CALCULATING MINIMUM BEND RADIUS FOR CONDUCTIVE CABLES

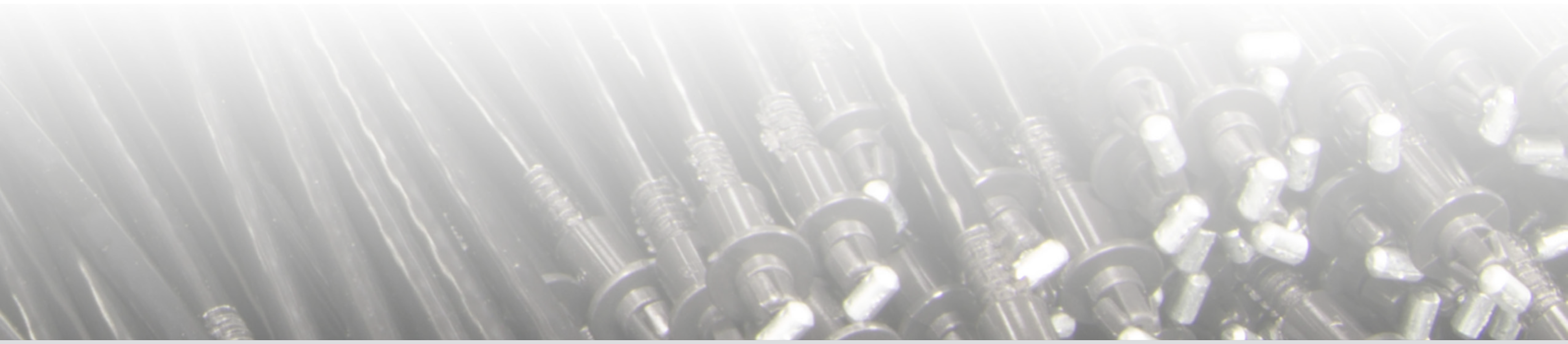
Understanding Cable Bend Radius To Prevent Damage

Conductive cables require an understanding of how **bend radius** can influence cable integrity, fatigue, and service life. Estimating the bend radius of a cable before installation will help establish parameters for optimal performance.

Minimum bend radius determines how tight a cable can be bent without putting too much stress on the cable, inevitably causing damage like cracks or kinks. It provides a safe operational range for the cable's application, ensuring optimal performance. This white paper focuses specifically on minimum bend radius of conductive cables.

As a rule of thumb, electrical power conductors don't carry physical loads other than their own weight, and are therefore fairly tolerant in accepting bends. They are fixed in place for most applications, but there are exceptions like chainflex applications where movement does occur. Generally though, they are not subjected to movement, and thus experience little more than thermal stress from expansion and contraction.

Household or general industrial electrical services often don't follow the rules, but it is more of a deciphering and aesthetic problem than a threat against the wiring integrity.



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Making a Quick Minimum Bend Radius Calculation

For those that need a quick answer about minimum bending radii (but always deferring to manufacturer specifications, of course), we can use a fast calculation without referring to charts. On the job site we can say the following:

- For a single conductor cable rated >1,000 volts, with metal shielding, the Minimum Bend Radius (MBR) will be 12 times the overall cable diameter[1]
- For single/multiple conductor cables with no metallic shielding, the MBR will be 8 times the overall diameter of the cable[2]
- For multiple conductor cables rated >1,000 volts, where each is individually shielded, it should be either 8 times the overall cable diameter, or 12 times the individual cable diameter, whichever produces the greatest number[3]
- Any MC-type cables equipped with corrugated sheath or interlocked armor have an MBR of 7[4]
- In cases where MBR is dubious or unspecified, it is generally safe to assume an MBR of 15 for a low stress application.

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Medium-Voltage Cables

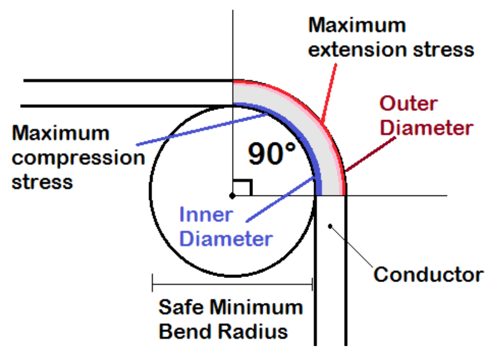
In the last case our concern is that a medium-voltage cable provided with a copper tape shield could suffer cracks in the outer jacket despite the fact that the interior conductors are within their bending specification. Err on the side of lower stress.

