EDITION 17
VOLUME 1

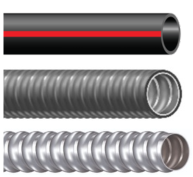
20 BEST PRACTICES TO FOLLOW
DURING CABLE INSTALLATION

WRITTEN BY: **Dr. Yuhsin Hawig**, VP of Applications Engineering | **Mark Dulik,** Principal Engineer & Certified Cable Splicer

PURPOSE OF CONDUIT

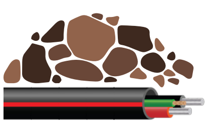
Many methods can be deployed to install electrical wiring, including cable trays, conduit, messenger support systems, duct banks, or direct burial. This engineering whitepaper focuses on cable installations via conduits and lists critical guidelines to follow to complete projects safely and effectively. The purpose of placing cables within conduits is to provide a barrier both electrically and physically to prevent electrocution and shield cables from mechanical forces. Conduit installations have been successful in data centers, power generation, industrial factories, manufacturing, oil & gas, commercial projects, utility grid hardening, and more.

CONDUIT TYPES



There are many different types of conduit in the electrical industry. Conduit selection depends not only on the location (for example: above or below grade) but also on code & standard requirements, budget restrictions, and whether it is a residential, commercial, industrial, or utility project. Electrical Metallic Tubing (EMT), Rigid Metal Conduit (RMC), and Flexible Metal Conduit (FMC) are the most common metallic ducts. Flexible HDPE & Rigid PVC conduit are the most frequently used materials made of lightweight plastics. Composite conduit containing fiberglass is also available in the marketplace. There are pros & cons for each option, and it is important to consult with conduit vendors to specify the design based on each unique project.

DIRECT BURIAL & BACKFILL



Cables installed in HDPE conduits are designed for below grade locations, which can be direct buried in earth or encased in concrete. HDPE ducts can be installed for aboveground use only if the conduit is encased in no less than 2 inches of concrete. Minimum cover requirements for burying both HDPE & PVC conduit per NEC® depend on circuit voltage ratings. 18 inches of cover is needed for circuits rated 15 kV or lower, and 24 inches of cover is a must-have for 35 kV circuits. A smooth, leveled trench ground plane is essential to prevent conduits from being punctured by rocks or sharp objects. If the natural soil on site is too rocky or has a very high thermal resistivity, then engineering backfill with a better thermal conductivity should be utilized.

EXISTING CONDUIT CLEANING

If existing conduit is to be re-used, conduit cleaning and proofing should be considered. Conduit should be cleaned out thoroughly by carefully scraping the internal conduit walls with brushes and mandrels designed for the specific conduit material. It is important to ensure that conduit is free from debris and foreign matter. Test balls can be pulled through conduits to verify that the conduit is not physically deformed or crushed. It is not uncommon to find aged ducts with an oval shape or partially collapsed walls. In those cases, replacement of damaged conduits is recommended for the safety and long-term reliability of the electrical wiring system.

LOW AMBIENT TEMPERATURE

Low temperatures are a cause for concern when installing cables. Cable should be handled with extra care and pulled more slowly using larger sheaves during cold weather. If cables must be installed in freezing conditions, they should be placed in a heated area such as an indoor warehouse for at least 24 hours immediately before installation. Cables containing a PVC insulation, a PVC jacket, or both should not be handled or pulled at ambient temperatures lower than -10˚C or 14˚F due to brittleness which triggers cracking. Cables containing a CPE insulation or jacket should not be installed below -20˚C or -4˚F. Other cable types such as XHHW, XLPE, or PE have a minimum installation temperature of -40˚C or -40˚F.

EXTREME TEMPERATURE SWINGS

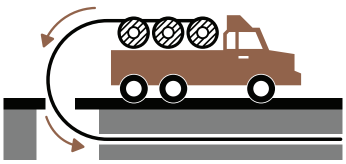
In climates where there are large intermittent or seasonal temperature swings, jacket shrinkback can occur at splices and terminations allowing entry of moisture and contaminants into the cable. This is due to a ratcheting effect associated with the expansion and contraction cycles of the cable. At these sealing points, using mechanical restraints, shrinkable sleeves, or electrical tape are effective ways to restrict the jacket movement due to thermal cycling.

