

## What Designers Should Know About

# Medical Cables

**Specifying a medical cable means considering flexibility, chemical resistance, and more.**

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Medical cables have to meet requirements that are more demanding than the nonmedical variety. MedFlex is a family of cables from Northwire Inc. that offers a combination of flexibility, tough mechanical properties, and non toxic features. The design is suited for applications such as surgical devices and patient monitors, and can be customized for either permanent or semi-disposable use.

**C**ables are highly engineered products that must perform consistently and reliably in a wide range of environmental extremes. Cables for medical applications are complex, heavily regulated, and demanding to design and manufacture. They must work after repeated exposures to one or more sterilization processes, including autoclave, ETO, gamma, e-beam, and high-level disinfectants and sterilants. A little background on components and considerations can help select a better medical cable.

### **Engineering a medical cable**

Cable design includes choosing the right material for insulation, tape-shield laminate, and jacket. Each of

## Hold your judgment on PVCs

PVC is probably one of the most misunderstood of all the thermoplastics. Despite the minor controversy regarding the material's use and the use of a few plasticizers in medical-grade cables, PVCs are high on the list of candidate materials. This is largely because these compounds can be effectively formulated to provide many attributes important in medical-grade cables.

PVC is readily available in a broad range of durometers that provide elasticity and flexibility. When formulated with specialized plasticizers, antioxidants, stabilizers, lubricants, and other additives, PVCs become more durable. New PVCs are being introduced that do not use plasticizers at all, further opening new applications for PVCs in medical-grade cables.

For example, the material can be engineered to meet a wide range of temperature requirements from -50 to 105°C, resist chemicals, and be produced in translucent or opaque variations. The material is also available in a variety of molecular weights, including an ultra-high molecular weight where it becomes a thermoplastic elastomer (TPE). These formulations exhibit excellent gamma stability, ETO compatibility, and resistance to low temperatures, high-pressure disinfectants, and sterilants.

these can be a different plastic, so the designer should understand plastics and their value in product design.

It is important to select plastics formulated for functional attributes as well as the specific sterilization method they will undergo. Dramatic changes in physical properties can occur immediately after sterilization while some can show up months later. Gamma and e-beam sterilization, for instance, produce high-energy ionization in polymers at the molecular level whereby cross-linking can actually occur. Cross-linking occasionally enhances a few properties, but the opposite occurs more often. Excess cross-linking could likely cause materials to become brittle and stiff, discolor, and smell. In some materials the molecular-chain continuity is destroyed and the plastic ultimately breaks down. Although differences may be slight, it has been reported that polymeric materials become less brittle from

## How to read the chart

ATC: Autoclave, steam sterilization at 121 to 134°C and 15 to 19 psi. Exposure time: 5 to 45 min.

ETO: Ethylene oxide gas at 25 to 75°C and at subatmospheric, 25 psi. Gas concentration: 450 to 1,000 mg/liter

GAM: Gamma radiation from Cobalt 60 or an electron beam (Ebeam). Radiation dosage: 2.5 Mrads minimum

STS: Steris Paracetic acid (0.2%)

VHP: Hydrogen peroxide (gas plasma/vaporization)

CID: Cidex, activated dialdehyde solution (Glutaraldehyde up to 3.4%)

O: Outstanding, E: Excellent, VG: Very good,

G: Good, F: Fair, P: Poor

electron-beam sterilization than in the gamma-ray process. In addition to sterilizing finished parts, cables may also be tested for bacteria and germs before assembly. Plastics are melted during extrusion and formed at high temperatures. Water at a much lower temperature, however, is used for quenching the molten plastic. This water requires treatment to prevent bacterium propagation. Microbial levels are controlled by regularly treating the water with chemicals and maintaining a clean work environment. Isolating the extrusion area from workers' food and beverages and disinfecting reels and packaging supplies, keep microbial counts low and let assemblers work on the cable in a clean room.

### Flexibility versus flex life

Of course, medical cables have to be flexible, but they must also have sufficient flex life. Flexibility refers to a cable's ability to remain soft and pliable. Flex life is a cable's ability to maintain consistent performance after repeated flexing cycles, often at high speeds and for millions of repetitions. In disposable or limited-use applications, flex life is not as critical.

