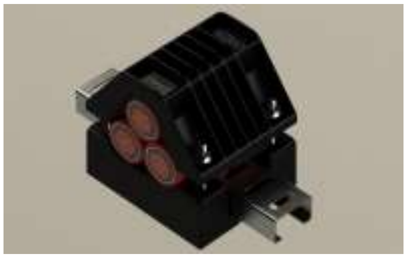
CABLE CLEAT FAQs

1. What is a cable cleat?



A cable cleat is a cable restraint device (e.g. cable clamp) that is designed and tested to provide securing and retention of cables when installed at intervals along the length of cables. A cable cleat is typically fixed to a mounting surface (e.g. cable ladder rung), and fastened around one or more cables. Conduit clamps and pipe clamps (P-clamps) are not cable cleats. Neither are cable times (according to IEC 61914 and UL 2239). Cable cleats may be applied to single conductor or multi-conductor cables.

In addition to securing cables that are subject to axial, lateral and torsional forces, Talon® cable cleats provide strain relief for vertical cables and restrain and protect high voltage, medium voltage and low voltage cables from mechanical damage resulting from short circuits. Talon® T3 cable cleats utilize a high-strength interlocking frame that simultaneously encloses cables and a support rung. Only Talon® cable cleats — ***Hold the Cables. Hug the Rung.*** ®

2. Are cable clamps the same as cable cleats?

While the terms *clamp* and *cleat* are sometimes used interchangeably, they are governed by different standards with exclusive, but analogous test protocols (see FAQ 10). The most important consideration when evaluating cable restraint products is to ensure the testing is applicable to cables (not pipe or conduit) and is performed under conditions that are at least as demanding as the intended usage.

Talon® cable cleats have passed rigorous 3rd party testing in accordance with ASTM B117, IEC 60695, IEC 61914, ISO 4892-2, UL 94 and UL 2239.

3. What is the difference between non-rigid and rigid cable cleats?

One characteristic of non-rigid materials is deformation during mechanical stress. Non-rigid cable restraints are typically manufactured from ductile materials such as unreinforced thermoplastic resin or metal banding. Metal banding (including cable ties) is universally recognized to be non-rigid. Even metal banding that has been doubled or hemmed can deform significantly during a (static) lateral pull test or (dynamic) short circuit test. If the deformation is permanent, future product reliability and cable protection may be compromised. When in doubt on whether product deformation is problematic, it is advisable to perform an axial resistance test after the lateral retention pull test or short circuit test. If a product cannot pass the subsequent axial resistance test, it may require replacement after exposure to mechanical stress.

Rigid cable cleats are typically manufactured from reinforced thermoplastic resin or relatively thick metallic cross-sections. Rigid cable cleats retain their physical shape during exposure to static and dynamic mechanical loading and are not typically prone to deformation. Because of technological advances in non-metallic materials and their natural immunity to galvanic corrosion, cable cleats manufactured with high-strength reinforced thermoplastic resins are rapidly replacing legacy aluminum clamps. Talon® cable cleats utilize a high-strength interlocking frame that simultaneously encloses cables and a support rung and do not suffer permanent deformation during testing.

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4. **Why are cable cleats required?**

Cable cleats are required for the securing and retention of cables. This protection is especially important when cables are exposed to axial, lateral or torsional forces, such as those caused by short circuit fault currents or the weight of cables in vertical runs. From a regulatory compliance perspective, proper cable retention facilitates conformance to electrical installation standards. For example, NFPA-70-2014, The (US) National Electrical Code, Article 392.20 (C) requires single conductors to be “securely bound in circuit groups to prevent excessive movement due to fault-current magnetic forces”. In that same Code, Article 110.36 requires insulators used as supports for single conductor cables to be “capable of safely withstanding the maximum magnetic forces that would prevail if two or more conductors of a circuit were subjected to short circuit current”. Other national wiring standards contain similar provisions for cable retention and protection from electromechanical forces.

Some installers mistakenly place cables in clamps that are designed for pipe or conduit, or they improperly apply cable ties or banding and damage the cable sheath or compress the insulation. Electrical inspectors should be vigilant about correcting such misapplications to ensure cables are restrained by products that are tested and suitable for the application and provide long-term cable protection.