Southwire®

For more information, please contact cabletechsupport@southwire.com or visit **southwire.com**.

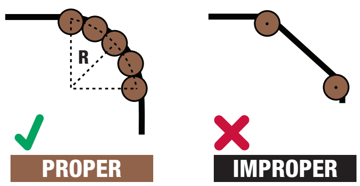
EDITION 17
VOLUME 1

20 BEST PRACTICES TO FOLLOW
DURING CABLE INSTALLATION



UNDERGROUND DUCTS

For pulling cables into a below-grade conduit, the curvature of the cable feed should be a continuous smooth arc. This can be accomplished by using appropriate feeding sheaves, flexible feeding tubes, or automatic cable feeding machines.

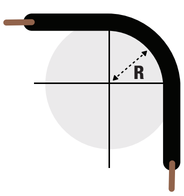


CABLE SHEAVES

On cable pulls pulled by hand or with pulling machines, sheaves are placed at the entry of the pull to eliminate sharp bends and guide the cables into the duct to eliminate damage. It is a good practice to have personnel oversee the cable entry and ensure cables are entering conduit straight, without twists or sharp bends. Sheaves are also used for direction change in a cable pull; pull tensions and minimum bend radius should be observed at these points to avoid cable damage and personal injury. There are a variety of sheaves available to fit your specific cable pull.

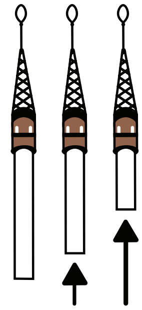
PULLING LUBRICANT

Pulling lubricant is applied to the cable surface prior to installation to reduce the coefficient of friction. The chemical compatibility of the lubricant with cable and conduit is extremely important. We recommend only using a cable lube brand that has been tested per IEEE 1210. The lubricant should not have any detrimental effects on the conduit or on the physical or electrical properties of the cable insulation, semiconducting, or jacket materials. The lubricant should not compromise the performance of the cable per thermal ratings, flame propagation, oil & sunlight resistance, or other UL or CSA listed markings.



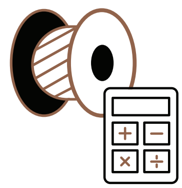
MINIMUM BENDING RADIUS

A non-shielded and non-armored cable can tolerate a sharper bend than a shielded or armored cable. When bent too sharply, the metallic component such as helically applied copper tape can separate, buckle, and cut into the insulated cable core. Therefore, the minimum bending radius for a single conductor with a metallic shield is 12 times the cable radius compared to 8 for unshielded designs. The minimum bending radius for interlocked armored cables is 7 times the cable radius.



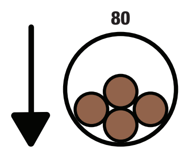
ALLOWABLE TENSION ON PULLING DEVICE

Do not exceed the allowable tension stated by the manufacturer of the pulling eye, 10,000 pounds, whichever is less. Traditional conservative practices limit the allowable tension of a basket grip to 1,000 pounds. Under specific conditions, this limit can be safely exceeded.



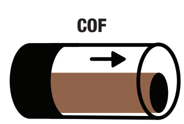
MAXIMUM PULLING TENSION

The conductors of the cable are generally the only component that can bear the pulling forces without being damaged. Do not use metallic shielding wires, tapes, braids, or armor not designed for the purpose of pulling tension calculations or pulling. For fully annealed soft drawn copper, the maximum pulling tension or allowable conductor stress is 8 lbf (pound-force) per kcmil. For example, 500 kcmil copper single conductor, 4000 lb (500 kcmil x 8 lb/kcmil) is the maximum allowable pulling tension. For power cables containing 8000 or 1350 ¾ hard stranded aluminum conductors, the maximum pulling tension is 6 lbf (pound-force) per kcmil.



PULLING TENSION DERATING

Pulling between 1 to 3 conductors at the same time does not require a pulling tension derating. However, if four or more conductors paralleled or multiplexed, are being pulled together, the maximum pulling tension should be lowered with a derating factor of 80%. For example, pulling four 500 kcmil copper conductors will yield a maximum pulling tension of 12,800 lb (80% x 4 x 4000). Pulling mixed cable sizes needs to be handled with extra care. Using the lowest maximum pulling tension or the value from the smallest conductor for calculations with a conservative derating factor of 75% is recommended.



