# ANHUI FEICHUN SPECIAL CABLE CO., LTD.

安徽飞纯特种电缆有限公司

**Technical Specification for Variable Frequency Drive Rated Power Cable Systems**

**Three Configuration Options for Diverse Industrial Applications**

## Variable Frequency Drive Cable Series - 250 kcmil Three-Conductor Configuration

This technical specification establishes the requirements, construction details, and performance characteristics for a family of three-conductor power cables specifically engineered for variable frequency drive applications operating at voltages up to two thousand volts. The cable series is available in three distinct configurations, each designed to address specific installation requirements and environmental conditions encountered in modern industrial facilities. All configurations share a common conductor size of 250 kcmil with three integral grounding conductors and feature cross-linked polyethylene insulation with copper tape shielding for electromagnetic compatibility. The configurations differ in their mechanical protection systems, ranging from standard tray cable construction through steel tape armored versions to heavy-duty double-armored mining cable, allowing specifying engineers to select the appropriate protection level based on the severity of the installation environment and the mechanical stresses anticipated during both installation and operation.

### ◆ AVAILABLE CABLE CONFIGURATIONS

#### Configuration A: Type TC-ER Tray Cable

**3/C 250 kcmil + 3 Grounds, 2000V (VFD), Type TC-ER, XLPE, Shielded (Copper Tape), PVC Jacket** VFD RATED

*Alternative Designation: CABLE ELEC 126.7mm² 1X3C+3T+SH 1kV CP | Aislación: XLPE-CP*

#### Configuration B: Type MC Armored Cable

**3/C 250 kcmil + 3 Grounds, 2000V (VFD), Type MC (Steel Tape Armor), XLPE, Shielded, PVC Jacket** VFD RATED

*Alternative Designation: CABLE ELEC 126.7mm² 1X3C+3T+SH 1kV STA | Aislación: XLPE-CP-STA*

#### Configuration C: Heavy-Duty Mining Cable

**3/C 250 kcmil + 3 Grounds, 2000V (VFD), Double Armored (Steel Tape + SWA), Heavy Duty Mining** VFD RATED

*Alternative Designation: CABLE ELEC 126.7mm² 1X3C+3T+SH 1kV SWA | Aislación: XLPE-CP-STA+SWA*

## 1. SCOPE AND APPLICATION

This specification establishes the design, materials, construction, testing, and performance requirements for three configurations of 250 kcmil three-conductor power cables specifically engineered for variable frequency drive applications. The cables are designed to address the unique electrical challenges associated with pulse-width modulated drive systems, including high-frequency harmonic currents, elevated voltage stress from rapid switching transients, and electromagnetic interference concerns that can affect both the cable system and adjacent electronic equipment.

The cable series finds primary application in industrial facilities employing variable frequency drives for motor control, including manufacturing plants, mining operations, water treatment facilities, petrochemical complexes, and commercial buildings with sophisticated HVAC systems. The three configurations provide graduated levels of mechanical protection suitable for environments ranging from standard indoor installations through harsh industrial conditions to severe-duty mining applications. The inclusion of copper tape shielding in all configurations ensures electromagnetic compatibility by containing high-frequency electromagnetic emissions within the cable structure while providing a low-impedance path for high-frequency return currents generated by the switching action of the drive electronics.

### Configuration A: Type TC-ER Tray Cable Application Profile

The Type TC-ER configuration represents the most economical option and is suitable for installations where cables are protected from mechanical damage through their placement in cable trays, supported by messenger wire systems, or installed within raceways and conduits. This configuration is appropriate for indoor industrial environments, commercial facilities, and generating stations where the cable routing does not expose the cable to significant mechanical stress beyond normal handling during installation. The exposed run rating permits use in visible installations where aesthetic considerations are secondary to functional performance. This configuration is well-suited for elevated tray installations, vertical risers in industrial buildings, and distribution circuits within protected areas of manufacturing facilities.

### Configuration B: Type MC Armored Cable Application Profile

The Type MC configuration incorporates steel tape armor that provides substantial mechanical protection while maintaining reasonable flexibility for installation in industrial environments. This configuration is appropriate for installations where cables may be subject to moderate mechanical stress, including exposed runs along structural members, installations in areas with vehicular traffic, and applications where protection against inadvertent impact damage is required. The steel tape armor provides effective protection against crushing forces, impact damage, and rodent intrusion while permitting installation bend radii compatible with typical industrial routing constraints. This configuration is particularly well-suited for manufacturing facilities, food processing plants, pulp and paper mills, and chemical plants where robust construction is required but the extreme mechanical protection of mining cable is not justified.