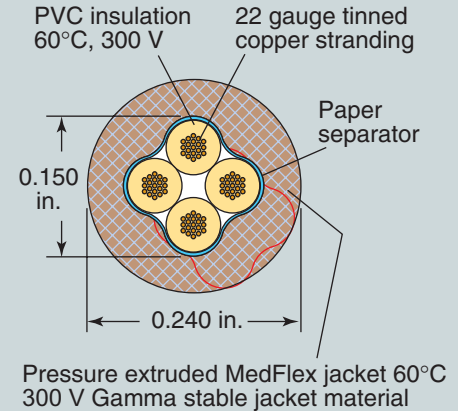
In a flexing environment it's important to know how cable materials interact with each other. A material's coefficient of friction, flex modulus, and elasticity are key for flexural endurance. Special tapes and lami-

## How plastics stand up to sterilization

| Plastic  | ATC | ETO | GAM | STS | VHP | CID |
|--|-----|-----|-----|-----|-----|-----|
| Polypropylene (copolymer)<br>T/E: 3,500/>600<br>Dielectric constant: 2.25                | F   | F   | G   | VG  | VG  | G   |
| Polyethylene (LLDPE)<br>T/E: 3,000/>300<br>Dielectric constant: 2.27                     | P   | E   | E   | VG  | VG  | G   |
| PVC (polymeric)<br>T/E: 2,500/300<br>Dielectric constant: 4.20 @ 1 MHz                   | P-F | E   | G   | E   | E   | E   |
| PVC (non-toxic, gamma stabilized)<br>T/E: 2,300/300<br>Dielectric constant: 4.50 @ 1 MHz | P   | E   | E   | VG  | VG  | VG  |
| Polyurethane (ether base)<br>T/E: 4,000/500<br>Dielectric constant: 7.0                  | P   | E   | E   | VG  | VG  | G   |
| Northwire MedFlex (UHMW)<br>T/E: 2,200/300<br>Dielectric constant: 4.25 @ 1 MHz          | F   | E   | VG  | VG  | VG  | VG  |
| Northwire EnduroFlex (TPR/TPO)<br>T/E: 1,500/400<br>Dielectric constant: 3.35            | E   | E   | VG  | E   | E   | E   |
| Silicone<br>T/E: 1,100/500<br>Dielectric constant: 3.1                                   | O   | E   | G   | VG  | VG  | VG  |
| FEP Teflon<br>T/E: 3,000/275<br>Dielectric constant: 2.1                                 | O   | O   | P-F | O   | O   | O   |

The matrix provides a quick reference for selecting various plastics for specific types of sterilization. Property values are representative of the actual products and not of a plastic grade in general.

## Anatomy of a cable



The cross section of a MedFlex cable shows its components.

nates help protect surfaces from abrasion during flexing and extend a cable's flex life. The helical lay of primary components, sub-assemblies, tapes, and fillers all play a role. The extrusion technique used in jacketing the complete cable or an extruded sub-assembly membrane can also contribute significantly to a cable's flexibility and flex life. Pressure, semi-pressure, and tube techniques can have a positive or negative effect on flexural properties of extruded materials. The tooling used and specific extrusion manufacturing techniques are all critical variables in extrusion. Consequently, two

## A glossary for cable terms

A discussion of cables and their construction is likely to encounter these terms:

**Fillers:** Materials that help maintain the shape of an inner cable bundle.

**Flex life:** A number of cycles of twisting, or bending, or both that a cable must withstand during its working life.

**Flexibility:** The limpness of a cable.

**Jacket:** A cable's outer protective covering. On some constructions, the ca-

ble's electrical insulation is also the jacket.

**Pressure extrusion:** A production method that involves extruding plastic or rubber over conductors so all internal voids (interstices) are occupied. This is a filler-less construction.

**Semi-pressure extrusion:** A reduced-pressure extrusion process that minimizes deformation of the inner cable core.

**Tape-shield laminate:** An electrically conductive

foil or Mylar tape that acts as an electrical shield.

**Tape:** Any of several tapes wrapped over a bundle to hold it together. Tapes can make a jacket more easily stripped, and they act as an internal lubricant especially in applications that call for a flexible cable or high flex-life cable.

**Tube techniques:** Any of several methods that extrude a tube that fits over the fillers and conductors.

cables made by different suppliers with exactly the same raw materials and built to the same bill of materials can have different flexibilities. ■