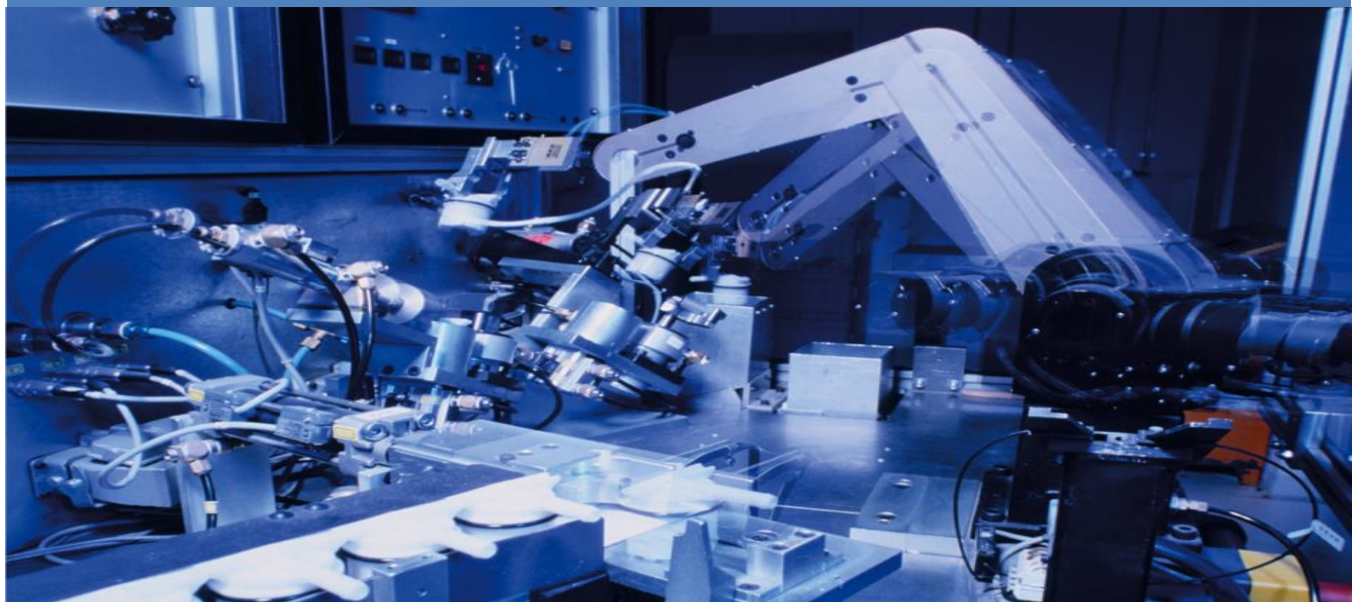
WHITE PAPER

Flex Life vs Flexibility

LOROM

CABLE & SYSTEM DESIGN



The design criteria for both flex life and flexibility is the same but the properties and application of the elements can be vastly different. The design elements are the following:

- Construction size
- Insulation material
- Conductor construction
- Cable lay length
- Separator tapes
- Shield type
- Jacket material

Flexibility can be achieved by keeping the following in mind when designing cables with a high degree of flexibility along with the capability of achieving a small bend radius.

- Construction size – As small as possible
- Conductor construction - stranded construction with fine wires
- Separator tapes - capable of allowing the core construction to slide within the cable jacket
- Cable lay length – as short as possible
- Jacket material – soft materials with a low flex modulus

A highly flexible cable does not guarantee a long flex life. Cables that have a long flex life are not always flexible so the design criteria may need further study to design the optimal approach. To design a small cable construction requires the use of highly efficient dielectrics that can reduce the size of the insulation without sacrificing performance. Insulation materials that have dielectric properties that have low dielectric constants can reduce the size of cables by efficiently meeting the required transmission parameters with the thinnest insulation possible.

