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# MSD

## MOTION SYSTEM DESIGN

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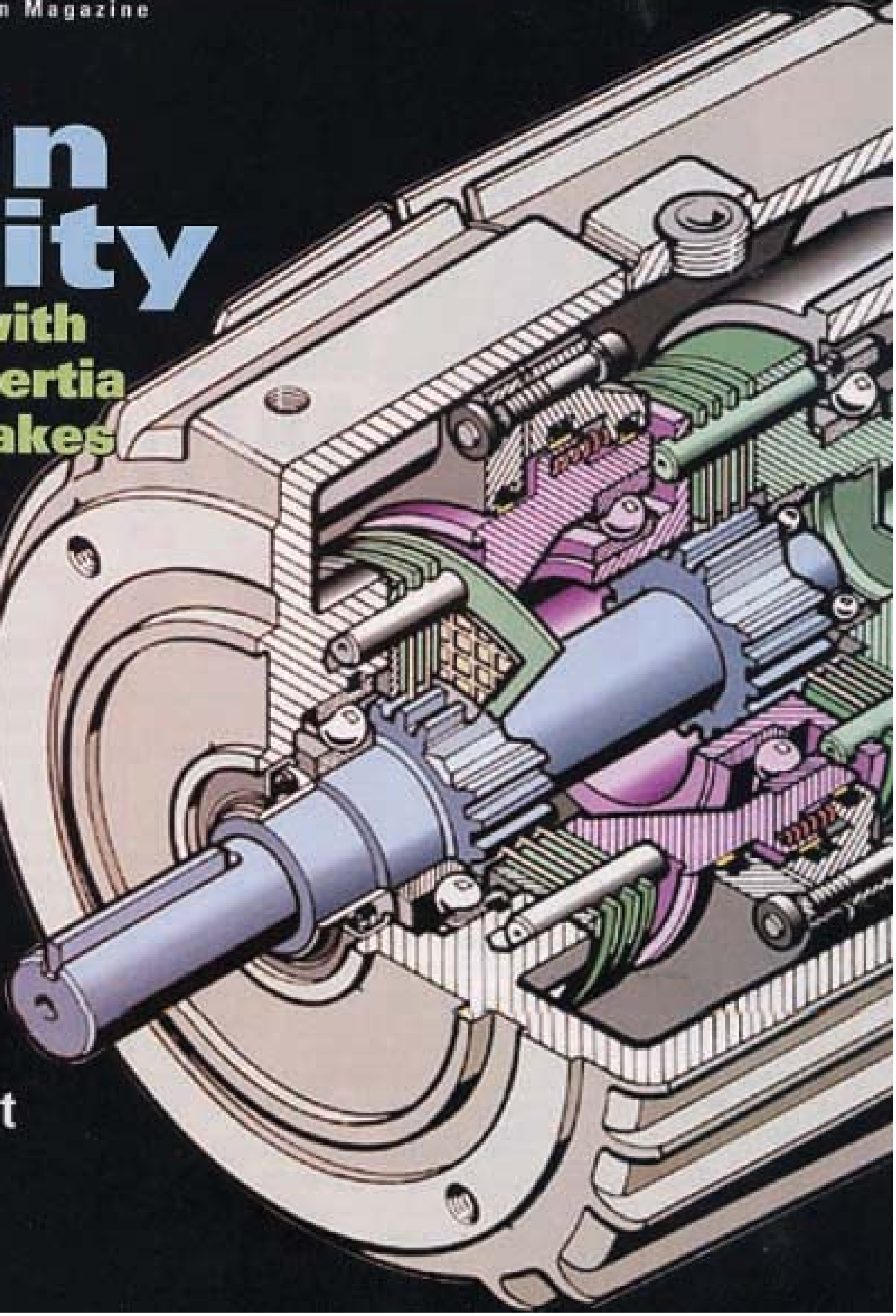


# Spin City

Rev up with low-inertia clutch-brakes

Wired for motion

Polymers slide in the drive

Design by objective: Extreme environment

# Wired for motion

## How to make sure your power and information cables bend but don't break.

Today's machines live and breath electricity. Without electrical power and low-level control signals, every piece of automated equipment would grind to a halt. The life-giving force can be anything from a two or three-volt digital signal to 480-V three-phase power, pulsing through a network of copper cable.

