Will It Work?

Key questions – and answers – regarding flex circuit reliability.

IS ANY RELIABILITY information such as MTBF data available for flexible circuits?

The short answer is no. To the best of our knowledge, there is no generic mean time between failures data published for flexible circuits. Most of that information is empirical and is usually found by asking someone who has been watching flex circuits perform, and sometimes fail, for a few decades – namely, a manufacturer. The reason there are not any simple reports on flex circuit reliability is that there are *so* many different constructions and uses. We assume the question on reliability pertains generally to physical features, and specifically to how a circuit performs when it is bent or formed. We are also going to make the very big assumption that your application is static in nature and will not flex repeatedly after installation. (If the application is dynamic, well, that is an entire column's worth of information that will have to wait for another issue of PCD&F.)

To answer this question, we would have to ask several critical questions about the circuit and its end-use. We will address each question individually to illustrate how each impacts the circuit performance, and how difficult it would be to have a generic flex circuit reliability report.

How is the circuit being formed, assembled and used? How a flex circuit is formed and handled during assembly can have a major impact on circuit reliability. For better or worse, most flex circuit forming is done by the end-user. Reason: Most circuits are shipped by the flex circuit manufacturer un-formed to minimize shipping costs and storage volume. In addition, circuits formed by the flex circuit manufacturer must be shipped in custom trays to protect the form during shipping. The cost of these custom shipping trays is passed to the end-user. The problem with this scenario is that very few end-users have a thorough understanding of the dynamics going on inside a flex circuit when it is formed. End-users also often lack the resources or technical expertise to fabricate a flex circuit forming fixture that will produce reliable and repeatable results independent of the operator doing the forming. The result is a lot of flex circuits are being formed by hand around the edge of a desk or a handheld mandrel. This is both unreliable and difficult to control, especially if multiple operators are doing the forming operation. On the other hand, a well-designed and built forming tool, properly used, will yield a very reliable form.

Another variable that can affect reliability is handling during assembly. If the form in the flex is severe (very tight radius or over 90°), any exercising of the bend during assembly can result in reduced reliability. It is like bending a metal coat hanger back and forth until the wire breaks. Flex circuit conductors will behave in a similar manner. It is imperative that a severe bend in a flex circuit is constrained and not permitted to flex during assembly. This also holds true for handling that may occur after the circuit is installed due to service or maintenance.

How many conductive layers does the circuit have and what is the approximate thickness? As layer count increases on a flex circuit, so does thickness. Additional requirements such as controlled impedance and high current carrying capacity can also drive up overall circuit thickness. As thickness increases, so does the probability of reliability issues when it is flexed or formed. When a circuit is formed, conductors and materials to the outside of the bend are subjected to stretching (tension) forces, while those on the inside of the bend will be subjected to compression forces. Either of these forces can cause problems if they exceed the limits of the flex circuit materials. For this reason, it is a good idea to look for ways to minimize overall circuit thickness in applications with severe bends.

What temperature(s) will the circuit be exposed to in both assembly and end use? Flex circuits operate best at room temperature and get very fragile at elevated temperatures (anything above 125°F). The higher the temperature, the more fragile the circuits will become. All the items discussed so far become even more critical at higher temperatures. We have seen examples where a circuit was formed by hand and installed, and everything looked fine. However, after being exposed to elevated temperatures, the internal stresses imparted by the forming operation caused the now weakened adhesive bonds in the fragile circuit to fail, resulting in delamination.

What, if any, tooling is being used to create the form on the circuit? As mentioned, a well-designed forming tool can be invaluable in producing a repeatable, reliable form. We could fill an entire column just covering forming tools and methods, but suffice it to say, your flex supplier is probably the best resource for guidance on building and using the proper forming tool for your application. PCD&F

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