Insulation Properties

Insulation	Dielectric Constant	Tensile (PSI)	Elongation (%)	Abrasion Resistance
Teflon	2.1	2600 - 3000	260 - 320	Good
Polyethylene	2.3	1510 - 2150	175 - 590	Good
Polypropylene	2.2	2800 - 4400	650	Poor
SR-PVC	2.9	3900	240	Excellent
PVC	3.7 – 8.1	1500 - 4400	200	Good
TPE	2.8	1250 - 2200	290 - 680	Good
Polyurethane	5.7 – 7.7	>4800	530 - 750	Excellent

Conductor Types

Conductor stranding allows for both a flexible cable and a cable with long flex life. This is accomplished by using fine strands grouped together with the shortest lay length in the following configurations.

- Concentric
- Equilay
- Unidirectional
- Unilay
- Bunched
- Rope Strand

Separator Tapes

Separator Tapes can also be beneficial to both flexible cables and those requiring a long flex life. The separator tape decouples the jacket from the core by allowing the free movement of the core inside the cable jacket. Some separator tapes are better at this task then others do to their low co-efficient of friction of the material used.

- TFE Skive Tape – Best Performance, Most Expensive
- Paper – Good Performance, Low Cost
- Polypropylene – Fair Performance, Low Cost
- Mylar – Poor Performance, Low Cost

Shielding

When shielding is required for cables that need to be flexible and exhibit long flex life certain shields perform better than others. Shielding is required whenever there are concerns for signals that need to be protected from interference from outside sources as well as radiated signals from the cables that are under flex. The shield types that should be considered are the following.

- Served Shields
- Braided Shields
- Tape Shields

Each shield needs to be considered because without adequate shielding the primary objective of protecting the signals traveling through the cable maybe interfered with and that could be lead to poor transmission performance. Certainly we need to look at shielded cables that are flexible and have adequate flex life as well. With all design parameters being considered we still need to make these cables flexible. Here are the properties that need to be considered when designing a flexible shielded cable.

Tape Shields – Thin and light weight with 100% coverage, which is most effective at high frequencies.

Braided Shields – Good Flexibility and Flex Life and most effective at low frequencies

Served Shields – Superior Flexibility and Flex Life with up to 97% coverage

Certainly if you need your high flex cables need to be shielded a served shield would give you the best performance in all areas of performance. The only way to be sure is to design your cable to be shielded properly and adjust the shielding material by optimizing the shield angles to give the best flexibility and flex life possible.

Jacket Materials

Jacket material choses can make our break your design. The most flexible jackets do not necessarily work for the highest flex life. Hardness, Tear Strength, Tensile Strength, Elongation and Co-efficient of Friction need to be considered when choosing the right jacket material for the application. Below are some of the common jacket materials and their properties.

Material	Tensile (PSI)	Elongation (%)	Tear Strength	Hardness	Co- Efficient of Friction
PVC	1500 - 3000	200	NA	A70 – A95	Fair
TPE	1700	450	380	A95	Fair
Polyurethane	5000	200	290	A82	Good
Teflon	2500	250	NA	D55	Excellent

Lorom's Flex Laboratory

Flex Life vs Flexibility

- Flex Life is determined by cyclic bending under load
- Flexibility is determined by minimum bend radius
- Flexible cable constructions do always perform well in Flex Life Testing
- Trade-offs need to be understood for a proper cable design

Conclusion

Cable materials and construction details must be considered when long flex life is expected. The cable flex life should be approached differently than cable flexibility and the cables operating environment needs to be considered for these materials even before the cable's flex life can be considered for the design. Certainly if the materials degrade do to its operating environment the flex life of the cable will degrade as well. The following considerations must be part of any cable design when looking to increase flex life

- Insulation and jacketing materials must possess sufficient memory to maintain a set deformation when stressed.
- Overall, the overall cable construction must have the components free to move within the cable jacket so that they do not generate enough frictional heat and abrasion to cause failure
- Inner conductors must be high strength alloys to withstand repeated flexing with cold hardening
- Design conductor stranding to minimize the strain of bending
- Optimize cable lay to reduce strain on cable bundle.