To say that cable is important today is an understatement. The profits of entire manufacturing facilities hang on slender strands of copper and the insulation and shielding that protect them.

In motion applications, cables face a particularly immense challenge. Not only must they transport energy and information, they also have to withstand the rigors of continuous flexing and bending. Understanding why cables break is the first step to problem-free motion; learning how to install and maintain them is the next.

### Understanding cable stress

Continuous flexing applications induce stress on copper, conductor insulation, shielding, and outer jackets. This repetition works copper extremely hard and generates high temperatures. Installing cables in small bend radii also produces heat as does current flowing in the conductors. Over time, thermal and mechanical stress causes copper to become brittle, increasing the chance of fatigue failure.

Shielding materials, based on tinned copper braid, face similar challenges, experiencing the same thermal and mechanical stress as the copper conductors. If the shield happens to shear, it loses its ability to filter EMI/RFI emissions, leaving the conductor open to noise problems and false signals.

Another source of failure is the conductor insulation and outer jacket. Insulation must be durable and resistant to temperature degradation as well as oil. During flexing, conductor insulation is exposed to high compression forces when clamped in the cable carrier. Conductors also must be abrasion resistant since they slide along adjacent conductors during operation. Insulation is exposed to higher temperatures just as the copper is. Heat can soften insulation material, reducing abrasion resistance and increasing cut-through potential.

The cable's outer jacket must likewise resist abrasion because it's also subject to stresses from other cables, hoses, conduits, and accessories within the cable carrier. The cable carrier itself is also abrasive.

Other concerns involve the environment as the outer jacket is exposed to oils and lubricants, metal chips, and solvents. Failure of the outer jacket will expose conductor insulation to all of these elements. If the insulation cannot withstand the environmental challenges, the machine is destined for trouble.

## Proper installation critical

Installing cable properly ensures peak performance and takes just as long as installing it incorrectly. During flexing, cables are subjected to copper stresses and vibration: connectors and crimped and soldered terminations get the brunt of it. Clamping cables to a fixed termination point and supporting them within the cable carrier reduces the risk of connections breaking at the termination.

## Steps to overcome obstacles

- **Use of finer copper strands in the conductor.** Finer strands are less susceptible to copper fatigue than thicker strands.
- **Use of PVC or TPE insulation, depending on application.**
- **Non-slip agent applied over each layer of conductors.** This facilitates sliding of adjacent conductors.
- **Non-wicking textile wrap.** This permits conductor's outer layer to slide easily along the outer jacket.
- **Shield separated from conductors by a thin inner jacket (for shielded cables).** This protects conductor insulation from the shield in the event of copper fatigue within the shield.
- **Choices in the outer jacket.** For applications requiring a long flex life in environments that involve non-aggressive oils/lubricants, a PVC jacket will work. However, if a cable is installed in a harsh environment, a polyurethane jacket is preferred.

## Continuous considerations

Several factors must be considered when selecting a continuous flex cable. The first involves the bend radius. Does the cable minimum bend radius meet the requirements of the application? Is a shield required? Will the outer jacket be resistant to the oils and chemicals present? Are there metal chips? What is the speed and acceleration of the cable carrier? Will cable be subjected to significant abrasion? These are some of the parameters to consider when specifying cable.

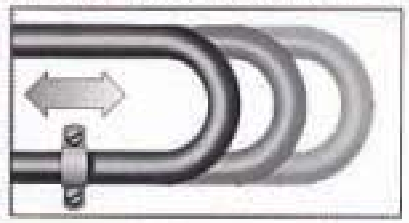
Installation and maintenance is the second part of the equation, and when combined with proper selection, reduces the risk of cable failures. Things to watch out for include:

- Only cables designed for continuous flexing should be used in a moving cable track application.
- When selecting cable for cable track the following must be taken into consideration: environmental conditions such as temperature, chemical influences, indoor or outdoor operation, as well as traveling speed and frequency of operation.

## Typical Motions for Flexing Cables

The flex type and application of the cable will determine how the cable is manufactured. When the cable is designed with a special flexing application, the cable has to be manufactured on a unique cabling machine that will minimize any back-twist on the cable core.

**Continuous Flex** - The cable is rolling/flexing back and forth in a linear motion. Usually these cables are used in C-track applications where the bend radius is designed for 10 x the cable diameter or less.