Flat Cables

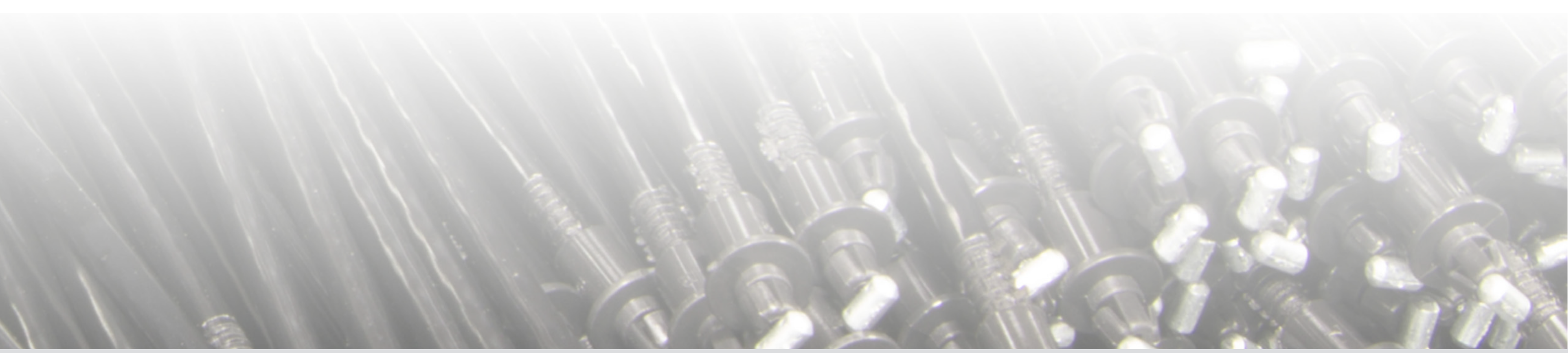
In the case of a flat cable, base your calculation on the maximum width of the cable since flat cables are generally attached "flat" to surfaces. The units of measure are inconsequential since we're speaking of ratios, so feel free to use whatever you are most comfortable with, such as fractional inches or millimeters.

The Reasoning

With a round conductor, the outer edge on a curve will pass through a greater length of arc than the inner diameter. In the figure below, the blue area will be under the greatest compression providing an expansion force perpendicular to the axis, in the direction of the outer diameter, which could result in a kink.



Conversely, the red area is the portion experiencing the maximum stretching strain, imparting a force towards the inner diameter. This helps to resist the kink-effect. The goal, however, is not to balance these opposing forces; the goal is to minimize these forces.



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Considering Thermal Expansion and Contraction

Due to thermal expansion and contraction, these strains will ultimately weaken the conductor, causing thinning, reducing load carrying capacity, and increasing heat generation, through increased resistance. We eliminate this problem by not allowing it to occur in the first place.

For example, a single-conductor 1.5-inch cable rated >1,000 volts, used for municipal distribution would use the following formula to determine MBR:

1.5" O.D. × 12 = 18 MBR (remembering the "R stands for radius), then we can safely say that this cable can be bent around a diameter of 36".

Similarly, a multi-conductor cable with individually shielding for each could be calculated in two ways:

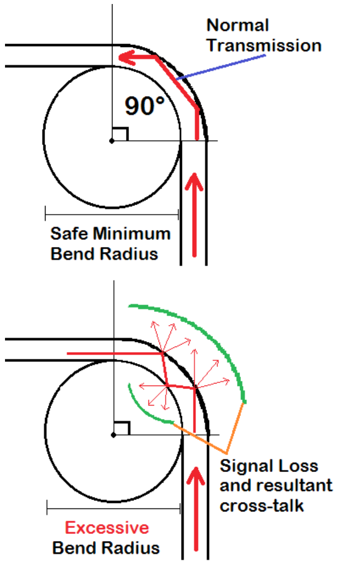
A cable of 1.5" O.D. with four individually shielded ¼" conductors could be calculated as

1. ¼ × 12 = 3 multiplied by the number of conductors (4) for a value of 12 MBR, or
2. 1.5" O.D. × 8 = 12 MBR

Optical Conductors

In the case of fiber optics, following the recommended bend radius is even more important. Glass fibers are very flexible, but they are constructed in two layers. The inner core is designed to transmit light with minimum loss, and the outer layer is designed to keep the light within the individual fiber.