5. **Where are cable cleats required?**

Talon® cable cleats mechanically restrain and secure cables subject to axial, lateral and torsional forces. Typical installations benefitting from Talon® cable cleats are:

- Low, medium and high voltage, ac and dc systems
- Single-conductor cables, including single cable and bundled cable (e.g. trefoil) configurations
- Multi-conductor cables susceptible to through-faults of moderate-to-high short circuit levels
- Cables in extreme environments (e.g. arctic, desert, high altitude, offshore/marine, tropical, underground)
- Cables exposed to aggressive external forces (e.g. cyclical loading, high-shock, pulse loads, seismic movement, short circuits, vibration)
- Vertical cables requiring strain relief and long straight cable runs (esp. cables in cable ladder or cable racks)
- Cables in manholes or vaults
- Retrofit applications on unrestrained cables resulting from loose cable ties or permanently deformed non-rigid cleats/clamps
- Any installation where a design professional must certify the cable system’s compliance to a national wiring standard

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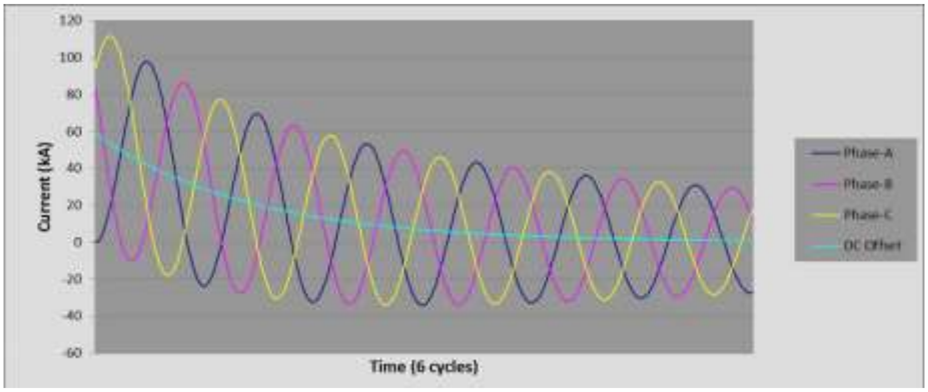
6. What happens to cables during a short circuit?



Since alternating current follows a repetitive oscillating (sinusoidal) pattern, short circuits produce alternating attractive and repulsive forces between conductors. These dynamic electromechanical forces are constantly changing in magnitude and direction and can exceed 40 kN/ m (2,741 lbf/ ft). Even when the short circuit current is quickly interrupted, it is important to recognize the maximum electromechanical forces typically occur within the first half cycle, which is long before a circuit breaker can open. During a short circuit, the high current flowing through the conductor's resistance rapidly heats the cable, resulting in axial (longitudinal) and lateral (radial) thermal cable expansion. The combination of thermal expansion and electromechanical forces causes cable deflection (i.e. bowing or bending), producing an axial pull on the cable terminations. If the terminations fail before the short circuit is interrupted (a typical failure mode on under-restrained cables), the cables can whip uncontrollably until the current is extinguished, risking further electrical and mechanical damage, as well as unleashing other safety concerns.

Optimum cable protection is provided when the electromechanical and thermal expansion forces are controlled and do not result in cable restraint deformation, stressed cable terminations, damaged cable ladder, etc. Cables that are exposed to potential short circuit current should be restrained by cable cleats. Talon® cable cleats protect high voltage, medium voltage and low voltage cables from mechanical damage resulting from short circuits.

7. How can I calculate electromechanical forces between conductors?

The Lorentz Force Law may be used to calculate the electromechanical force between two conductors, as follows:

$$F/L = \mu_0 * i_1 * i_2 / 2\pi s$$

Where:

- F = Electromechanical force between conductors
- L = Lineal spacing between cable restraints
- μ_0 = Magnetic permeability constant
- i_1 = Instantaneous current magnitude in conductor #1
- i_2 = Instantaneous current magnitude in conductor #2
- π = pi (mathematical constant representing the ratio of a circle's circumference to its diameter)
- s = Spacing between conductor centers

Most alternating current short circuit current waveforms involve asymmetry due to transient and subtransient reactance, as well as unidirectional current contribution (i.e. dc offset). As such, the most appropriate calculation for short circuit electromechanical forces between two conductors is the Lorentz Force Law. Since the Lorentz Force Law only considers two conductors, basic mathematical techniques may be utilized to solve for three or more conductors. Talon Products is pleased to assist with your cable force calculations utilizing our proprietary software.

