Cable goes TWIST-FRIENDLY

Cold working and friction heating can turn ordinary wiring into a big maintenance item on equipment that is in near-constant motion.

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Consider how typical industrial-automation equipment works today. Most of it is in use nearly 24/7. It frequently contains robotic elements and assemblies that execute motions repeating hundreds of times or more every minute. No question that these applications put stringent demands on moving parts. This is true even for the cabling that connects moving equipment to controls. This cabling can see millions of flex cycles in the course of normal use.

However, most cable is not designed for this sort of repeated bending, twisting, and movement. The problem is that repeated flexing can eventually cold harden conductors to the point of failure. Similarly, the friction generated between various internal components of a moving cable can generate enough heat to compromise the insulation and jacketing over time. The implications of these problems are obvious for maintenance and machinery uptime.

Making matters worse is the reality that there are no widely accepted standards for measuring the flex life of cable. We have actually tested cables that were claimed to have a certain "high" flex life. Some failed in as little as 500 flex cycles. Many did not last as long as their manufacturer claimed they would.

However, there are ways of de-

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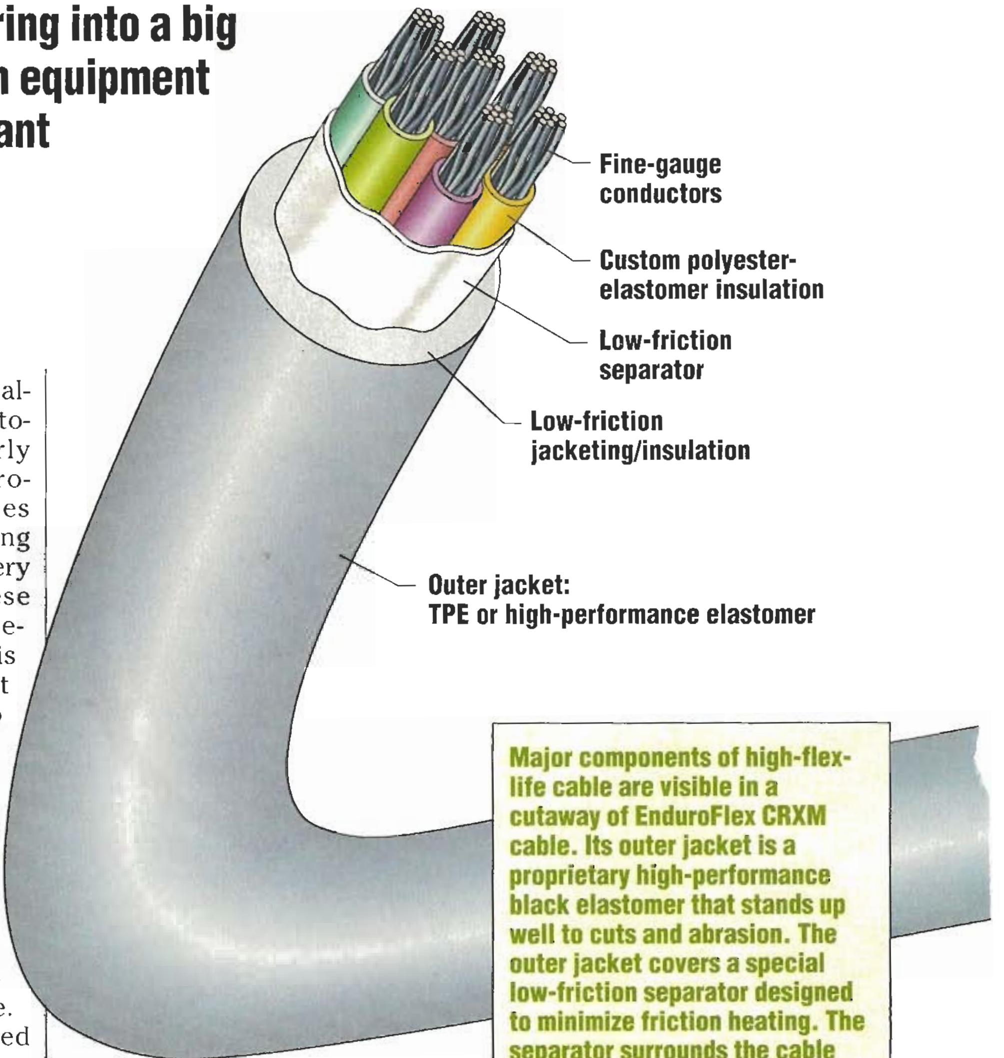
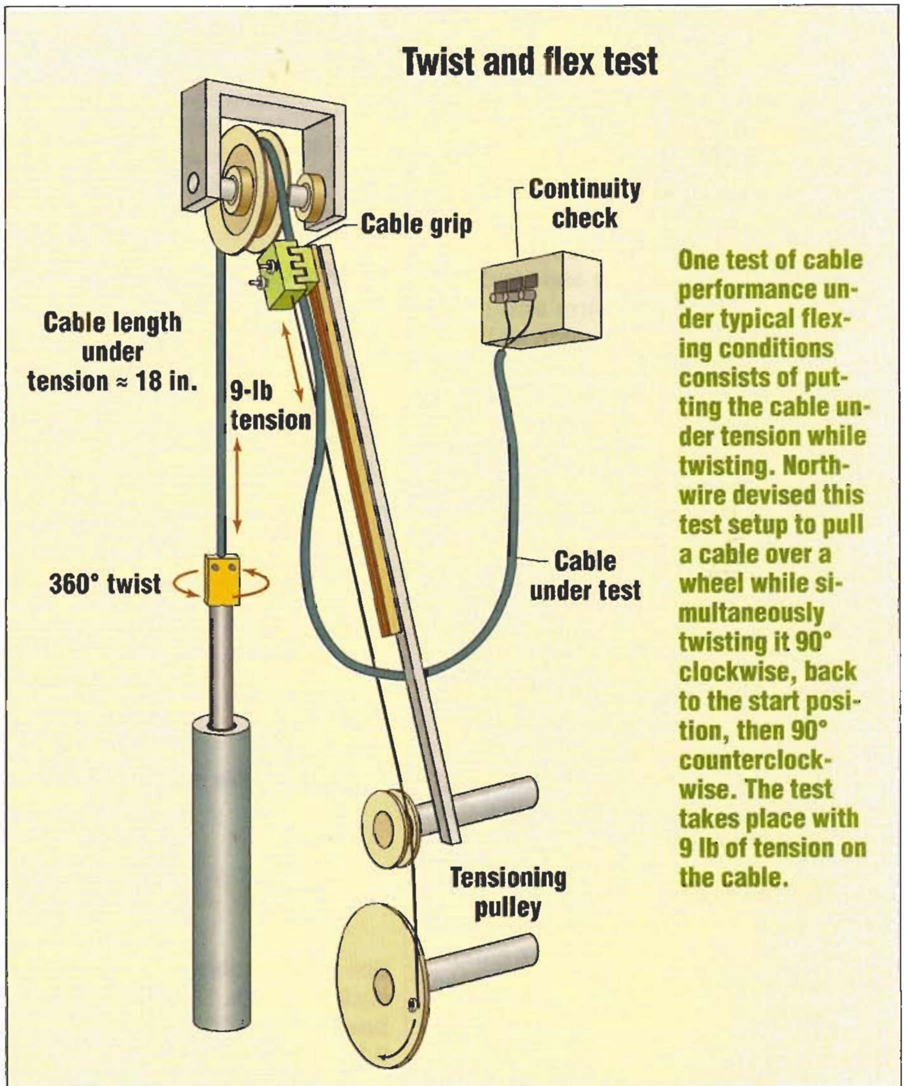
Cable components



