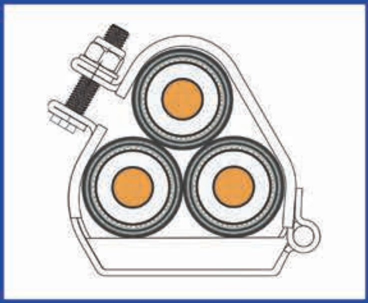
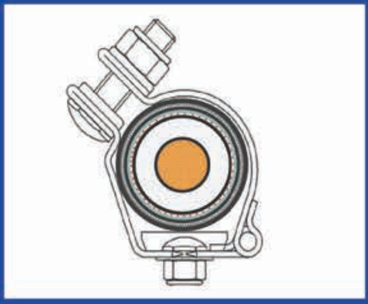
CONNEX CABLE CLEATS

CONNECTING THE WORLD

CABLE CLEATS
SOLUTIONS





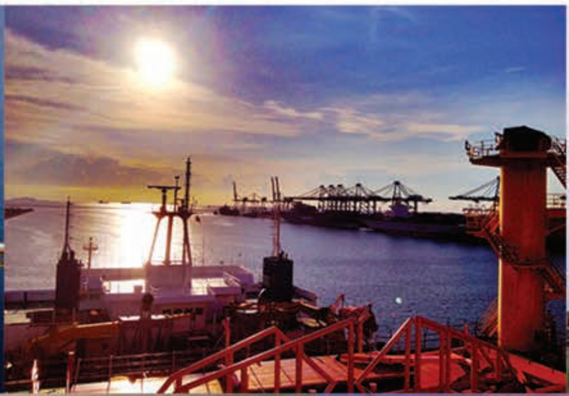
CONTENTS

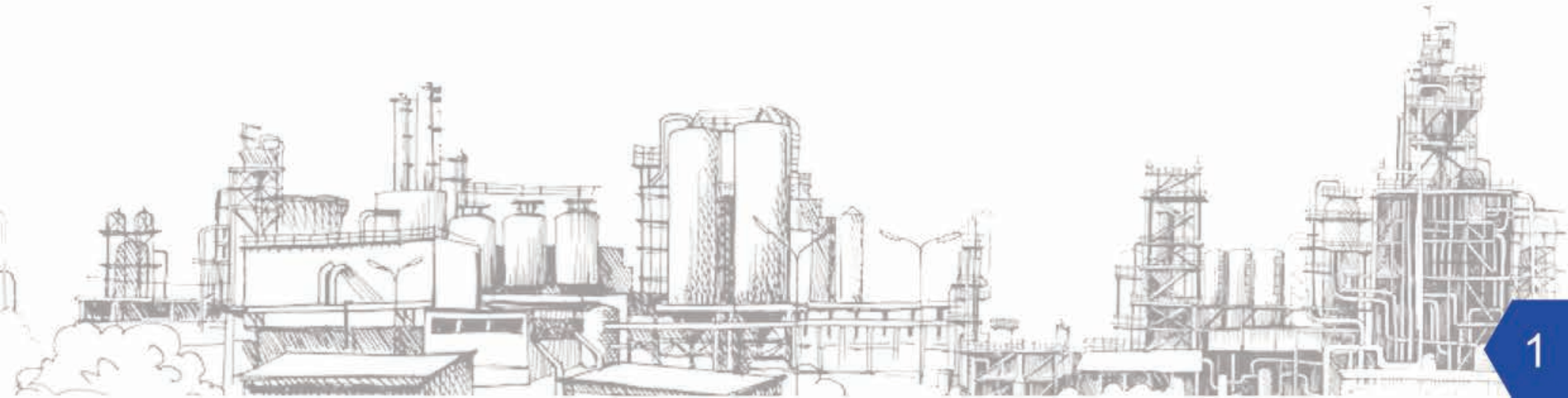
ABOUT CONNEX

Over many years, we have been focusing most on cable-related products such as cable cleats / strap, cable glands, cable ties, cable tags, and cable markers. We have been developing these cable accessories products under the brand "CONNEX' located in Tainan City Taiwan., By focusing on multiple techniques, our products have become qualified accessories used in many oil and gas projects worldwide.

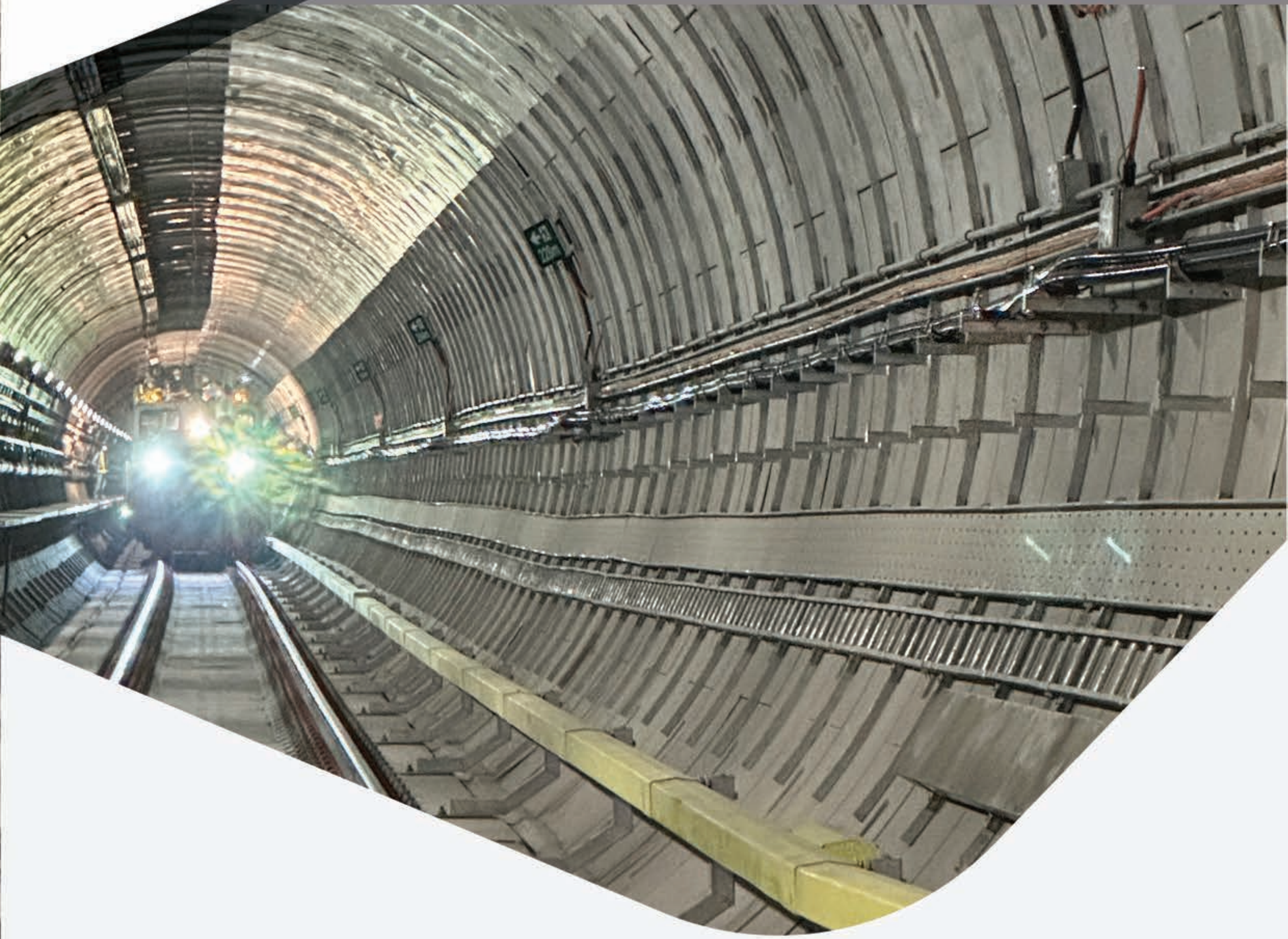
With many professional project references, CONNEX is a brand of choice for various projects in the oil and gas cable industry. It has independent development methods, so it can be sure that the products are of high quality. By seeking new technologies of development and excelling in our services, we can provide a series of innovative products as well as sincerely offer satisfactory service to our customers.