### Configuration C: Heavy-Duty Mining Cable Application Profile

The heavy-duty mining configuration employs dual mechanical protection consisting of an inner steel tape armor layer overlaid with steel wire armor, providing maximum mechanical protection for the most demanding applications. This configuration is specifically engineered for mining operations, quarries, tunneling projects, and other applications where cables are subjected to severe mechanical abuse including impact from falling rock, abrasion from contact with rough surfaces, and crushing forces from heavy mobile equipment. The dual armor system provides redundant mechanical protection that ensures continued operation even if the outer armor layer is compromised. The construction permits direct burial in rocky soil conditions and withstands the mechanical stresses associated with cable dragging operations common in mining environments. This configuration represents the highest level of mechanical protection available and is specified when cable reliability in harsh environments is paramount to operational continuity.

## 2. APPLICABLE STANDARDS AND REGULATORY COMPLIANCE

All cable configurations have been designed, manufactured, and tested in accordance with nationally recognized standards and have been evaluated by independent testing laboratories to verify compliance with applicable safety and performance requirements. The cables carry appropriate third-party certifications that demonstrate conformance to industry standards and facilitate approval by authorities having jurisdiction. Compliance with these standards ensures that the cables will perform safely and reliably when properly applied within their design parameters.

### UL 83

Thermoplastic-Insulated Wires and Cables - establishes construction and testing requirements for building wire insulation systems including THHN/THWN-2 conductor insulation

### UL 1277

Electrical Power and Control Tray Cables - defines requirements for tray cable construction, jacket materials, and flame propagation characteristics for Type TC and TC-ER cables

### UL 1569

Metal-Clad Cables - establishes construction, testing, and performance requirements for Type MC cables with metallic armor protection systems

### UL 1685

Vertical-Tray Fire-Propagation and Smoke-Release Test - validates cable performance in vertical installation configurations with respect to flame spread and smoke generation

### IEEE 1202 / CSA FT4

Flame Test Standard - 70,000 BTU per hour vertical tray test demonstrating superior flame resistance characteristics suitable for critical installations

### ICEA S-95-658

Standard for portable and power feeder cables for use at 600 volts or less - establishes construction and testing criteria for industrial power cables

### ASTM B3 / B8

Soft or Annealed Copper Wire and Concentric-Lay-Stranded Copper Conductors - defines copper conductor material properties and stranding configurations

### ASTM B787

19 Wire Combination Unilay-Stranded Copper Conductors - specifies advanced stranding configurations for improved flexibility and electrical performance

### CSA C22.2 No. 174

Cables for Use in Hazardous Locations - certifies suitability for installation in classified areas as defined by Canadian electrical code

### CSA C22.2 No. 131

Type TECK 90 Cable - Canadian standard for armored cables suitable for harsh environments and hazardous location applications

### NEC Articles 336, 501, 725

National Electrical Code requirements for power and control cable applications including installation in hazardous classified locations

### CSA C68.10 / LTGG

Cold Bend and Impact Rating at minus forty degrees Celsius - certifies cable flexibility and mechanical integrity at extreme low temperatures

The cables carry Underwriters Laboratories listing for Type TC-ER and Type MC applications as appropriate to each configuration. All configurations are rated for sunlight resistance, permitting outdoor installations without degradation of jacket materials. Configuration A is approved for direct burial applications where soil conditions and local codes permit. Configurations B and C are approved for use in Class 1 Division 2 and Class 2 Division 2 hazardous locations as defined by the National Electrical Code, expanding their application range to include installations in areas where flammable gases, vapors, or combustible dusts may occasionally be present. The Canadian Standards Association certifications permit installation in Canadian facilities and provide cold temperature ratings to minus forty degrees Celsius for both cold bend flexibility and impact resistance, ensuring reliable performance in extreme cold environments typical of northern climates and refrigerated facilities.

