and many formulations absorb water, making them unsuitable in wet and high-humidity environments.

Others are fabricated with engineered polymers such as ultrahigh-molecular-weight (UHMW) polyethylene, PTFE, Delrin, and similar materials. One all-polymer cable-carrier manufacturer, igus® Inc. of East Providence, R.I. (www.igus.com) has engineered its own polymer material blend based on polymer-bearing technology. It reportedly combines high strength and abrasion resistance, providing excellent life in most applications.

These tougher, stronger, sturdier materials, in conjunction with newer carrier designs, have allowed all-polymer carriers to replace hybrid and metal carriers in most applications. Other benefits, in addition to light-weight, include quiet operation, corrosion resistance, and no need for lubrication.

All-plastic open-style carriers, available in a broad range of sizes and designs, are the first choice for most light to medium-duty applications where high speed and long travel are factors. Snap-together construc-

tion simplifies installation and maintenance, and snap-open versions permit quick access to the cables via crossbars anywhere along the carrier. Other versions that permit ready access include open, split, hinged, and zipper designs.

Sizes range from around 0.25 in.² to units that carry hoses with diameters exceeding four inches. Travel lengths can be more than a quarter mile. Typical uses range from machine tools and industrial robots to pick-and-place and light industrial applications.

Completely enclosed plastic carriers with a link-type design have an enclosed top and bottom to economically protect hoses and cables in damaging environments. They work well at high speeds and, with proper guiding, can be used for travel lengths of several hundred feet. The enclosure method varies, but several designs allow easy access to cables and hoses with removable slide strips or plates.

Steel is usually the material of choice in heavy-duty applications — those where loads are extreme; with severe shock and vibration; or in hot, aggressive environments such as steel mills and foundries. Surface treatments and hardened pins and plates add to performance. These come in open and closed-link designs, as well as conduit-type carriers formed with small convolutions designed to keep chips, weld spatter, coolant, cutting oil, and similar contaminants away from cables and hoses.

Finally, while most carriers provide linear travel, some equipment — like a 6-axis robot — requires cable support in several directions. Multi-axis cable carriers like igus’s Triflex R product line is essentially a modular “pipeline” that uses ball-and-socket connections between plastic sections to provide multi-axis freedom of movement. The tubular conduit can twist up to 360°/yard and provides the strength needed to support modern cables and hoses without using interior steel-support cables. The smooth outer surface lets it glide over machinery without catching or tangling. The units include integrated supports and brackets and typically ship as one piece.

Selection tips

Cable carriers are an integral part of a machine and should be considered early in the design process. Engineers should gather necessary data about the installation including travel length, size and weight of cables and hoses, the operating environment (such as dirt and debris, extreme temperatures, and chemicals), and machine speed and acceleration.

Two of the most important design factors are size and strength. To size the carrier, a good rule of thumb is to allow 10% clearance around cables and 20% clearance around hoses to prevent binding. The resulting dimension is the minimum inner confines of the carrier. In general, fill the carrier cavity no more than 60% to prevent damage – over-filling the cavity is probably the
Designs and materials... 1

Selection tips... 2

Additional factors... 3

The E4-350 carrier... 4

FROM THE SMALLEST ‘MICRO’ ENERGY CHAIN® TO THE WORLD’S LARGEST POLYMER ENERGY CHAIN®, IGUS® CABLE CARRIERS ARE CAPABLE OF LONG AND SHORT TRAVEL DISTANCES AT HIGH SPEEDS IN ALL AXES.

most-common design mistake.
Design enough free space into the carrier to allow for linear variations, to prevent hose abrasion and ensure safe operation. High-pressure hoses, for example, require special consideration because their length can vary by as much as +2 to –4% with pressure fluctuations.

However, many carriers are mistakenly selected on size alone. Though it is true that the conduits must have a certain amount of room to move within the carrier, strength is equally important. The carrier must withstand the acceleration forces that the moving mechanism imposes.

Strength-related factors include the total weight of the conduits, including fluid in the hoses; length of run; maximum unsupported span; and maximum acceleration rate. Carrier suppliers can help determine the load limit and select the right carrier. And some major carrier manufacturers offer online tools to aid the process. igus®, for example, has a product selector that lets users enter data such as space limitations, cable diameters and bending limits, unsupported lengths, the preferred type of design, necessary certifications, and special considerations, such as 3D movement. The program generates a list of appropriate products for the stated application. Related online tools advise users on how to configure and separate hoses and cables; as well as predict the service life of the carrier system based on operating conditions.

Engineers can also make the basic calculations based on:

\[ F_a = \frac{W}{32.17} \text{ (lb)} \]

where \( F_a \) is the force needed to accelerate the filled cable carrier from rest, \( W \) = weight of carrier and fill (lb), and \( a \) = acceleration (ft/sec\(^2\)). Calculate the push force, \( F_p \), needed to move the carrier along its support surface:

\[ F_p = \mu W \text{ (lb)} \]

where \( \mu \) = the coefficient of friction between the carrier and support surface or glide bar. For a plastic carrier sliding on a metal surface, \( \mu = 0.5 \). For a plastic surface, \( \mu = 0.2 \).

