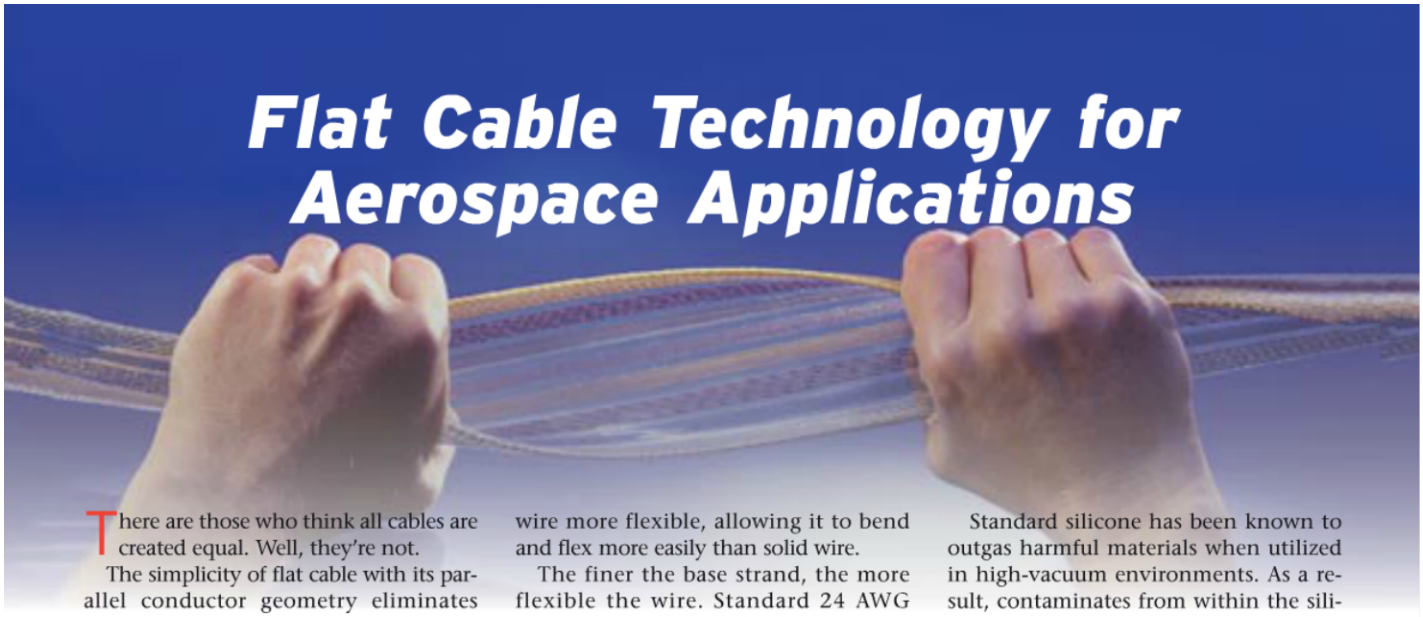
Flat Cable Technology for Aerospace Applications



There are those who think all cables are created equal. Well, they're not.

The simplicity of flat cable with its parallel conductor geometry eliminates many of the common sources of wiring error and malfunction. Registration of the conductors is one-to-one with the terminating connector or board so that proper contact assignment is almost automatic.

The use of flat cable often eliminates much of the conventional wire weight. Such things as redundant insulating materials, fillers and tapes are not required. In addition, the composite flat cable construction is so mechanically strong that it is not necessary to have large conductors for strength. The copper cross-section can thus be reduced to what's required to carry the current load or to satisfy voltage drop requirements. Strength is enhanced by the fact that all conductors and insulation equally share tensile load.

Extruded flat cables can be made in conductor sizes from 4/0 AWG to 44 AWG, single extrusion widths of up to 4 inches and cable heights of 1 inch, plus they can be utilized in continuous operating temperatures of -65°C to +260°C.

Since they are extruded, flat cables are available in continuous lengths, cut to order, prepped for termination or as assemblies with just about any circular or rectangular connector, including Mil-DTL-38999, Solder Tab Nano, Micro-D, Ethernet, IDC, Hermetically Sealed, Lugs and custom connectors and PCB components. Assemblies can be soldered, crimped, potted and over-molded.

To design a custom cable, space restrictions, bend radius, environmental issues, application specifics, and mechanical, electrical and vacuum requirements are needed.