Major components of high-flex-life cable are visible in a cutaway of EnduroFlex CRXM cable. Its outer jacket is a proprietary high-performance black elastomer that stands up well to cuts and abrasion. The outer jacket covers a special low-friction separator designed to minimize friction heating. The separator surrounds the cable bundle containing fine-gage copper conductors insulated with a custom polyester elastomer that is also designed to minimize friction heating. Cables made with the design illustrated here are flex tested to a minimum of 10 million cycles.

signing cable to last over millions of flex cycles. The industry generally considers a 10 million-cycle cable to be a "high-flex-life" or "continuous-flex" cable. And though there is no such thing as a standard flex cycle for measurement purposes, techniques adopted from Mil Specs and the medical-device industry can help in devising a test regime that gives designers a confident estimate of how long a cable will last in the real world.



INSIDE A CABLE

One point to note concerns cable nomenclature. High-flex-life cable is not the same thing as high-flex cable. The latter is designed to be supple and highly flexible but not necessarily to withstand repeated flexing.

And there are several differences between ordinary cable and that designed for frequent flexing. The conductors of a high-flex-life cable are insulated with a low-friction material, often a polyester elastomer. (Some manufacturers may use a different material but treat it with a lubricant.) Conductors are generally grouped together into a single core or bundle. The cable is constructed to minimize friction between individual components such as the outer jacket, the individual conductors, fillers, and wraps (serves). One way to realize a low-friction interface between the outer jacket and the wire bundle is to wrap the conductor bundle with PTFE tape.

Finally, individual copper conductors in high-flex-life cable are fine stranded to minimize cold-working effects. Conductors typically range from 26 to 18 awg. One widely used high-flex-life cable employs a 19-strand bunched conductor. It is also possible to find high-flex-life cables with conductors in concentric constructions, but we find a bunched stranding construction performs better in continuous-flex applications.

As a quick review, wire cold hardens when it stretches beyond its yield point. Bend a wire around a radius small enough and it can stretch. Repeated stretching beyond the yield point changes the wire's internal structure, causing it to harden, become brittle and eventually break. Thus finer-gauge wire is less prone to cold hardening because it can bend around a smaller radius than can a wire of a larger diameter. Most cable manufacturers recommend a minimum bend radius over which their cables should flex. Our recommendation is to bend the cable no more than 10× the cable diameter.