## 3. TECHNICAL SPECIFICATIONS - 250 KCMIL CONFIGURATION

The following technical specifications define the electrical, mechanical, and dimensional characteristics common to all three cable configurations. Values represent nominal measurements based on standard manufacturing practices and are subject to normal manufacturing tolerances as defined in applicable standards. The data serves as the foundation for engineering calculations, installation planning, and equipment specification verification.

| Parameter | Value / Specification | Unit |
|---|---|---|
| **Conductor Size** | 250 kcmil (126.7 mm²) | kcmil / mm² |
| **Number of Phase Conductors** | Three (3) Conductors | — |
| **Conductor Material** | Soft Annealed Bare Copper | — |
| **Conductor Stranding** | Class B Compressed Stranding (37 strands) | — |
| **Conductor Diameter Over Stranding** | 0.575 inches (14.6 mm) | inches / mm |
| **Voltage Rating (VFD Application)** | 2000 Volts | volts |
| **Standard Voltage Rating** | 600 Volts / 1000 Volts | volts |
| **Insulation Material** | Cross-Linked Polyethylene (XLPE) | — |
| **Insulation Thickness (VFD Application)** | 80 mils (2.03 mm) nominal | mils / mm |
| **Maximum Conductor Temperature** | 90°C Continuous / 105°C Emergency | degrees Celsius |
| **Minimum Installation Temperature** | Minus 40°C | degrees Celsius |
| **Metallic Shield** | Copper Tape with 25% Minimum Overlap | — |
| **Shield Thickness** | 5 mils (0.127 mm) | mils / mm |
| **Grounding Conductors** | Three (3) Bare Copper, AWG Size 4 | — |
| **Outer Jacket Material** | Polyvinyl Chloride (PVC), Black | — |
| **Jacket Thickness (Type TC-ER)** | 80 mils (2.03 mm) | mils / mm |
| **Allowable Ampacity at 90°C (in tray)** | 290 amperes | amperes |
| **Allowable Ampacity at 75°C** | 255 amperes | amperes |

## 4. CONSTRUCTION DETAILS BY CONFIGURATION

While all three cable configurations share common conductor, insulation, and shielding systems, they differ significantly in their mechanical protection arrangements and overall jacket systems. The following sections detail the construction of each configuration, highlighting the specific features that distinguish each design and the engineering rationale for the different protection levels.

### Configuration A: Type TC-ER Construction Details

The Type TC-ER configuration employs a straightforward construction methodology optimized for installations where mechanical protection is provided by cable trays, raceways, or conduit systems. The construction sequence begins with the individual conductor assemblies and proceeds through successive layers to the final protective jacket.

#### Phase Conductor Assembly

Each phase conductor consists of soft annealed bare copper stranded in accordance with ASTM B3 and B8 requirements using compressed Class B stranding with thirty-seven individual wires. The stranding process employs compression techniques that reduce the overall conductor diameter while maintaining the full electrical cross-sectional area, resulting in a more compact cable design. The conductor is insulated with cross-linked polyethylene applied to a nominal thickness of eighty mils for the two-thousand-volt VFD application. The cross-linking process creates three-dimensional molecular bonds that provide superior thermal, electrical, and mechanical properties compared to non-cross-linked thermoplastic materials. A copper tape shield is applied longitudinally over each insulated conductor with a minimum overlap of twenty-five percent, providing electromagnetic shielding and a path for high-frequency harmonic currents generated by the variable frequency drive switching action.

### Grounding Conductor System

Three bare copper grounding conductors manufactured to AWG size 4 specifications are incorporated into the cable assembly. These grounding conductors are stranded in Class B configuration and provide both safety grounding and a return path for shield currents. The bare copper construction facilitates termination operations and ensures reliable electrical contact with shield termination hardware throughout the cable length.

### Cable Core Assembly

The three insulated and shielded phase conductors are cabled together with the three grounding conductors using appropriate fillers to maintain cable roundness. Non-hygroscopic filler materials prevent moisture migration through the cable interstices while providing mechanical support for the conductor assembly. A binder tape is applied over the cabled core to maintain geometric integrity during subsequent manufacturing operations and throughout the service life of the cable.

### Outer Jacket System

A flame-retardant and sunlight-resistant black polyvinyl chloride jacket compound is extruded over the cable core to a nominal thickness of eighty mils. The jacket formulation incorporates stabilizers that resist degradation from ultraviolet radiation exposure, permitting outdoor installations without protective covering. The compound meets stringent flame propagation requirements including the seventy-thousand BTU per hour vertical tray test, limiting fire spread in the event of external fire exposure. A ripcord is incorporated beneath the jacket to facilitate jacket removal during termination operations, reducing installation time and minimizing the risk of conductor damage during jacket stripping.

## Configuration B: Type MC Armored Cable Construction Details

The Type MC configuration builds upon the basic tray cable construction by adding steel tape armor between an inner jacket and the final outer jacket, providing substantially enhanced mechanical protection while maintaining sufficient flexibility for industrial installation requirements.