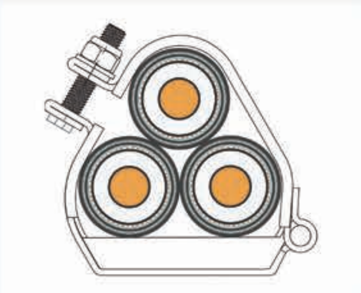
Along with other major global green energy supplying industries such as wind turbine, mass transit system, solar energy, or even oil & gas Onshore/Offshore industries. These are our opportunities to expand and be a part of such an innovative product that supports these various projects.





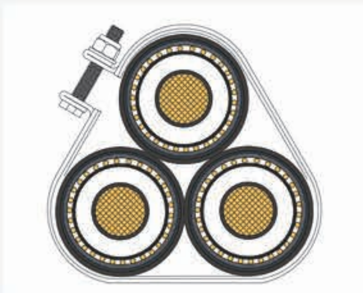
CABLE CLEATS TREFOIL & SINGLE / STRAP





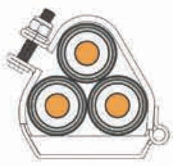
TREFOIL

SINGLE



STRAP

A cable cleat is a device that secures cables in electrical installations.
Proper selection ensures the safety and longevity of the system by preventing cable movement and damage, especially during a short circuit fault.



CABLE CLEATS SELECTION

Selecting the right cable cleat involves a comprehensive assessment of the cable, installation environment, and system's electrical characteristics. You must consider:

* Cable Diameter and Type: The cleat must match the cable's outer diameter and be suitable for its configuration (e.g., single-core, multi-core, or trefoil).
* Fault Current: The cleat's primary role is to withstand the extreme electromechanical forces generated by a short circuit. You need to know the peak short circuit current of your system. This is the single most important factor for cleat strength and spacing.
* Environment: The material of the cleat should be chosen based on the installation environment. For example, stainless steel is ideal for corrosive or harsh conditions (e.g., offshore, coastal)
* Support Structure: The cleat must be compatible with the mounting surface, such as cable ladder, tray, or strut.

Features and Benefits

The key features and benefits of correctly selected cable cleats are:

* Safety: They prevent cables from becoming a safety hazard during a short circuit by containing the violent whipping motion. This protects personnel and surrounding equipment.
* System Integrity: They maintain the correct cable formation, preventing damage to the cable's sheathing and conductors. This ensures the electrical system's long-term reliability.
* Cable Organization: They provide a neat and organized cable management system, which simplifies maintenance and inspections.
* Protection from Environmental Factors: Cleats can be made from materials that resist corrosion, UV degradation, and extreme temperatures, extending the life of the installation.

Standard and Technical EN IEC 61914:2021

EN IEC 61914 is the international standard that specifies requirements and tests for cable cleats. The 2021 edition is the latest revision. Its primary focus is on ensuring a cleat's ability to resist the electromechanical forces generated during a short circuit.

* Key Aspects of the Standard:
  * Short Circuit Testing: The standard requires cleats to undergo rigorous short circuit tests with a duration of 0.1 seconds, which is sufficient to determine the cleat's true strength at the peak current.
  * Mechanical and Environmental Testing: It includes tests for mechanical strength (e.g., lateral and axial load), corrosion resistance, impact resistance, and resistance to UV and other environmental factors.
  * Marking and Documentation: Cleats must be marked with specific information, and manufacturers must provide clear documentation on the cleat's performance and application.

The standard defines the criteria for a "pass" or "fail" in a short circuit test, providing a standardized way to compare and select compliant products.

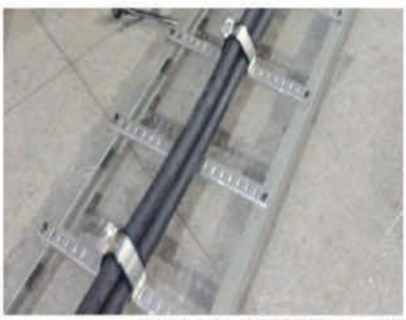
TEST REPORT
EN IEC 61914:2021
Cable cleats for electrical installations(IEC 61914:2021)

Report No.: J25B048129353SR

attached map

Figure 1: Sample photo

Figure 2: Sample photo



IEC61914:2009/9.5 Short-circuit test（180kA）

TREFOIL SHORT CIRCUIT INFORMATIONS

A trefoil formation is used for three-phase systems with single-core cables. This configuration minimizes the effects of circulating currents and eddy currents. However, during a three-phase short circuit, a very strong repulsive force is generated between the cables.

The force (F) is calculated using the following formula:

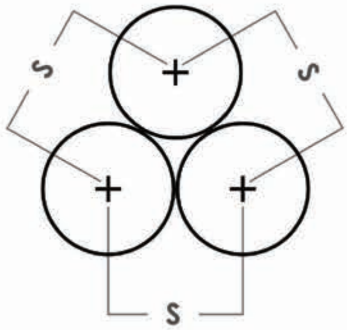
F = \frac{0.17 \times (I_p)^2}{S}

where:

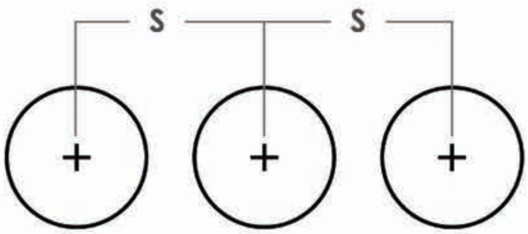
* F is the maximum force per meter of cable (in Newtons/meter)
* I_p is the peak short circuit current (in kA)
* S is the center-to-center distance between two adjacent cables (in meters). For a trefoil formation, this is the outer diameter of the cable.

This force is exerted at a 60° angle, pushing the cables outward and away from each other.

A trefoil cleat must be specifically designed and tested to withstand this force and maintain the triangular formation.