**Torsional Flex** - The cable is being twisted clockwise and counter-clockwise with angles varying from 90 to 300 degrees. This type of flexing usually occurs on robotic equipment that is being twisted and flexed constantly for a long period of time.

**Bending Flex** - The cable is being flexed back and forth with one of the ends being stationary. This is referred to in the industry as a "tick-tock" motion. Majority of the stress on the cable is on the two focal points where the bend and the load are being applied.

• The cable's recommended minimum bend radius should not be exceeded.

• Cables must be prepared for installation into the cable track without twists, bends or kinks. Cable should always be unwound from the outside layer of the reel or spool and should never be pulled from a coil.

• Before insertion into the track, cable should be laid out or hung for at least 24 hours prior to installation to relax any stresses resulting from transit or storage. If cable cannot be relaxed, it should be shook out by grasping it at mid-point and shaking as you move to each end. Then, wrap each end of the cable with masking tape and mark the top of each cable end. Maintain this alignment throughout installation and clamping.

• When placing cable, track should be laid out flat with the bending direction facing upward then fitted with cables in working position. Cables should be laid into the track and not woven between or around other cables. Cables should lay loosely side by side in the track. A minimum clearance of five percent of the cable diameter should be allowed on each side. When cable is installed in a track where spacers are provided, they should be separated from each other.

• The cables' weight must be evenly distributed. Heavier cables should be placed toward the outside of the track, while lighter ones should occupy the track's center. When the cable track is side mounted, place larger cables toward the outside and smaller cables toward the inside of the track. Smaller cables must not be pulled tight against the inner track curve and cables must not be pushed tight against the outer track.

• Cables should not be fixed to the track or tied together in the track.

• After cable track is installed, cables should be cycled through several flexes and observed for freedom of movement. It is important for cables to move with complete freedom within the bend radius, so that movement of cables among themselves and with the track is possible.

• Cables should be clamped into position at both ends of the cable track. Prior to clamping, alignment marks on the taped ends should be correctly positioned. Do not crush the cables when clamping. Clamping points must be located at a distance of 15x cable diameter from the end point of the flexing movement. (When calculating 15x cable diameter it is important to use the largest cable in the track.)

## Designed to flex

Control and power cables operating in high-speed automated equipment such as gantry robots, pick and place machines, automated handling systems, machine tools and conveyor systems are subjected to a continuous repetition of flexing (back and forth in one plane) and torquing (longitudinal twisting). While it is possible to use standard control cables in these applications, it is not recommended, as they will not deliver the long-term performance of cables specifically designed for this purpose.

Robotic cables are designed to perform reliably in a moving application without fatigue or failure for at least several million cycles. In contrast, standard cables use coarse copper stranding and plastic materials that need only satisfy voltage, flame, and aging requirements. Robotic cables must meet these requirements while withstanding long term bending as well.

In addition, robotic cable materials must be resilient so that once the cable completes a flexing cycle, materials immediately return to their original unstressed condition. The copper conductors must be made of finely drawn strands rather than coarse strands. Cables must also be designed so that the individual conductors inside the jacket have freedom to move. This movement prevents damaging stress to the conductors.

Using cables specifically designed for robotics and other automated applications produces tangible improvements in cable life performance.

When specifying cable for your automated application, match your application's requirements with the proper cable by asking your cable supplier for specific test data to ensure that cable will perform to its maximum capabilities. ●

### Call to action

Prior to the age of high-speed automation, control, power, and data communication cables were installed in stationary applications. Products were designed to survive temperature extremes, moisture, oil and chemicals, while providing the necessary electrical requirements. As mass production capabilities emerged, factories began to use automated equipment to perform many routine tasks. Storage retrieval systems, metal parts stamping, moving of heavy equipment with gantry robots, painting and welding all began to join the automation arena.

For the first time, applications required multi-conductor cables to withstand continuous motion. At this early stage, only power cables were installed within cable carriers. Controls resided in a special room, keeping data and communication cables safely away from the action. These were relatively stationary applications, subjected only to the rolling motion imparted by cable carriers. Cable lengths could be anywhere from 5 to 50 ft., traveling up to 5 ft/sec over bend radii from three inches to several feet.

As technology advanced and controls moved out to the machine, data communication cables began appearing in cable carriers. The finer, more sensitive wire in these cables weren't as well suited for dynamic applications, but the knowledge gained in those early days has helped evolve more rugged cable solutions.