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CAUTION: Equations that are based on the peak current magnitude in only one conductor should not be used for calculating forces between cables where the short circuit includes asymmetrical current. IEC 61914:2009 includes this severe limitation, which was raised to the IEC by the president of Talon Products, Charles Darnell, a Registered Professional Electrical Engineer, IEEE Senior Member and member of ANSI US National Committee of the IEC. The IEC 61914 working group subsequently agreed to add a qualifying statement in Edition 2.0 stating, "…equations B.5, B.6 & B.7 should not be used to extrapolate short circuit test results."

8. What is the recommended spacing between cable cleats?

LINEAL SPACING

Lineal cable cleat spacing decisions for cable protection are based on the dynamic electromechanical forces between cables, cable deflection limits, axial retention (i.e. strain relief) requirements and the geometry of the cable support system. Talon Products is pleased to assist with customer cable force calculations utilizing our proprietary software. The results of the force calculations will allow customers to choose a lineal spacing that fits their unique application.

***CAUTION**: Some cable cleat spacing charts may only consider the results of the IEC 61914 static cable cleat lateral resistance test, which (in the case of non-rigid cable restraint designs) may include severe cable cleat deformation. Others may be based on an extrapolated force calculation that is erroneously based on the peak current magnitude in only one conductor. Some spacing charts may similarly disregard dynamic cable cleat strength and other critical factors such as cable protection, cable deflection, strain relief requirements and potential damage to the cable support system. During short circuit conditions, cable cleats are subjected to alternating attractive and repulsive forces between conductors. Therefore, cable cleats must be designed and tested to withstand multiple applications of dynamic force during an extremely short time period; not just a single static lateral pull test. Since each installation is unique, it is best to discuss the application with your Talon Products Authorized Sales Representative.*

HORIZONTAL (i.e. side-by-side) SPACING

Horizontal cable cleat spacing decisions are based on cable ampacity requirements, spacing between the cables and the width and load distribution of the cable support system. National wiring standards like the (US) National Electrical Code provide cable ampacity tables that account for the mutual heating between conductors. For example, in order to achieve the desired ampacity, trefoil cable bundles are typically separated from adjacent conductors with a free airspace of at least 2.15 times the cable diameter of the largest cable. With their patented rigid cable cleat design that simultaneously encloses cables and a support rung, Talon® T3 cable cleats installed side-by-side will comply with this spacing factor for cable diameters greater than ø31 mm (1.22 in). For smaller cables or lower spacing factors, the cable cleats may be staggered on adjacent rungs (a "best practice" that is favored by many installers, even when horizontal spacing is not an issue). Since each installation is unique, it is best to discuss the application with your Talon Products Authorized Sales Representative.

9. Aren't electrical cables protected by circuit breakers or fuses?

Electrical cables are not fully protected by circuit breakers or fuses. Overcurrent protective devices provide thermal protection for the cable insulation. However, they are unable to protect cables from mechanical damage. Even with overcurrent protection devices that offer an "instantaneous" protection setting, irreversible cable damage will typically occur in inadequately restrained cables within the first half cycle of the fault initiation (i.e. before circuit breakers can interrupt the fault). In the case of fuses, the restraint system must withstand the forces associated with the maximum let-through current. In most cases, overcurrent protective devices for power cables are adjusted with intentional time-delay for system coordination with downstream devices, thus increasing the potential for damage in inadequately restrained cables.

All cables that are exposed to potential short circuit current should be restrained by cable cleats. Talon® cable cleats protect high voltage, medium voltage and low voltage cables from mechanical damage resulting from short circuits.

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10. What are the relevant standards for cable cleats?