Three cables in trefoil formation with bundling clamp:



Three cables in parallel arrangement with single clamps:

For each arrangement the test must be carried out with a three-phase short-circuit at the peak shortcircuit current (ip) as specified by the manufacturer.

One end of the cable route is connected to a three-phase power supply and the other end to a threephase short-circuiting busbar.

The maximum force on the conductor is given by:

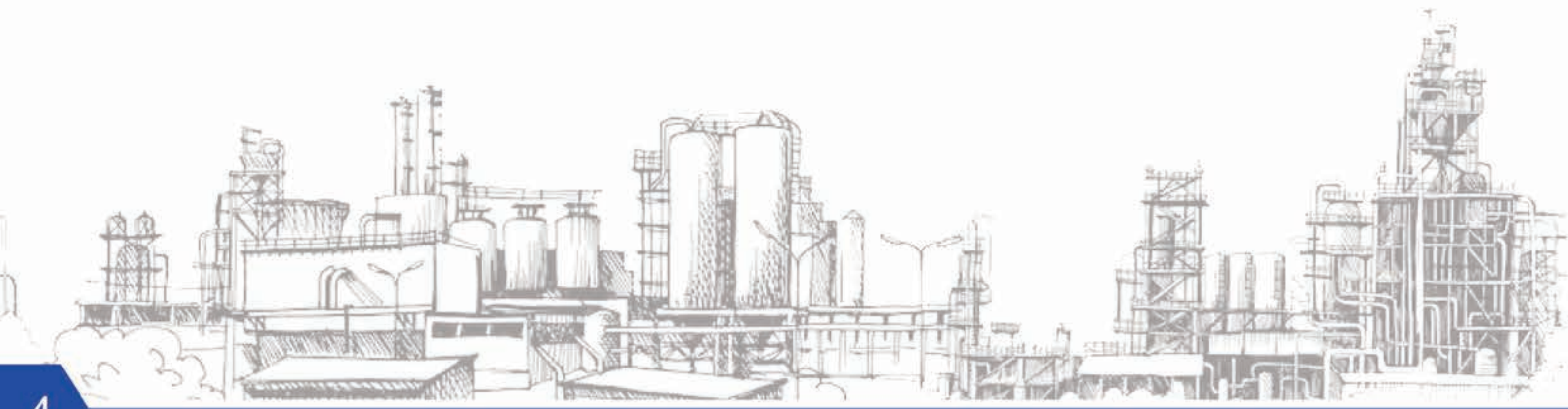
$$F = \frac{0{,}17 * i_p^2}{s}$$

F = maximum force on the conductor (N/m)
ip = peak short-circuit current (kA)
s = cable centre-line distance (m)

The peak short-circuit current (ip) as specified by the manufacturer is given by:

$$i_p = \sqrt{\frac{F_s * s}{0{,}17 * D}}$$

Fs = maximum dynamic force on the clamp (N)
D = maximum distance between two neighbouring clamps (m)



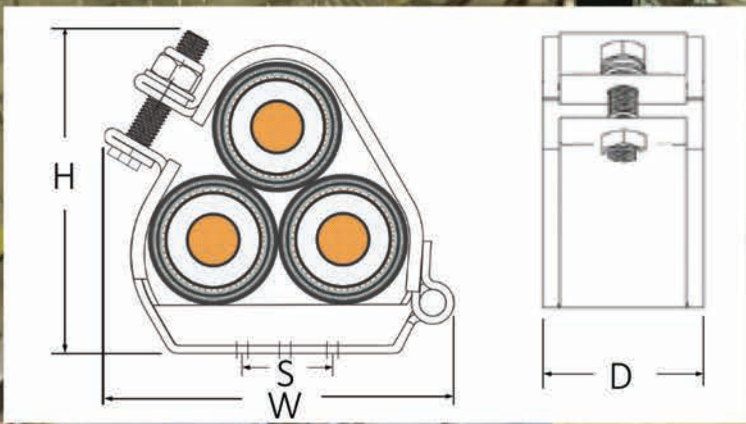
STAINLESS STEEL TREFOIL CABLE CLEATS

Construction

*Suitable for use with cable diameters 23 to 128mm.
*Single or double bolt fixing with reversible base for range taking
*Operating temperatures -40°C to +120°C.
*Designed to hold cables together in a trefoil arrangement and to provide resittance to electromechanical forces.
*Easy installation, with wrench tightening from the top side.
*Manufactured from non-magnetic, corrosion resistant 316/316L stainless steel.
*Cable Resting Base and Liners are made from LSOH materials.
*Suitable for in trefoil formation with high fault current requirements.
*Suitable for standard and LSOH cable sheaths.
*Can be used indoor & outdoor environments.
*Suitable for use with all standard ladders, trays, rack support or strut systems.
*Mounting Bolt M8 or M10

STAINLESS STEEL TREFOIL CABLE CLEATS

EN IEC 61914 : 2021

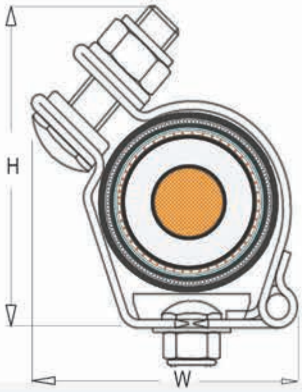


Part Number	Suitable Cable Dia (mm)	Dimension (mm)				
	(OD)	(W)	(H)	(D)	(S)	Weight (g)
TF-C 23-28 SS	23-28	86	71	60	Centre to Centre	503
TF-C 27-32 SS	27-32	92	78	60	25	834
TF-C 30-35 SS	30-35	98	84	60	25	559
TF-C 33-38 SS	33-38	102	90	60	25	587
TF-C 36-42 SS	36-42	108	97	60	25	626
TF-C 40-46 SS	40-46	115	105	60	25	659
TF-C 44-50 SS	44-50	120	112	60	25	695
TF-C 48-55 SS	48-55	129	121	60	50	733
TF-C 51-58 SS	51-58	133	127	60	50	172
TF-C 55-62 SS	55-62	140	134	60	50	797
TF-C 59-66 SS	59-66	145	142	60	50	835
TF-C 63-70 SS	63-70	150	150	60	50	867
TF-C 67-74 SS	67-74	157	157	60	75	908
TF-C 71-78 SS	71-78	164	164	60	75	938
TF-C 74-82 SS	74-82	172	172	60	75	978
TF-C 77-85 SS	77-85	178	178	60	75	1011
TF-C 82-88 SS	82-88	184	184	60	100	1049
TF-C 88-96 SS	88-96	200	198	60	100	1084
TF-C 96-103 SS	96-103	214	210	60	100	1118
TF-C 103-111 SS	103-111	230	225	60	125	1154
TF-C 111-119 SS	111-119	245	240	60	125	1187
TF-C 119-128 SS	119-128	264	257	60	150	1227

Performance Data	
Cleats Performance	Classification
Type	Composite
Operating Temperature	-40°C to + 120°C
Inpact Resistance	Very Heavy
Needle Flame	>120secs