### Inner Jacket Layer

Following assembly of the cabled core as described for Configuration A, a black polyvinyl chloride inner jacket is extruded over the core to a nominal thickness of one hundred ten mils. This inner jacket serves multiple functions including providing mechanical support for the armor layer, preventing armor-to-conductor contact that could lead to mechanical wear, and providing a smooth surface for armor application. The inner jacket also serves as a moisture barrier protecting the cable core from moisture ingress through gaps in the armor system.

### Steel Tape Armor

Steel tape armor is applied longitudinally over the inner jacket with appropriate overlap to provide continuous metallic coverage around the cable circumference. The steel tape provides robust mechanical protection against impact forces, crushing loads, and penetration damage from sharp objects. The armor thickness and overlap configuration are selected to provide the optimum balance between

mechanical protection and cable flexibility. The longitudinal application method permits tighter bending radii compared to helically applied wire armor while still providing excellent crush resistance and impact protection.

### Outer Jacket System

A final polyvinyl chloride outer jacket is extruded over the armor layer to a nominal thickness of seventy-five mils. This outer jacket protects the steel armor from corrosion and provides electrical insulation to prevent contact between the armor and grounded surfaces or adjacent cables. The jacket compound incorporates the same flame-retardant and sunlight-resistant additives employed in Configuration A, ensuring consistent environmental protection characteristics across the cable family.

## Configuration C: Heavy-Duty Mining Cable Construction Details

The heavy-duty mining configuration represents the ultimate in mechanical protection, employing dual armor systems that provide redundant mechanical protection suitable for the most severe service conditions encountered in mining operations and similar extreme environments.

### Inner Armor System - Steel Tape

Following the inner jacket application as described for Configuration B, a steel tape armor layer is applied to provide the first level of mechanical protection. This inner armor layer serves as the primary defense against mechanical damage and provides structural support for the outer armor system. The steel tape construction provides excellent resistance to crushing forces and impact damage while maintaining reasonable cable flexibility.

### Outer Armor System - Steel Wire Armor (SWA)

Over the steel tape armor, a layer of galvanized steel wire armor is applied in a helical configuration. The steel wire armor provides maximum mechanical protection and substantially increases the cable's resistance to tensile forces, making it suitable for cable dragging operations common in mining applications. The galvanized steel construction provides inherent corrosion resistance essential for wet mining environments and direct burial applications in corrosive soils. The combination of steel tape and steel wire armor creates a dual protection system where the outer wire armor bears the brunt of mechanical abuse while the inner tape armor provides backup protection, ensuring cable integrity even if the outer armor is damaged.

### Heavy-Duty Outer Jacket

The final outer jacket for the mining configuration employs a heavy-duty polyvinyl chloride compound formulated specifically for abrasion resistance and tear strength. The jacket thickness is increased compared to the standard MC configuration to provide additional protection against mechanical damage and to ensure adequate coverage over the wire armor. The compound meets mining industry requirements for flame resistance and incorporates fillers that enhance abrasion resistance, extending jacket life in demanding service conditions.

### Configuration Comparison Matrix

| Feature | Config A: Type TC-ER | Config B: Type MC | Config C: Mining |
|---|---|---|---|
| **Primary Application** | Indoor industrial installations with cable tray protection | General industrial with moderate mechanical exposure | Mining and severe-duty applications |
| **Armor Protection** | None - relies on raceway/tray | Steel Tape Armor (STA) | Dual Armor (STA + SWA) |

| Feature | Config A: Type TC-ER | Config B: Type MC | Config C: Mining |
|---|---|---|---|
| **Mechanical Protection Level** | Standard | Enhanced | Maximum |
| **Installation Flexibility** | Highest | Moderate | Lowest |
| **Direct Burial Capability** | Yes (approved) | Yes (with limitations) | Yes (preferred for harsh soils) |
| **Approximate Overall Diameter** | 1.74 inches | 2.10 inches | 2.45 inches |
| **Approximate Weight** | 3,129 lb/kft | 4,200 lb/kft | 5,800 lb/kft |
| **Minimum Bend Radius** | 10.4 inches (6 x OD) | 16.8 inches (8 x OD) | 24.5 inches (10 x OD) |
| **Relative Cost** | Lowest | Moderate | Highest |
| **Typical Installation Environment** | Protected indoor areas, cable trays, conduit systems | Industrial plants, exposed runs, areas with vehicle traffic | Mines, quarries, severe mechanical stress environments |

## 5. VARIABLE FREQUENCY DRIVE APPLICATION CONSIDERATIONS

Variable frequency drives present unique electrical challenges that differentiate VFD cable requirements from conventional power cable applications. The rapid voltage switching characteristic of pulse-width modulated drive outputs generates high-frequency harmonic currents and elevated voltage stress on cable insulation systems. The two-thousand-volt rating specified for these cables addresses the voltage spikes generated by long cable runs between drives and motors, which can reach levels substantially exceeding the nominal drive output voltage due to wave reflection phenomena.

