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BENDING DIAMETERS

A survey of inquiries for information submitted to Marion IPEC shows that one of the most repetitive requests concerns data on minimum bending diameters. This is not wholly unexpected since no simple formula exists in cable applications literature to cover this property. The most generally used source of information is the recommendations by IPCEA for specific cable constructions.

Since the primary function of an electrical cable is to conduct current, it is only natural that major attention has been focused on electrical properties. Cable engineers have taken advantage of the fact that a cable is a capacitor and have exhibited considerable ingenuity in calculating and predicting electrical characteristics.

Greater appreciation for bending diameters can be gained if it is recognized that cables are exposed to a physical environment as well as electrical. For this physical environment a cable should be considered as a machine and amendable to the same laws of mechanics as equipment designed primarily for mechanical purposes. Torsion, tension, shear and compression forces are not discriminatory. With some imagination and ingenuity, laws governing these forces can be applied to cable technology and bending diameters in particular.

The geometrical shape of the conductor usually dictates the geometrical shape of the insulated conductor. A round conductor offers the best profile mechanically, consistent with reproducibility and control in manufacture.

Most electrical conductors are composed of a multiplicity of wires. The number of wires in a given AWG size is dependent on the ultimate application and usually designated as Class A, B, C, G, H, K, etc. The nearer the end of the alphabet, the greater the number of wires and greater the flexibility.

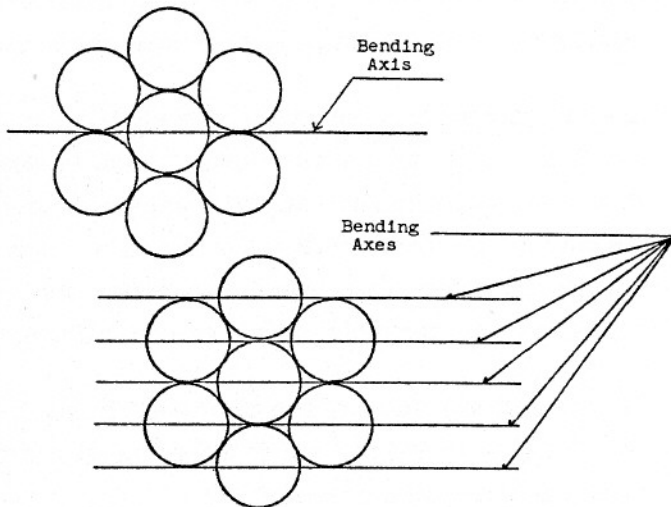
Maximum efficiency or balance in a conductor composed of a number of wires is obtained only when all of these wires work together during bending, flexing or under tension. This balance is obtained by stranding or forming these wires into a helix. Subsequent operations such as taping or cabling also involve helical application of tapes, insulated conductors and fillers.

The recommended minimum bending diameter for a specific cable construction is related to and dependent on the length of lay of individual components making up the construction. Generally this length of lay is 12-16 times the calculated diameter of the finished core in which that component appears—for example:

- (1) In a stranded conductor with a 1 inch O.D. the outer layer of wires will have a lay from 12-16 inches.
- (2) Three cabled conductors in the core of a Type W cable with a calculated core diameter of 2 inches would have a lay of 24-32 inches.

In any stranded, bunched or cabled configuration it is absolutely necessary for all helical components to have a common bending axis during bending or flexing. The only way this can be achieved is to make sure that the minimum bending diameter of these components is greater in inches than the longest lay in inches of any component that appears in a specific cable.

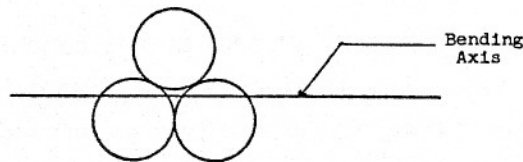
Example (1) – 1/C, 7/W strand with a 1/2 inch O.D. and lay of 6 inches (12-1 ratio) when the diameter of bending is over 6 inches, all seven wires have one common bending axis.



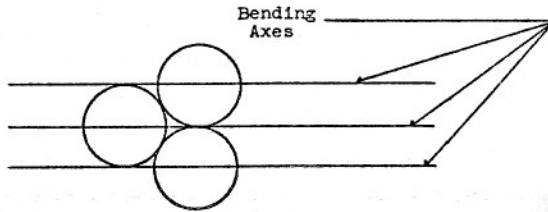
When the bending diameter is less than 6 inches or one complete helix, each wire bends upon its own axis.

Individual wires or layers will either buckle or stretch upon bending, resulting in deformation and damage. In flexible cables the result is shortened flexing life.

Example (2) – 3 - 1 inch O.D. conductors triplexed will have a calculated O.D. of approximately 2.15 inches and a lay of 35. inches (16-1 ratio). When the bending diameter is over 35. inches all conductors will bend on one common axis:



When the bending diameter is under 35. inches each conductor will bend on its own axis resulting in kinking or deformation.

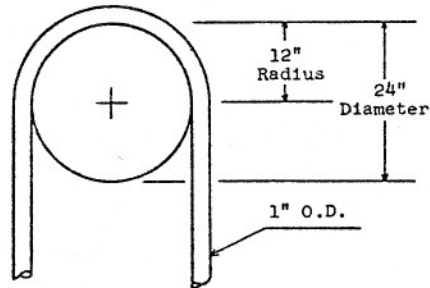


IPCEA expresses minimum bending in terms of radii. Multiply this by 2 and you will get minimum bending diameters. For example, the minimum bending radius for all cable with metallic shielding tapes is 12 times the overall diameter of the completed cable.

Example:

Cable with a 1.0 inch O.D.

- (1) Minimum bending radius of 12 inches.
- (2) Minimum bending diameter is 24. inches.



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