	Classification
Resistance to 1 Short Circuit	80.0KA rms, 180KA peak, Ø=36mm Spacing = 300mm
Resistance to 2 Short Circuit	80.0KA rms, 180KA peak, Ø=36mm Spacing = 300mm
	57.0KA rms, 125KA peak, Ø=36mm Spacing = 600mm
Corrosion	High, Outdoor - wet conditions

STAINLESS STEEL SINGLE CABLE CLEATS



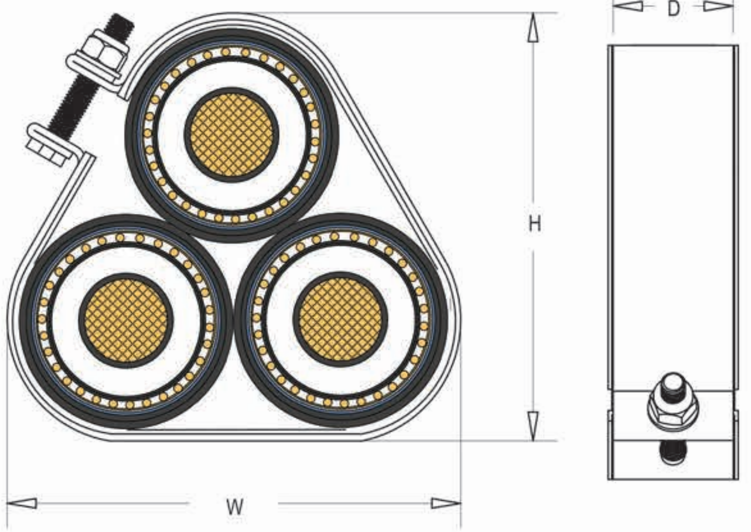
EN IEC 61914 : 2021

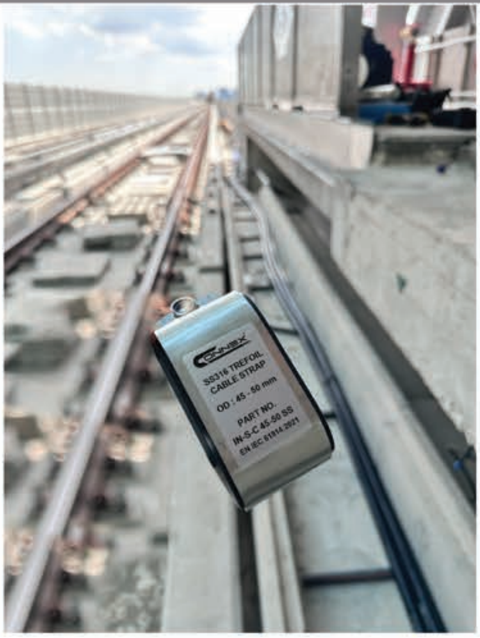
Part Number	Cable Range				Cable Cleat Diamensions				
	MIN. DIAMETER		MAX. DIAMETER		H		W		D
	mm	in.	mm	in.	mm	in.	mm	in	mm
SG-C 22-26 SS	22	0.86	26	1.02	60	2.36	57	2.24	55
SG-C 28-32 SS	28	1.10	32	1.26	60	2.36	57	2.24	55
SG-C 30-34 SS	30	1.18	34	1.34	61	2.40	59	2.32	55
SG-C 32-36 SS	32	1.26	36	1.42	63	2.48	61	2.40	55
SG-C 34-38 SS	34	1.34	38	1.50	66	2.56	63	2.38	55
SG-C 36-40 SS	36	1.42	40	1.57	67	2.64	64	2.52	55
SG-C 38-42 SS	38	1.50	42	1.65	69	2.72	65	2.56	55
SG-C 40-44 SS	40	1.57	44	1.73	70	2.76	68	2.68	55
SG-C 42-46 SS	42	1.65	46	1.81	81	2.80	69	2.72	55
SG-C 44-48 SS	44	1.73	48	1.89	73	2.87	72	2.83	55
SG-C 46-50 SS	46	1.81	50	1.97	74	2.91	73	2.87	55
SG-C 48-52 SS	48	1.89	52	2.05	75	2.95	77	3.03	55
SG-C 50-54 SS	50	1.97	54	2.13	78	3.07	78	3.07	55
SG-C 52-56 SS	52	2.05	56	2.20	79	3.11	80	3.15	55
SG-C 54-58 SS	54	2.13	58	2.28	80	3.15	82	3.23	55
SG-C 56-60 SS	56	2.20	60	2.36	81	3.19	85	3.35	55
SG-C 58-62 SS	58	2.28	62	2.44	82	3.23	87	3.43	55
SG-C 60-64 SS	60	2.36	64	2.52	85	3.35	88	3.46	55
SG-C 62-66 SS	62	2.44	66	2.60	87	3.43	90	3.54	55
SG-C 64-68 SS	64	2.52	68	2.68	89	3.50	91	3.58	55
SG-C 66-70 SS	66	2.60	70	2.76	90	3.54	92	3.62	55
SG-C 68-72 SS	68	2.68	72	2.83	92	3.62	94	3.70	55
SG-C 70-74 SS	70	2.76	74	2.91	95	3.74	97	3.82	55
SG-C 72-76 SS	72	2.83	76	2.99	97	3.82	99	3.90	55
SG-C 74-78 SS	74	2.91	78	3.07	98	3.86	102	4.02	55
SG-C 76-80 SS	76	2.99	80	3.15	100	3.94	104	4.09	55
SG-C 78-82 SS	78	2.99	82	3.23	102	4.02	106	4.17	55
SG-C 80-84 SS	80	3.15	84	3.31	105	4.13	107	4.21	55
SG-C 82-86 SS	82	3.23	86	3.39	107	4.21	110	4.33	55
SG-C 84-88 SS	84	3.31	88	3.46	109	4.29	111	4.37	55
SG-C 86-90 SS	86	3.39	90	3.54	110	4.33	113	4.45	55
SG-C 90-94 SS	90	3.54	94	3.70	115	4.53	121	4.76	55
SG-C 94-118 SS	94	3.70	118	4.65	133	5.24	139	5.47	55
SG-C 118-130 SS	118	4.65	130	5.12	140	5.51	144	5.67	55
SG-C 127-150 SS	127	5.00	150	5.91	161	6.34	166	6.54	55

Performance Data	
Cleats Performance	Classification
Type	Composite
Operating Temperature	-40°C to + 120°C
Inpact Resistance	Very Heavy

	Classification
Resistance to 1 Short Circuit	80.0KA rms, 180KA peak, Ø=36mm Spacing = 300mm 57.0KA rms, 125KA peak, Ø=36mm Spacing = 600mm
Corrosion	High, Outdoor - wet conditions