It's All About the Wire

Today, most wire utilized in cables is made up of multiple base wire strands, rather than being made of a solid piece of metal/wire. Multiple strands make the wire more flexible, allowing it to bend and flex more easily than solid wire.

The finer the base strand, the more flexible the wire. Standard 24 AWG wire has 7 base strands, 'flexible' wire has 19 base strands, while Cicoil High-Flex wire utilizes 66 base strands. All Cicoil wire has base stranding of 40 AWG minimum, versus 36 AWG and larger in other 'flexible' wires. Cicoil wire conductors have two to three times more base strands than conventional 'flexible' wire, which makes them extremely flexible. Wires with smaller base stranding will have a much smaller bend radius than wires with larger stranding. In addition, finer stranded wire has significantly longer life in flexing applications, as bending stresses are distributed across many more wire strands, thereby dissipating the strain on the overall conductor.

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Jacket

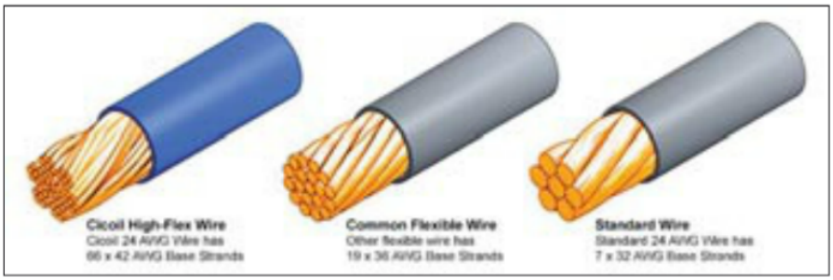
The outer jacket on Cicoil's cables is made with a propriety material called, Flexx-Sil™, which is designed for high-flex, high-performance, and even high-voltage applications. This unique material combines the best aspects of silicone rubber, such as flexibility and extreme temperature exposure.

Standard silicone has been known to outgas harmful materials when utilized in high-vacuum environments. As a result, contaminates from within the silicone material are released and then condense onto highly sensitive electronics, circuit boards, optics, etc...

Crystal-clear, Flexx-Sil™ rubber has zero additives, does not oxidize or outgas harmful contaminants, and is Space Flight Approved by NASA. The ultra-pure cable is halogen-free, Class 1 Clean Room Rated and exceeds ASTM E-595 outgassing specifications for vacuum and Space use requirements.

Unlike, PTFE or Polyurethane jacketed cables, Cicoil's extrusion process separately encases each individual inner component, which prevents wires from rubbing against each other and creeping out when exposed to severe vibration, shock and turbulent flight conditions. Where other materials require conduit or "armor" for protection, the encapsulated design does not. In addition, the jacket is self-healing from small punctures and can easily be repaired in the field, whereas other cable types have to be discarded.

The Crystal-Clear Jacket also allows for quick, easy and safe inspection of cables in just about any application. Unlike cables infused with color additives and possible contaminants, the Flexx-Sil™ rubber design offers complete transparency, so you won't need to be concerned about what's under the jacket.

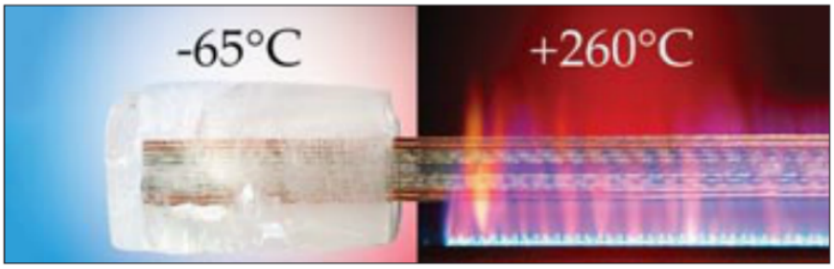


Patented Extrusion Process

Unlike the standard, open-floor extrusion line process utilized in the electrical cable industry, Cicoil utilizes a patented computer-controlled extrusion process, which allows individual components to be placed in a flat profile, precisely controlling the spacing of each component, insulation thickness and the overall cable shape. The thickness of the extruded flat cable is precisely controlled to within 0.005", and conductor spacing accuracy to within 0.002".

