PMI
UNDERWATER CABLE SOLUTIONS

The Gripping of Helical Elements

This is a brief discussion of how our products work. The helical gripping products are based on evolutionary developments of many years of innovative efforts in solving problems for cable and conductor users in all fields. Our entry into the underwater area, in 1969 led to new areas of applications and new ideas. The concept of how helical products work is supported by extensive laboratory test programs. Test and user experience in a variety of applications and environments have demonstrated the success of this principle for terminating cables.

Helical Accessories for Cables

The original helically preformed gripping products were armor rods designed to protect overhead conductors from damage at support points. This damage could occur from clamping stresses, arc-over, heating, or vibration fatigue.

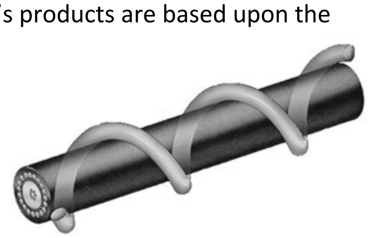
Early in the laboratory testing stage, it was observed that a gripping effect was present. In vibration fatigue tests, for example, no separation occurred at failed elements in conductors under a tension of 25% of the rated strength until the helical armor rods were removed. Afterwards, the broken wires separated causing the remaining wires to take up proportionate shares of the load. With this background, the early preformed gripping products were developed.

When more accurate and extensive information was obtained from laboratory testing, it became possible to determine design parameters that made possible efficient gripping characteristics. The basic design of these gripping devices is predicated on the concept of developing low unit pressure over a large area to develop high total force.

Many years later, our helical gripping products have been used extensively and successfully on a wide variety of cables and wire ropes. Their performance has been verified by a continuous program of laboratory testing field inspections, and a widespread use history. Our products continue to be engineered and designed using empirical relationships proven by years of testing and use.

Discussion of Gripping Principles

The gripping principles of PMI's products are based upon the geometry and behavior of helically preformed wire, such as the one shown to the right. Axial load causes elongation of the helix resulting in radial contraction. The contraction is a function of wire diameter, material, pitch length and initial diameter. When a preformed helical rod is wrapped onto a cable having a diameter greater than the inside diameter of the rod, the inside diameter of the rod increases thereby shortening the pitch length and creating radial compressive force on the cable. This compressive force and the coefficient of friction between the materials gives the helical products its initial holding force and prevents slippage of the cable at zero load.

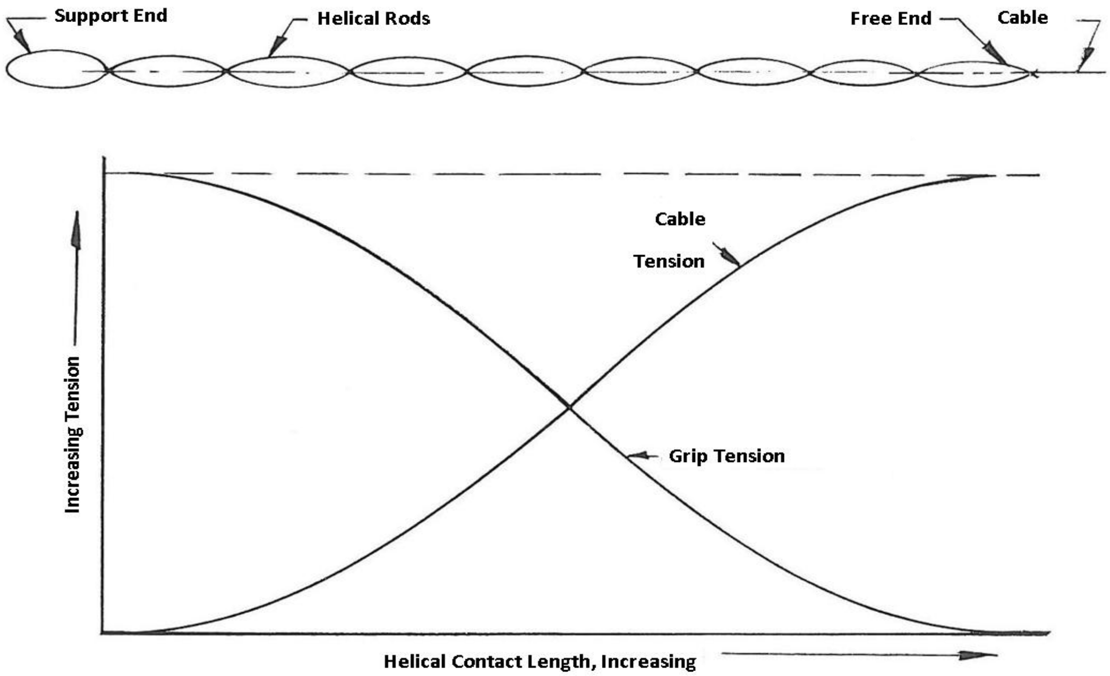


Holding one end of the helical rod and attempting to pull the cable out of the rod from the other end transfers the load from the cable to the rod because of the initial holding force. As axial load increases, elongation of the helix results in further radial contraction of the rod and increased holding force capability. The coefficient of friction, therefore the holding ability, is enhanced by applying grit to the inside diameter of the helical rod. The mechanism described above provides gradual transition of load from the cable into the helical rod until the full axial load is carried by the rod.

Helical rods develop minimum radial pressure and therefore low holding ability at the free end because it is anchored only by the initial compression. Subsequent increments in rod length gradually develop more holding ability because of additional anchoring provided by the previous segment. Holding strength increases with rod length because the area over which the radial compression and resultant friction forces act increases. With increasing length, more tension is transferred from the cable to the rods while cable tension under the rod decreases. With increasing axial load in the rod, there is greater radial compression on the cable.

This compounding effect continues until the full axial load is carried by the helical rods at the support point, and no axial load remains in the cable. Thus, the stress in the cable undergoes a transition from axial load to radial compression, but the combined stresses are relatively low. The gradual transition of axial load from cable to rod eliminates stress concentrations and sudden changes in stiffness.

Stress in the cable results from the combined action of axial tension in the cable and radial compression from the helical rod. The radial compression is proportional to the tension in the helical rod. The variation in cable and grip tension is



shown in the accompanying sketch. Radial compression increases while axial load in the cable decreases. This results is a combined effect that minimizes the chance of high stress concentration.

Radial Clamping Pressure

Since the rods are designed with a diametrical interference, there is an initial pressure and, therefore, an initial capacity for maintaining tension before loads are applied. As the tension in the cable is increased, the helical elements deform, each one carrying a portion of the tension and that portion gradually increases from a small percentage at the free end to 100% at the support point. The variation has been shown to be non-linear, increasing in some sort of parabolic or exponential fashion, building up rapidly so that the two-three pitches nearest the support point carry most of the load in the termination.

The relationship between tension and radial forces or clamping pressures is nearly proportional; that is, the clamping pressure builds up in much the same exponential fashion from free-end minimum to support-point maximum. However, the proportionality constant depends on the compliance, radial stiffness characteristics or compressibility of the cable being held. The compliance of the cable varies with the load and its own construction parameters.

Due to the length of the helical elements, the radial compressive forces are spread over a large area. This minimizes any detrimental effects due to the gripping mechanism. The lack of compression damage on cables using these products is clear evidence that radial compressive forces are not a problem.

For more information or to discuss your application, please contact us.

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