STAINLESS STEEL TREFOIL INTERMEDIATE STRAP





EN IEC 61914 : 2021

Part Number	Suitable Cable Dia (mm)	Dimension (mm)		
		(H)	(W)	(D)
IN-S-C 17-21 SS	17-21	59	92	55
IN-S-C 19-24 SS	19-24	65	98	55
IN-S-C 23-28 SS	23-28	71	102	55
IN-S-C 27-32 SS	27-32	78	108	55
IN-S-C 30-35 SS	30-35	84	115	55
IN-S-C 33-38 SS	33-38	90	120	55
IN-S-C 36-42 SS	36-42	97	129	55
IN-S-C 40-46 SS	40-46	105	133	55
IN-S-C 45-50 SS	45-50	121	138	55
IN-S-C 48-55 SS	48-55	127	140	55
IN-S-C 51-58 SS	51-58	134	145	55
IN-S-C 55-62 SS	55-62	142	150	55
IN-S-C 59-66 SS	59-66	150	157	55
IN-S-C 63-70 SS	63-70	157	164	55
IN-S-C 67-74 SS	67-74	164	172	55
IN-S-C 71-78 SS	71-78	172	178	55
IN-S-C 74-82 SS	74-82	178	184	55
IN-S-C 77-85 SS	77-85	184	200	55
IN-S-C 82-88 SS	82-88	198	214	55
IN-S-C 88-96 SS	88-96	210	230	55
IN-S-C 96-103 SS	96-103	225	245	55
IN-S-C 103-111 SS	103-111	240	264	55
IN-S-C 111-119 SS	111-119	257	278	55
IN-S-C 119-128 SS	119-128	263	292	55

Performance Data	
Cleats Performance	Classification
Type	Composite
Operating Temperature	-40°C to + 120°C
Inpact Resistance	Very Heavy

	Classification
Resistance to 2 Short Circuit	57.0KA rms, 125KA peak, Ø=36mm Spacing = 600mm Testing with Cable cleat TF-C series
Corrosion	High, Outdoor - wet conditions

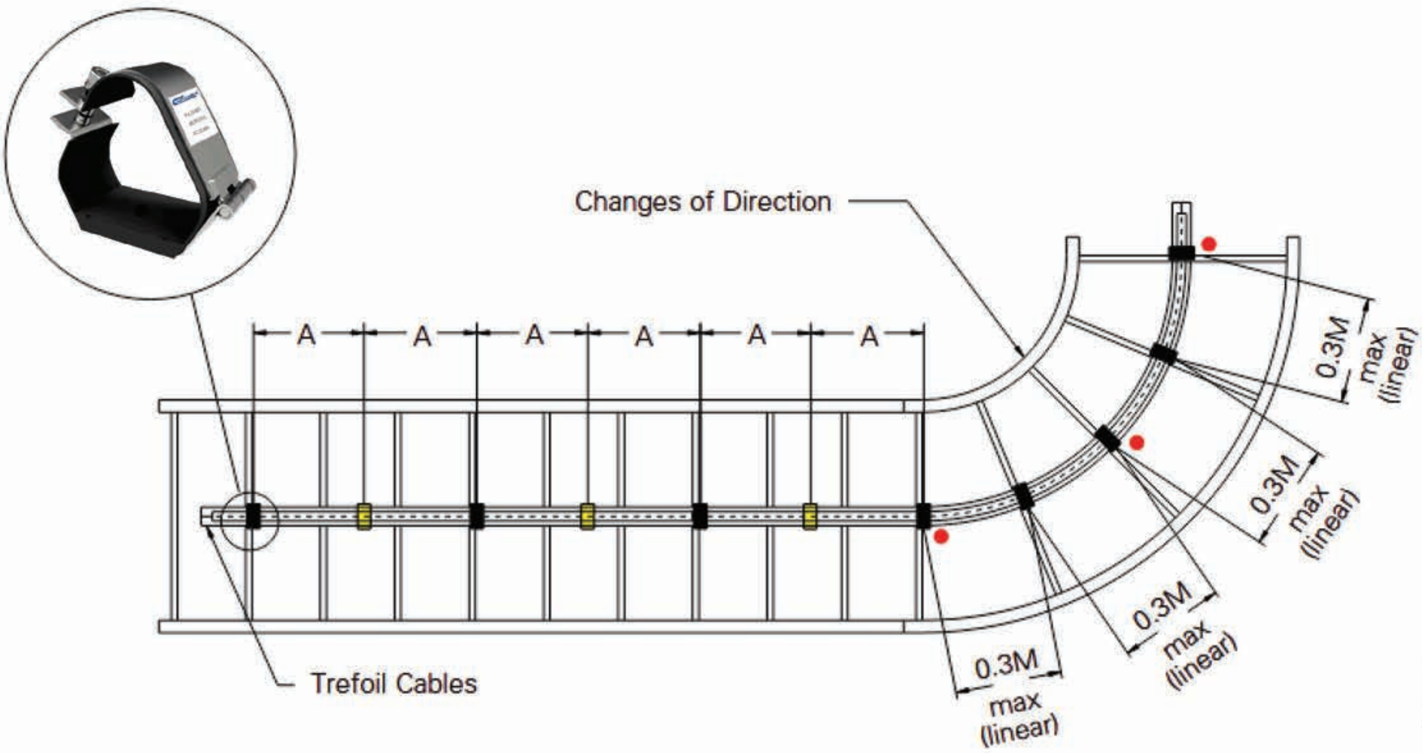
Trefoil Cleat Installation Spacing

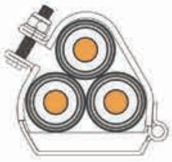
The required spacing between trefoil cleats is directly dependent on the calculated short circuit force and the cleat's tested strength. There is no one-size-fits-all distance.

* Calculation: To determine the correct spacing, you must:
  * Calculate the force per meter (F) based on your system's peak fault current and cable diameter.
  * Find the tested short circuit strength of the specific cleat you intend to use (e.g., in Newtons).
  * Divide the cleat's strength by the force per meter to find the maximum possible spacing (in meters).
* Practical Guidelines:
  * Manufacturer Recommendations: 600mm. and 900mm. = Linear spacing , 300mm. = Bending area , which is based on product's test data, to provide short circuit calculation to simplify this process.
  * Bends and Terminations: Cleats should be installed closer together at bends, joints, and cable terminations where additional stress and movement are expected.
  * Vertical Runs: For vertical cable runs, the cleats must also support the axial weight of the cable, which may require closer spacing than the short circuit calculation alone.

RESISTANCE TO MECHANICAL FORCES TABLE

Max. Cable Cleat Spacing (A)		Spacing Between Conductor Centers (mm)											
		23	25	27	29	31	33	35	37	39	41	43	45
mm	In.	i_p peak (kA)											
225	9	179	187	194	203	209	216	220	229	234	240	246	250
300	12	155	163	168	174	181	187	192	198	203	209	214	215
450	18	128	133	137	144	148	152	157	161	165	170	174	178
600	24	110	115	119	124	128	132	135	139	143	148	150	153
675	27	104	108	113	117	121	124	128	132	135	139	143	147
900	36	89	93	97	102	104	108	110	115	117	121	124	127





Short Circuit Current Calculation Based on IEC 30909 Method

The short circuit calculation in PowerFactory is able to simulate single faults as well as multiple faults of almost unlimited complexity. As short-circuit calculations can be used for a variety of purposes, PowerFactory supports different representations and calculation methods for the analysis of short circuit currents.