The solid one-piece construction can be made in unlimited lengths and the cables can combine power conductors and twisted shielded pairs, in different AWG sizes and various diameters, all combined in a single flat profile. Other components, such as tubing, fiber optics, mounting strips, coax conductors, thermocouple cable, and strength members can also be integrated into the cable design.

Lastly, all cables are cured continuously, with no debris, humidity or material contamination in an automated, climate controlled operating environment. This manufacturing process is a unique, one-of-a kind operation.



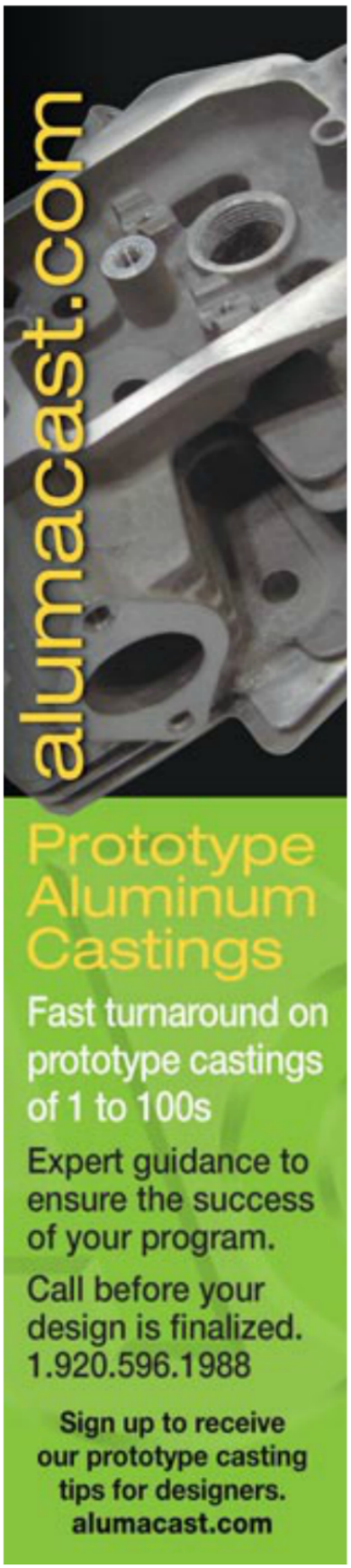
Temperature extremes to which Flexx-Sil outer jackets can be exposed.

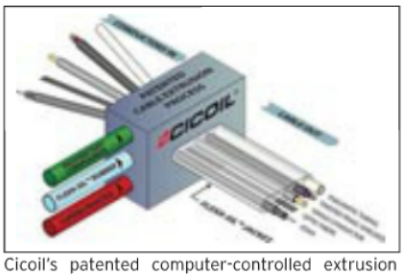
Extruded Flat Cables vs Molded Flat Cables

Flat molded cables may look similar to Extruded Flat Cables from a distance, but once you take a closer look, the similarities no longer apply.

In the molding process, wires are stretched between pins in a metallic mold that typically ranges from 1 to 6 feet in length. Liquid silicone and chemical curing agents are poured over the wires, and once settled, additional silicone is poured to attain proper cable thickness. The cable will need to fully cure over another 2-3 days.

Unlike the ultra-clean manufacturing process of extruded flat cables, molded flat cables are exposed to contamination by dust, metal chips and





Cicoil's patented computer-controlled extrusion process.

airborne debris during the pouring and curing processes.

After the curing process is complete, the cable needs to be cut out of the mold with an X-ACTO knife, leaving numerous holes from the pins and sharp edges, which will impede overall cable strength and flexibility. As a result, the pin holes need to be filled in by hand with silicone, and the cable has to be cured again. In addition, excess flash needs to be removed from the cable jacket by hand with sharp blades as well.

Since it is a manual process, the "poured" method results in varied component spacing and inconsistent cable thickness with each batch of cable produced. The odds of receiving a duplication of identical flat cables is almost impossible. Complex designs and variations in profile, such as hybrid cables with different AWG sizes and tubing, can't be combined into a single flat cable.

Gravity causes molded cables to be thicker at the bottom and thinner at the top, which will cause cable failure as a result of wire breakage through the thin cable top, especially in flexing applications

Extruded flat cables have rounded radiuses on each end, making them mechanically stronger and more flexible than molded flat cables. Utilizing a computer controlled extrusion process, any outside cable profile can be created as the application requires, so the same exact cable will be produced the same way every time.