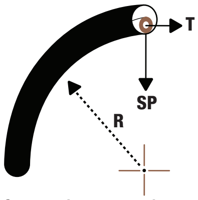
COEFFICIENT OF FRICTION (COF)

The coefficient of dynamic friction is a measure of the frictional force between a moving cable and the duct. It can vary from 0.1 to 1.0 with lubrication and can exceed 1.0 for unlubricated pulls. Exterior cable material based on PVC, Nylon, PE, XLPE, LSZH features a COF of 0.35 in a PVC or HDPE plastic conduit. Cables containing CPE exhibit a higher COF of 0.5 in the same plastic conduit. Pulls should never be stopped and restarted because the static COF will always exceed the dynamic COF. Higher ambient temperatures (80°F & above) can increase the COF for cables with a non-metallic sheath.

For more information, please contact cabletechsupport@southwire.com or visit **southwire.com**.

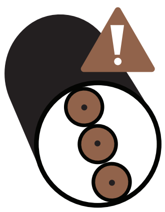
EDITION 17
VOLUME 1

20 BEST PRACTICES TO FOLLOW DURING CABLE INSTALLATION



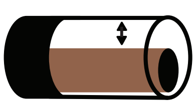
SIDEWALL BEARING PRESSURE

Sidewall bearing pressure or sidewall pressure (SWBP or SP) is exerted on a cable as it is pulled around a bend. Excessive sidewall pressure can cause cable damage and is the most restrictive factor in many installations. A maximum sidewall pressure of 1000 lbf/ft is recommended for utility primary & secondary products (600 V- 46 kV), industrial power & control cables (300 V-35 kV), and building wire single conductors sized 8 AWG & larger. For building wire single conductors sized 14, 12, and 10 AWG, we recommend the maximum sidewall pressure of 500 lbf/ft.



JAMMING RATIO & PROBABILITY

Jamming is the wedging of three or more cables when pulled into a conduit. This usually occurs because of crossovers when the cables twist or are pulled around bends. The jamming ratio (D/d) can be determined by dividing the conduit inner diameter (D) with the cable outside diameter (d). In calculating jamming probabilities, a 5% factor is used to account for the oval cross-sectional area of the conduit bends. The cable diameters should be measured since actual diameters may vary from the published nominal values. Jamming probability can be lowered by changing the conduit size or by pulling plexed cable assemblies rather than parallel cables. Jamming occurs when the jamming ratio falls between 2.8 and 3.2.



CLEARANCE

Clearance is the distance between the top of the uppermost cable in the conduit's and the inner top surface of the conduit. It should be at least 10% of the conduit's inner diameter or at least one inch for large cables or installations involving numerous bends.

CONDUIT FILL

Conduit fill is the percentage of the area inside the conduit taken up by the cable(s). Per Table 1 (Percent of Cross Section of Conduit and Tubing for Conductors and Cables) in Chapter 9 from NFPA 70®, National Electrical Code® (NEC®), a maximum conduit fill ratio of 53%, 31%, and 40% are recommended for one, two, and three or more conductors, respectively.

PULL CALCULATIONS

Southwire's CableTechSupport™ Services offer comprehensive cable pulling calculations for existing customers. The online calculator, available on Southwire.com, is free of charge and can be accessed by any user. We recommend conducting pull calculations in advance to evaluate the entire cable route, coefficient of friction for different jacket materials, pull distance, the number of bends, as well as the angle of each bend.

Southwire CABLETECH SUPPORT™ Services

CABLETECHSUPPORT™ SERVICES

All conduit installs regardless of material types should follow NFPA 70®, National Electrical Code® (NEC®), or NESC® (National Electrical Safety Code®). Southwire's CableTechSupport™ Services offer many reference documents and engineering whitepapers to assist you with code & standard compliances for any challenging project. You can access the articles directly from the website below:
CLICK HERE TO VIEW

We also offer over ***10 free calculators online and apps*** to download.
CLICK HERE TO ACCESS CALCULATORS/APPS

Southwire®

For more information, please contact
cabletechsupport@southwire.com or visit **southwire.com**.