Short circuits can be phase-to-earth (80% of faults), phase-to-phase (15% of faults), three-phase (only 5% of faults)

Short circuit calculation is used to check the ratings of network equipment during the planning stage. For planning conditions, simplified methods are used with reduced set of data. Here we use equivalent voltage source at the fault location. In this case, the planner is interested in obtaining the maximum expected currents (in order to dimension equipment properly) and the minimum expected currents (to aid the design of the protection scheme). Short circuit calculations performed at the planning stage commonly use calculation methods that require less detailed network modelling and which will apply extreme case estimations. Examples of these methods include the IEC 60909 method.

For operational conditions, Complete Method is used with comprehensive set of data. Here we use either Superposition Method or Solution of Differential Equation (EMT) for precise evaluation of the fault current in a specific situation.

The fundamental difference between the assumptions used by the calculation methods is that for system planning studies the system operating conditions are not yet known, and therefore estimations are necessary.

Standard IEC 60909 applies to all networks, radial or meshed, up to 550 kV and it implements the symmetrical component principle. In this method, voltage at the fault location, equal to $c.U_n/\sqrt{3}$ where c is a voltage factor required in the calculation to account for voltage variations, changes in transformer tappings, and subtransient behaviour of generators and motors.

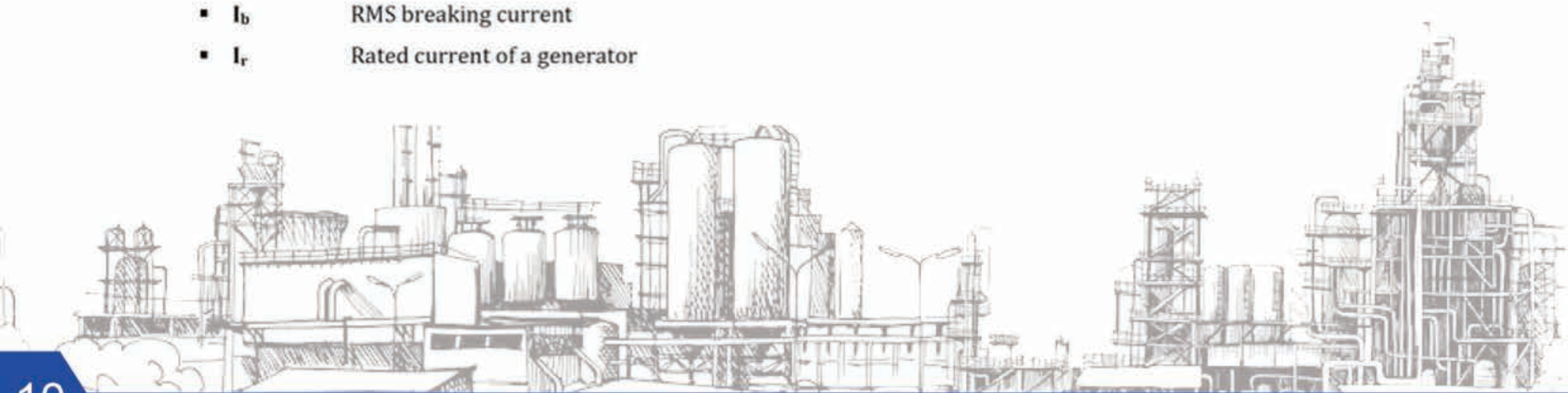
Initial short circuit current is calculated using the symmetrical components. Once the rms value of the initial short circuit current I_k'' is known, it is possible to calculate the other values; i_p, peak value, I_b, rms value of the breaking current, i_{dc}, DC component, and I_k, rms value of the steady state short circuit current.

Basic Quantities :

- **I_k''** Subtransient Short Circuit current
- **I_k'** Transient Short Circuit Current
- **R/X_p** R/X ratio for peak SC calculation (as per IEC 60909)
- **R/X_b** R/X ratio for DC current calculation (as per IEC 60909)

Derived Quantities :

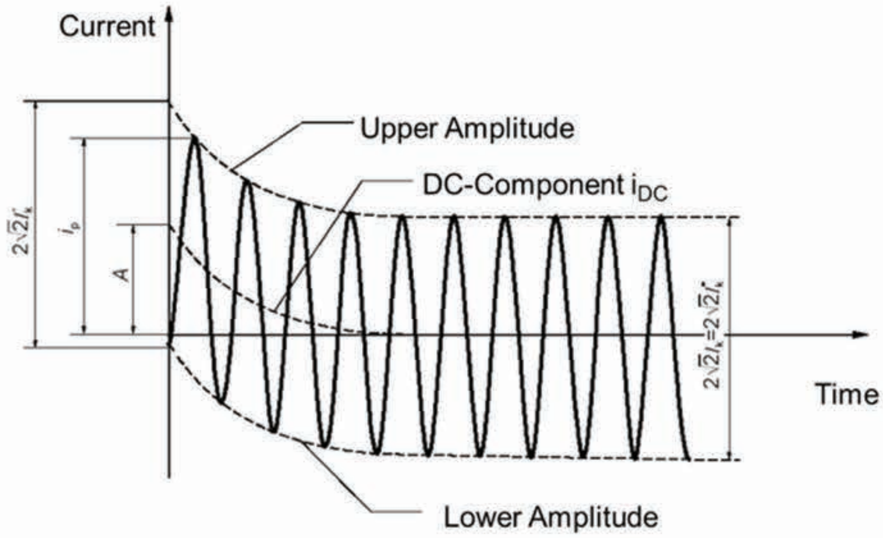
- **i_p** Peak (Make) Current.
- **i_{dc}** DC Short Circuit current (as per IEC 60909)
- **i_b** Peak breaking current
- **I_b** RMS breaking current
- **I_r** Rated current of a generator



Fault Far From Generator

This is the most frequent situation. Its response is represented by a reactor-resistance circuit.

When the short circuit is far from the generator, the short circuit currents do not have a damped, alternating component. This is generally the case in LV networks. In this case the initial I_k'', steady state I_k and breaking I_b short circuit currents are equal ($I_k'' = I_k = I_b$) and the positive sequence Z_1 and negative sequence Z_2 impedances are equal $Z_1 = Z_2$

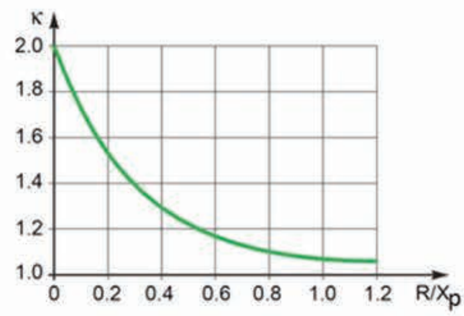


Typical Distribution and Transmission Fault Current Waveform

Value of i_p is calculated to determine the making capacity of the required circuit breakers. Its value may be obtained from the rms value of subtransient short circuit current I_k'' using the equation: $i_p = k\sqrt{2}I_k''$

where the coefficient κ is shown in graph below, as a function of the ratio R/X_p, or can be calculated from the expression:

$$k = 1.02 + 0.98\, e^{-3\frac{R}{X_p}}$$



Variation of k depending on R/X_p ratio.