Then total force is

\[ F_t = F_a + F_p \text{ (lb)} \]

Total force must not exceed the load rating of the carrier. For reference, a typical plastic cable carrier with a 2.5-in. inner height handles about 1,800 lb.

Some manufacturers make several grades of carriers within a given size range. Selecting a light-duty carrier for a high-acceleration application might cause carrier damage and machine downtime. Conversely, a heavy-duty carrier for a low-stress application wastes money.

**Additional factors**

**Bend radius.** Cable carriers also come with different bending capabilities and each has a suggested minimum bend radius. The carrier’s minimum bend radius should equal or exceed the recommended minimum bend radius of the stiffest cable or hose it will carry. A larger bend radius puts less stress on cables so they last longer.

As a rule, keep the bend radius at least 8 to 10 times the outer diameter of the largest cable or hose. (Bend radius is measured from the center of the curve loop to the center of the pivot pin on the carrier side link, not the overall curve height.)

**Separators.** Another common concern is conduit tangling and abrading. As the carrier reciprocates thousands of times, smaller conduits tend to work their way between larger ones.

Cables of different cross sections have different bending characteristics. If cables and hoses are placed in a carrier randomly, they will almost surely interfere with one
The solution is to install separators in the carrier. Put cables of different cross sections and diameters in separate compartments, and segregate hoses from cables altogether. Some manufacturers offer flexible systems of vertical separators and horizontal shelves to let users customize the carrier interior layout. Less flexible systems require custom-ordered separators for a specified conduit layout. They may not accommodate alternative arrangements should requirements later change. Some carrier designs are inherently more “cable-friendly” than others, with interiors carefully designed to minimize pressure points and abrasion. Moreover, carriers with easy-open crossbars or covers permit more frequent inspection of conduits and simplify replacement. Choose a specific interior design based on carrier type and number and variety of conduits.

Length. Carrier length depends on mounting and machine configurations, but typically length is approximately half the total travel plus the curve length. Usually on a machine, one end of the cable track moves and the other is fixed. Two basic mounting configurations are center and off-center mount. Center mount means that the track moves half to the left and half to the right of the fixed point. Or in other words, the fixed point is in the middle. This arrangement uses the shortest possible carrier.

An off-center mount configuration means that the movement is not equidistant from the fixed point. Sometimes the track can’t be mounted in the center because of machine restrictions. In this case more track is needed to compensate for the fact that the fixed end isn’t centered.

Support. Failure to support and guide the carrier in long travel applications is another common problem. For short travel lengths and light loads, most carriers are self-supporting. Manufacturers supply data on a carrier’s unsupported span as a function of travel and weight. For example, plastic carriers generally are rated for unsupported spans of 2 to 15 ft, depending on the size. Large steel systems can have unsupported spans approaching 50 ft.

Once a carrier exceeds the unsupported span length, it says. For many applications, some sag is acceptable. But eventually the carrier contacts and rides on itself. In a steel design, this can be catastrophic. Where a metal unit doubles back on itself, such as in center-mounted installations, if the upper run drags on the lower run, the carrier will quickly saw itself to pieces.

This necessitates a support system to prevent excessive friction, wear, and damage. A carriage support system consists of rollers, conveyor supports, and a moving framework that supports the carrier over the entire length of travel. Channel guides ensure accuracy and dependability, even at high loads and velocities. Plastic carriers have a much lower coefficient of friction, and they are often permitted to glide on top of themselves. Plastic carriers can also use plastic glide shoes – bearing surfaces that ride inside guide channels and provide even wear and alignment.

Regardless of the design, however, when a carrier is used in any arrangement besides horizontal flange-fixed, the manufacturer should be consulted, because the application will often require specialized supports.

Conduit. For any demanding linear-motion application, the conduit itself must withstand the external stresses of its environment. For example, most electrical cable is not designed to handle the constant tensile, compressive, and shear forces that carriers impose. Continuous bending causes most cables to “corkscrew” – a major reason conductors break – and the spiral twist may entrap and damage other cables.

The cable’s interior structure should be specially designed with isolated conductors to counteract the corkscrew effect. Also, cable jacket material must be abrasion resistant and slick enough to slide easily against other cables and against the carrier itself. Few cables are designed for carrier applications, but taking the extra effort to select the most “carrier-friendly” cable will pay for itself many times over in longer life.

Regardless of the application, always strain relieve cables at the moving end and, whenever possible, at both ends. The exception is hydraulic hoses; they should be strain relieved only at the moving end. Improper or lack of strain relief is a common cause of cable and hose failure. Strain relieve cables and hoses using profile rails, clamps, tie wraps, and tie-wrap plates.