When you create excessive bending, the angle of incidence for the laser light is so high that light begins to leak at the curve penetrating the external layer. With ordinary laser light, used for short communications in a plastic media rather than glass fibers (such as with home audio systems), the effect is obvious.



Long Distance Data Transmission

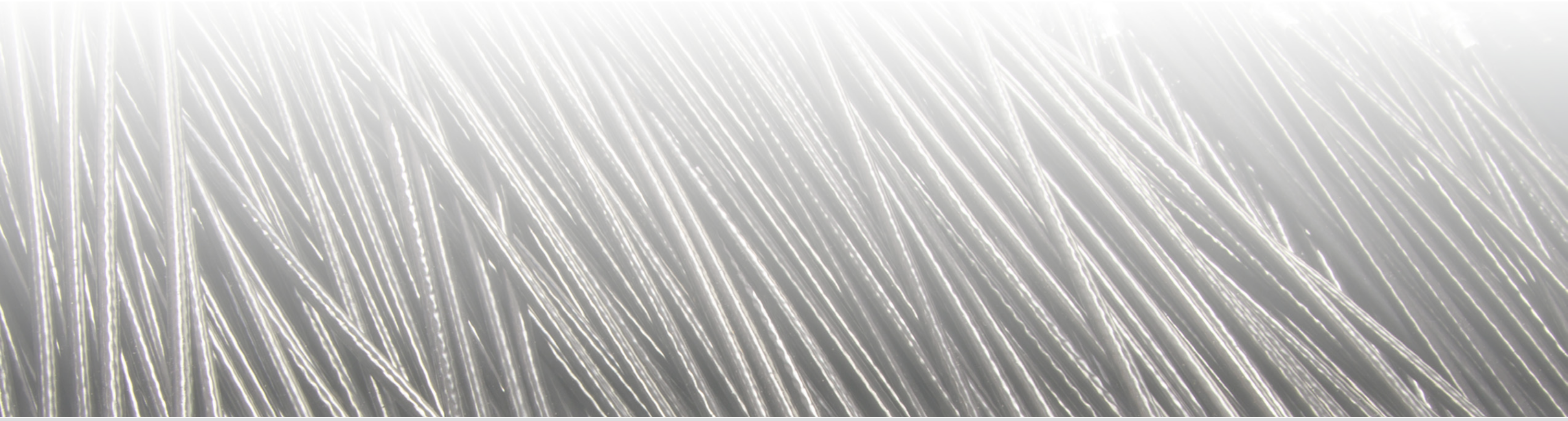
In long distance data transmission, we use infrared lasers which cannot be seen without special equipment, and is a direct threat to human eyes without proper eyewear. The outer sheathing is opaque for this reason, but that doesn't help when individual fibers are leaking light back and forth between them, corrupting data transmissions and requiring many resends to complete a task.

For this reason it is particularly important to follow manufacturers' recommendations. Generally speaking, the MBR for fiber optic cable runs between 6 and 8, so if you're uncertain, or the markings are unclear, don't go less than 8 MBR for unknown fiber optic cable.

The Takeaway

These are general guidelines that are suitable for field work, but for project planning it is best to obtain the specific charts from each manufacturer, for each of their products that you intend to use. Different manufacturing techniques will change these characteristics, as will the choice of materials used. Whenever they are available, use the actual numbers for the material at hand.

At CMA, we can work with you to ensure the cables selected for your project have the proper minimum bend radius for your application.



CABLE MANUFACTURING & ASSEMBLY CO. INC.

Questions?

If you have questions or are interested in speaking with us about the proper conductive cables for your project, we are happy to help.
Contact CMA today!

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[1] 2014 NEC Section 300.34 Conductor Bend Radius
[2] 2014 NEC Section 300.34 Conductor Bend Radius
[3] 2014 NEC Section 300.34 Conductor Bend Radius
[4] 2014 NEC Section 330.24 Bending Radius