Fault Near Generator

In this case the emf force is assumed to be constant and the internal reactance of the machine variable. The reactance develops in three stages. Subtransient (the first 10 to 20 ms), Transient (up to 500 ms), and Steady-state (or synchronous reactance). The reactance increases gradually after the fault with steady state reactance value being the highest.

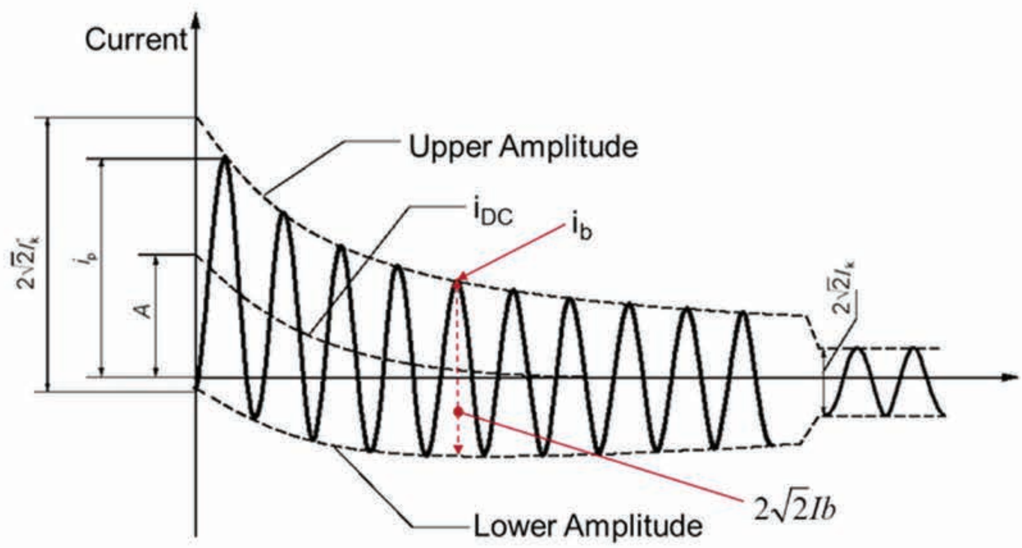
When the short circuit is near the generator, the short circuit currents are damped. This generally occurs in HV systems, but may occur in LV systems when, emergency generator is used.

The value of the fault current $i_{(t)}$ flowing into a three phase short circuit at the terminals of an initially unloaded machine can be derived on the basis of the equivalent networks and is therefore given by the following expression:

$$i_{(t)} = E\sqrt{2}\left[\left(\frac{1}{X''_d} - \frac{1}{X'_d}\right)e^{-t/T''_d} + \left(\frac{1}{X'_d} - \frac{1}{X_d}\right)e^{-t/T'_d} + \frac{1}{X_d}\right]\cos\omega t - \frac{E\sqrt{2}}{X''_d}e^{-t/T_a}$$

Where:

E	Phase-to-neutral rms voltage across the generator terminals
X''_d	Subtransient reactance
X'_d	Transient reactance
X_d	Synchronous (steady-state) reactance
T''_d	Subtransient time constant
T'_d	Transient time constant
T_a	Armature winding (Stator) time constant



Typical Near Generator Fault Current Waveform

Impedance correction factors

Impedance-correction factors were included in IEC 60909 to meet requirements in terms of technical accuracy and simplicity when calculating short-circuit currents

Peak short circuit current i_p

Peak value i_p of the short circuit current may be calculated for all types of faults using the equation:

$$i_p = k\sqrt{2}\, I_k''$$

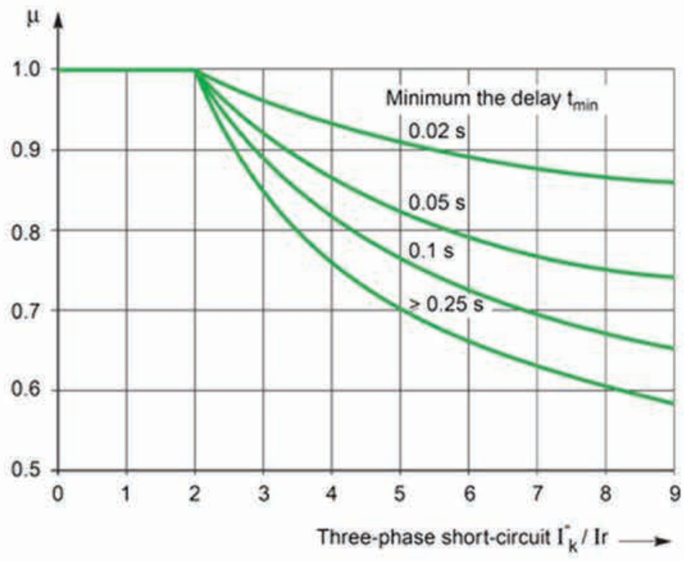
Short circuit breaking current I_b

Calculation of the short-circuit breaking current I_b is required only when the fault is near the generator and protection is ensured by time delayed circuit breakers. This current is used to determine the breaking capacity of these circuit breakers.

This current may be calculated with a fair degree of accuracy using the following equation:

$$I_b = \mu . I_k''$$

Where μ is factor defined by time delay and current ratios as shown on the graph below.