Extruded Flat Cables vs Round Cables

Highly flexible flat cables have many advantages over flexible round cables in constant motion and confined area applications. Round cables incorporate single and multiple bundles of insulated wires and are usually surrounded by several layers of other materials. The inner bundle is usually surrounded by a wrapped textile material, fillers or an inner jacket to minimize internal heating caused by friction caused by flexing, bending and twisting of the cable. In shielded round cables, there are additional protective layers consisting of low-friction wraps, additional inner jackets, braided copper, fillers and even lubricating agents such as talc. With the inclusion of more layers and materials, the cable increases in size and weight, which results in a less flexible cable.

Eliminating unnecessary insulation, fillers and tapes reduces the bulk and physical volume of flat cables. In addition, their low profile enables them to hug surfaces and take advantage of tight, or normally-unused space and exhibit much flexibility. A rectangular cross-section allows flat cables to stack, or layer, with almost no wasted dead space between cables, providing maximum conductor density for a given volume.

Flat cables have greater surface-to-volume ratio than their round cable counterparts, consequently having higher efficiency in dissipating heat. This allows a higher current level for a given temperature rise and conductor cross-section.

The spacing of conductors in the extruded flat cable never changes as the cable moves. Thus cable impedance, inductance, capacitance, time delay, crosstalk, and attenuation all remain constant. Similarly, the conductors in the cable all have the same physical and electrical length. This, coupled with the fact that the dielectric dimensions stay constant, means that signal skewing and differential time delays between signals in the cable stay at a minimum.

Extruded flat cables and flat cable assemblies form an inherently high-density interconnect system. Packing density of flat cable is higher than is possible with round cables. The fact that conductors can be visible in the Flexx-Sil™ extrusion simplifies coding, inspection, and tracing circuits for trouble shooting.

Extruded Flat Cables vs Flex Circuit

Flex Circuits offer engineers some useful properties, but sometimes they are used in applications that require more ca-

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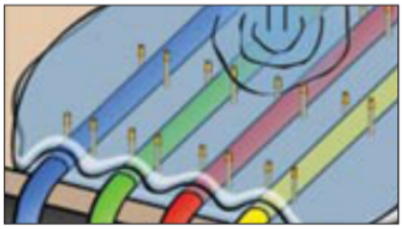
pabilities than they can offer. Despite the "Flex" in flex circuits, the flexing capability in the flat form factor is limited. Unlike flexible flat cables designed for millions of continuous flex cycles, Flex Circuits tend to be stiff and are very fragile. They can easily be dented, cracked, bent and damaged from exposure to severe turbulence, vibration, impact, long term flexing, mechanical stress and improper handling.

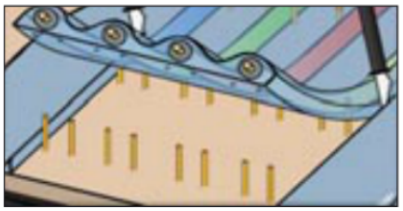
Where flat cables can incorporate different components within its profile, Flex circuits are typically limited to single conductors only. For applications exposed to EMI/RFI, shielding is attained by using neighboring conductors or flat shield planes above and below the circuit traced layer resulting in larger and very stiff assemblies. Flat cables can incorporate single shielded power conductors, twisted shielded data and Ethernet pairs, coax, triads and shielded cable bundles.

The initial tooling costs for Flex Circuits are high. Once made, tooling is expensive to change and new tooling may be required to accommodate application modifications. Flat extruded cables typically require a one-time $250 tooling charge, which is inexpensive compared to tooling used to manufacture Flex Circuits.

Similar to molded flat cables, Flex Circuits are individually produced and the size is fixed according to the tooling; whereas, extruded flat cable is manufactured in continuous bulk lengths and can be cut to suit various applications.



Conventional flat cable molding process.



Cutting conventional flat cables out of the mold.

Flex Circuits can be used in small spaces where equivalent round cables won't fit and can be shaped to fit the installation path. Flat extruded cables meet these requirements as well. Custom shaped flexible flat cables allow for very precise cable routing without folding, kinking or pinching. The custom shape of the flat cable also contributes to the elimination of signal failures due to physical stress at the cable connector.

This article was written by Rich Buchicchio, National Sales & Marketing Manager, Cicoil (Valencia, CA). For more information, visit ***http://info.hotims.com/65850-503.***

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