The copper tape shielding incorporated into all three cable configurations serves critical functions in VFD applications. The shield contains electromagnetic emissions generated by the high-frequency switching currents, preventing interference with adjacent control circuits and communication systems. The shield provides a dedicated return path for high-frequency harmonic currents, ensuring these currents do not circulate through facility grounding systems where they could cause ground potential rise issues and interfere with sensitive electronic equipment. The low impedance of the copper tape shield at high frequencies ensures effective harmonic current containment throughout the frequency spectrum generated by typical drive switching frequencies.

The enhanced insulation thickness specified for VFD applications provides additional dielectric strength to withstand the repetitive voltage stress imposed by drive switching action. The cross-linked polyethylene insulation material offers superior resistance to partial discharge activity compared to thermoplastic materials, extending cable service life in this demanding application. The insulation system has been tested to withstand the voltage spikes characteristic of VFD applications while maintaining long-term reliability under continuous exposure to harmonic currents that elevate conductor temperatures above levels seen in sinusoidal power applications.

## 6. QUALITY ASSURANCE AND TESTING

Each cable configuration undergoes comprehensive testing to verify compliance with applicable standards and specifications. The testing program encompasses electrical verification, mechanical property validation, and dimensional confirmation procedures designed to ensure consistent product quality across all production runs. Testing protocols follow recognized industry standards and include witness testing provisions for projects requiring third-party verification of cable properties.

Electrical testing includes conductor resistance measurements to verify proper conductor sizing and stranding integrity, insulation resistance testing at elevated voltage levels to detect any manufacturing defects in the dielectric system, and high-potential testing to confirm voltage withstand capability. Shield continuity testing verifies the integrity of the copper tape shield application and confirms adequate overlap throughout the cable length. Partial discharge testing may be performed on VFD-rated cables to verify the absence of voids or contaminants in the insulation system that could serve as initiation sites for premature aging.

Mechanical testing validates jacket physical properties including tensile strength, elongation, and tear resistance. Cold bend testing at minus forty degrees Celsius confirms cable flexibility at extreme low temperatures. Impact testing on armored configurations verifies armor integrity and confirms that the armor system provides the specified level of mechanical protection. Flame testing in accordance with IEEE 1202 and UL 1685 protocols confirms superior flame resistance characteristics and validates the low smoke generation properties essential for life safety in occupied buildings.

### Important Product Selection and Application Information

The technical data presented in this specification represents typical values for each cable configuration based on standard manufacturing practices and current material specifications. Actual cable dimensions, weights, and electrical characteristics may vary within normal manufacturing tolerances and should be confirmed for applications with critical space limitations or precise weight requirements. The ampacity values presented are based on National Electrical Code calculation methods for cables installed in cable trays with no more than three current-carrying conductors and assume an ambient temperature of thirty degrees Celsius. Actual current-carrying capacity in specific installations may be affected by factors including tray fill, grouping with other cables, elevated ambient temperatures, and installation configuration. Engineers should perform site-specific ampacity calculations for critical applications or installations that deviate from standard conditions.

Configuration selection should be based on a thorough analysis of the installation environment, mechanical stress exposure during both installation and operation, regulatory requirements, and lifecycle cost considerations. While Configuration A represents the most economical initial cost, the enhanced protection provided by Configurations B and C may prove more economical over the cable lifecycle in applications where mechanical damage risks are significant. Technical support is available from our engineering department to assist with configuration selection, installation planning, and troubleshooting. Custom configurations can be manufactured to address unique project requirements including special voltage ratings, alternative armor materials, or modified jacket formulations for specific chemical exposure conditions.

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**FEICHUN SPECIAL CABLES**

Website Address www.reelingcable.com www.feichuncables.com
Whatsapp Account + 86 13855123218
Email Address Zihao.yang@feichuncables.com & Ziyu.huang@feichuncables.com