Fine-stranded conductors typically used in high-flex-life cable also generally have ratings below 1 kV. High-power applications operating at higher voltages may need cables specially designed for the appropriate power levels.

It is useful to contrast the makeup of high-flex (limp) cable with that of high-flex-life cable. Both may incorporate fine-stranded inner conductors, tape wrap, and so forth. One major difference is that the outer jacket of limp cable is often a low-durometer (soft) PVC or other elastomer. In contrast, high-flex-life cable tends to use TPE in its outer jacketing. TPE generally exhibits excellent oil resistance and tends to better resist abrasion and cuts than thermoplastics such as PVC.

In addition, materials such as TPE polyurethanes tend to have more shape memory than other jacketing candidates such as PVC. At the risk of overgeneralizing, we find that plastics with shape memory work better in high-flex-life applications.

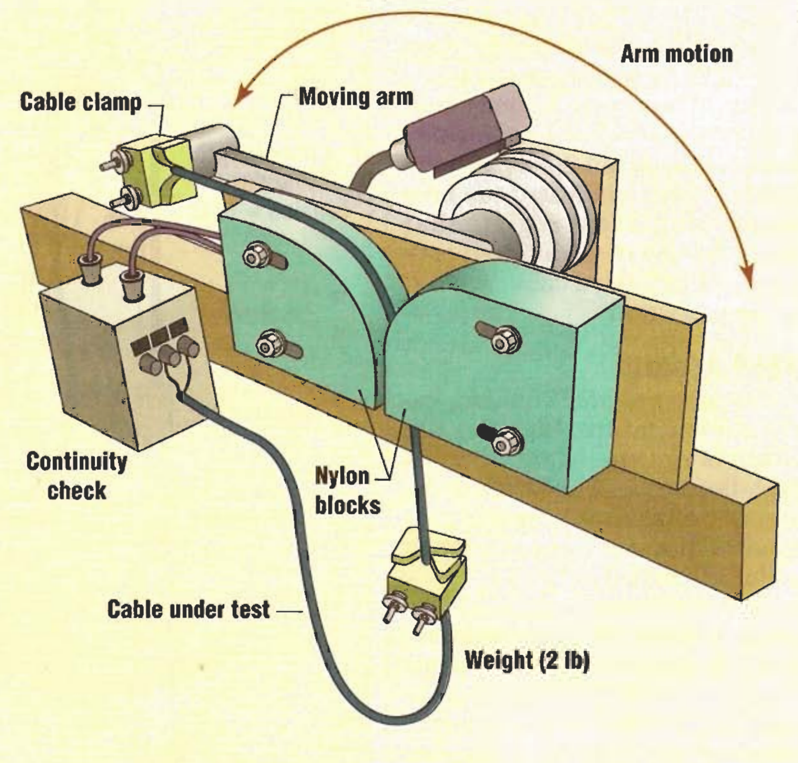
Another point to note is the stiffness of the cable, or that lack of it, has no bearing on its flex life. Some high-flex-life designs actually feel stiffer than others that don't last as long. There is no industry standard for quantifying limpness, nor is this quality defined anywhere.

TESTING FLEX

It is illustrative to look at tests that cable makers devise to establish cable-flex life. For example, our general rule is to design cables so they will withstand more than 10 million cycles on a special bend-and-twist machine and on what we call a tick-tock test. It is also possible to extrapolate the performance of some designs using Design of Experiments methods based on tests of similar cable. Our tests are based on a Mil-Spec test modified and updated by a prominent manufacturer of medical-imaging equipment.

Cable in track systems commonly experiences what's called rolling flex. Our rolling and torsional flex (twist and flex) testing entails pulling the cable about 18 in. over a wheel and twisting the cable 360°. The 18 in. of cable between the grip and the wheel is the portion that twists. A 9-lb weight hangs on the cable as it twists. One cycle comprises a 90° twist in each direction. The tester runs at about 30 cycles/min. We consider this combined twist-and-roll flex test to be the most severe component of our flex-life assessments.

Tick-tock cable test



One test for cable-flex lifetime consists of repeatedly bending the cable back and forth. The test setup shown here was devised by Northwire to bend a cable 90° in one direction, then 90° in the opposite direction. A 2-lb weight hangs on the cable as it is put through its paces.

Bending flex (tick-tock) takes place when one end of the cable is stationary while another point in the cable bends around a fixed object. One complete cycle of this test consists of having the cable first flex 90° over a nylon block, then back to neutral, and finally flex backward 90° over another nylon block. A 2-lb weight hangs on the cable as it flexes. One cycle completes every 2 sec.

Finally, cable in tracks also may experience rubbing abrasion, pinching, and twisting on multiaxis cable chains. There is an industry-standard test for abrasion resistance: the UL 1585 (part of 1510) abrasion test. UL also defines tests for "cold bend" (resistance to cracking when bent in the cold) and "cold impact" (resistance to cracking when hit in the cold). **MD**

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