IEC 61914 EDITION 1.0, 2009, CABLE CLEATS FOR ELECTRICAL INSTALLATIONS

The international cable cleat standard IEC 61914 provides testing criteria and requires cable cleats to protect the cables during short circuit testing. To comply with the standard, products must pass tests for resistance to flame propagation, impact and ultraviolet light exposure, as well as for lateral retention. The standard includes optional tests for axial retention and resistance to electromechanical forces. The president of Talon Products, Charles Darnell, a Registered Professional Electrical Engineer, IEEE Senior Member and member of ANSI US National Committee of the IEC is the US Representative to the IEC subcommittee responsible for the maintenance of IEC 61914.

NOTE: In August 2015, IEC 61914 Edition 2.0 reached the FDIS stage, with an expected publication date in 1Q2016. Edition 2.0 provides important clarifications and corrections, including a warning related to erroneous equations that should not be used to extrapolate short circuit test results.

Talon® cable cleats have been independently tested in accordance with UL 2239 and IEC 61914, including tests for axial retention and resistance to electromechanical forces during multiple successive short circuits.

UL 2239/ CSA C22.2, STANDARD FOR HARDWARE FOR THE SUPPORT OF CONDUIT, TUBING AND CABLE

This harmonized standard includes tests for resistance to flame propagation, impact and UV exposure, as well as lateral retention.

OTHER STANDARDS

As a result of the global acceptance of cable cleats, several codes, standards and recommended practices have adopted increased cable restraint performance requirements. Among these documents are API RP14F, API RP14FZ and IEEE 45.8.

11. What information is required to specify and purchase Talon® cable cleats?

Please to furnish as much of the following information as possible.

- Name and location of project
- Estimated quantity of cleats required
- Operating voltage
- ac (alternating current) or dc (direct current)
- If alternating current, what is the power frequency (e.g. 50Hz or 60Hz)
- 1-Phase or 3-Phase
- Cable diameter (outside diameter of each cable)
- Available fault current, including $I_{RMS\text{-}SYM}$, $I_{RMS\text{-}ASYM}$ and I_{PEAK}, if available
- Number of cables in each cleat
- If one cable per cleat, what is the proposed center-to-center spacing between adjacent cables
- If more than one cable per cleat, what is the configuration of the cable bundle (e.g. dual or trefoil)
- Mounting method (e.g. cable ladder, channel strut, structural steel, etc.)
- If utilizing cable ladder, please furnish manufacturer and model number (for straight section)
- Description of load type (e.g. axial, high-shock, seismic, short circuit, vertical/ strain relief, vibration)
- If any vertical installation, what is cable weight
- Chemical exposure (e.g. fuels, hydrocarbons, salts, organic solvents, etc.)
- Environmental exposure (e.g. indoor, outdoor, offshore/marine, buried, underwater, etc.)
- Special conditions (e.g. gamma radiation)

The comprehensive Talon® Cable Cleat Engineering Specification provides additional information on specifying cable cleats.

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12. What features make Talon® T3 cable cleats unique?

Talon® cable cleats utilize a rigid high-strength interlocking frame that simultaneously encloses cables and a support rung. Other unique value-added performance features and impressive test results include:

- **RIGID DESIGN** — suitable for continued use after exposure to short circuits
- **LARGE CLAMPING AREA** — low mechanical pressure exerted on cables
- **STRAIN RELIEF** — axial grip for cables in vertical runs
- **UNIVERSAL DESIGN** — accommodates one, two or three cables and virtually every cable ladder rung
- **MADE IN USA**

Only Talon® cable cleats — ***Hold the cables. Hug the Rung.***®

13. What information is included in an electromechanical force calculation?

Talon Products developed proprietary software to expand the results of a standard electrical fault-current study to include a mathematical model of a 3-phase short circuit current waveform. Based on the Lorentz Force Law, the program utilizes the current magnitudes in each phase to accurately and efficiently calculate the electromechanical forces between cables. Within just a few seconds of entering the basic electrical parameters, the program provides results in a user-friendly output file that includes all the necessary data to allow engineers to check and approve the calculation. In fact, customers regularly take advantage of the rapid turnaround time to evaluate different cable cleat lineal spacing options. The program provides the following information related to the severity of a short circuit.

- List of electrical parameters
- 3-phase oscillograph of short circuit current waveform
- Current magnitudes in each phase
- Vectorial plots and bar graphs of force magnitudes and directions
- Maximum electromechanical force magnitude
- Classification of force (attraction or repulsion)
- Time associated with moment of maximum force