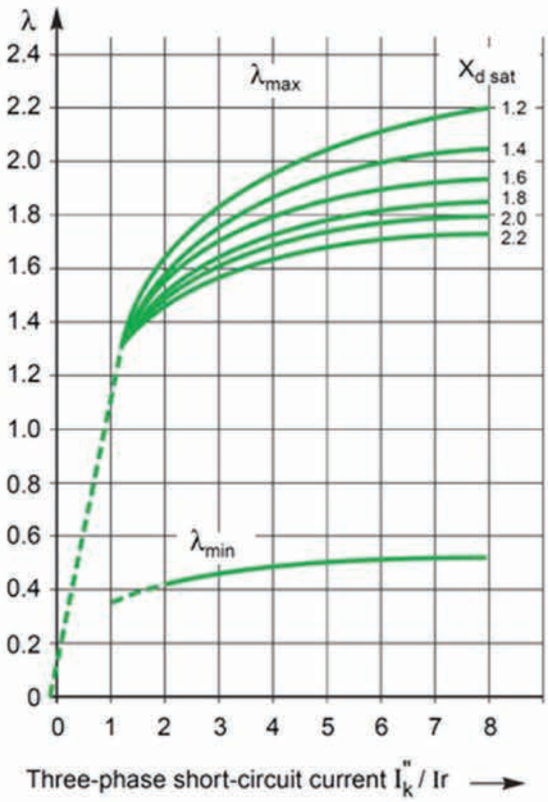


Factor μ used to calculate the short circuit breaking current I_b

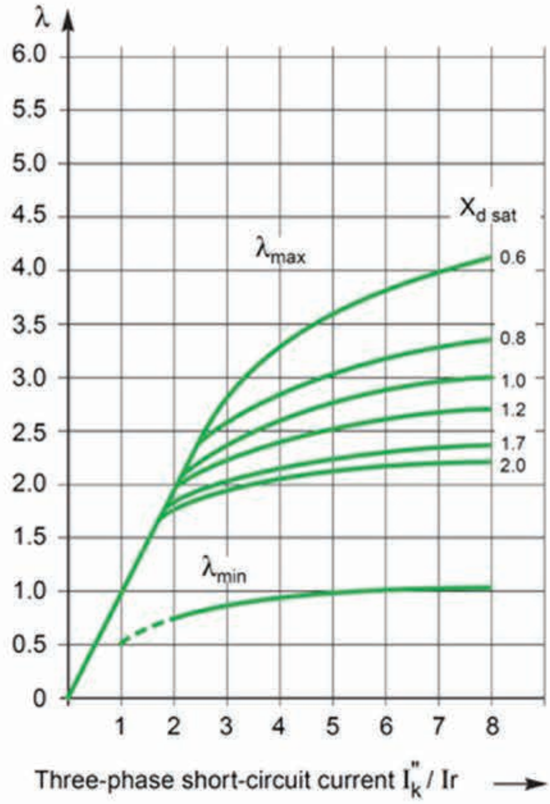
Steady state short circuit current I_k

The steady state short circuit current I_k depends on generator saturation influences. Its value can be estimated depending on whether the short circuit is supplied by a generator or a synchronous machine.

$$I_{k(\max)} = \lambda . I_r$$

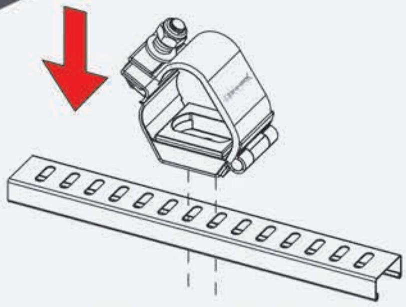


Factors λ for Turbo Generators

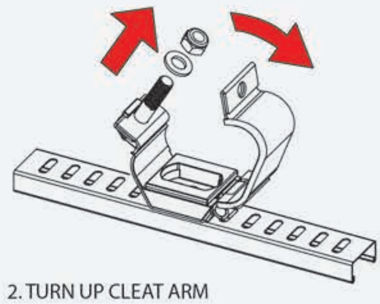


Factors λ for Salient Pole Generators

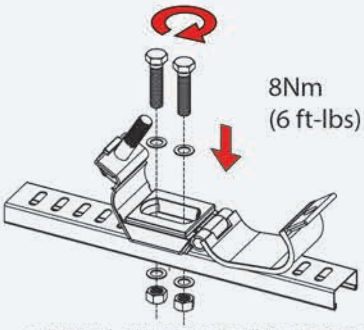
TREFOIL CABLE CLEATS ASSEMBLY INSTRUCTIONS



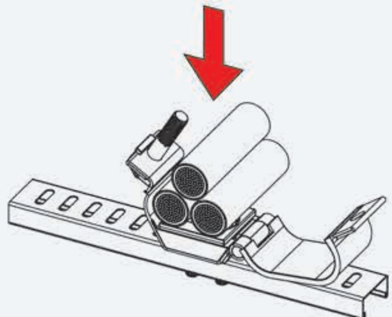
1. PUT DOWN CLEAT ON MOUNT SURFACE POSITION



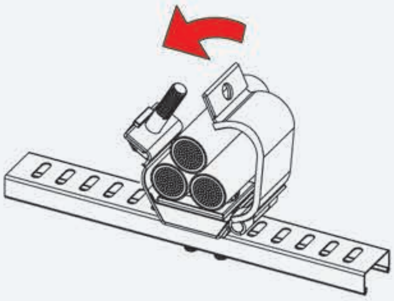
2. TURN UP CLEAT ARM



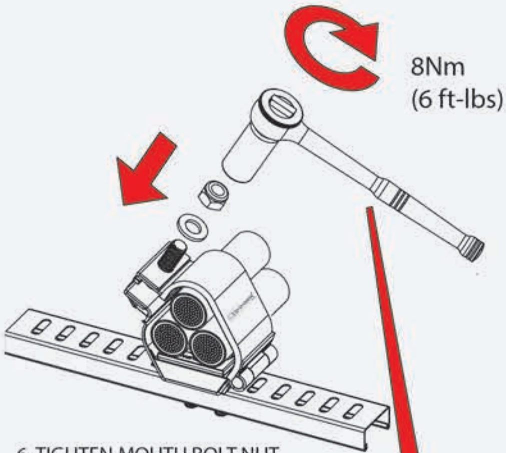
3. INSTALL CLEAT TO MOUNT SURFACE WITH FITTING BOLT (1 BOLT SET OR 2 BOLT SETS)



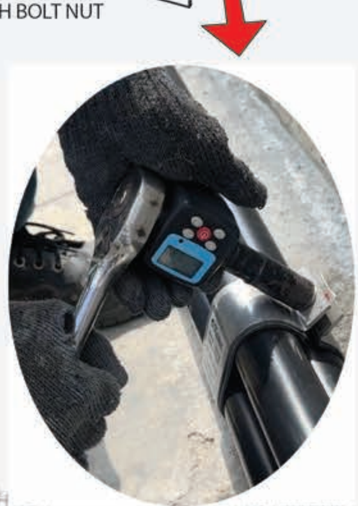
4. LAY CABLES DOWN

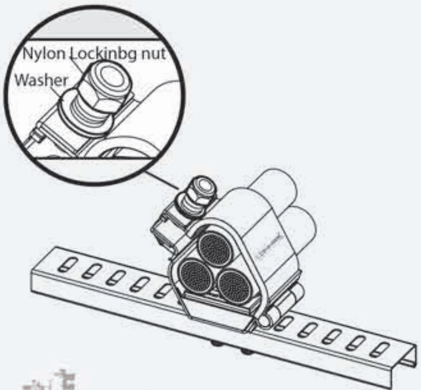


5. CLOSE CLEAT ARM



6. TIGHTEN MOUTH BOLT NUT





7. INSTALLED CLEAT

OTHER PRODUCTS

SGS

PROJECT REFERENCE

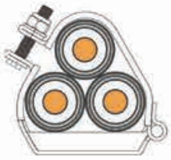
PROJECT Bacalhau FPSO (Nylon ties)
OWNER MODEC

PROJECT VIVA Gasoline
OWNER VIVA Energy Refinning PTY Ltd.

PROJECT Mitchaline Line 4
OWNER Mitchaline Co., Ltd. (Hadyai)

PROJECT MRO
OWNER SCG Chemical

PROJECT BST NBL P2
OWNER BST Elastomer



PROJECT REFERENCE

PROJECT MEDCO – Bualuang Phase 5
OWNER MEDCOENERGI

PROJECT Zawtika Development Project 1E
OWNER PTTEP/Myanmar Oil & Gas

PROJECT G7 & G8 and Switch Gear for Wassana Reactor
OWNER Valeura Energy (Gulf of Thailand) Ltd.

PROJECT Santos Onshore
OWNER UPSTREAM Developments

PROJECT Exxon Crisp
OWNER Exxonmobil Singapore

PROJECT WaterWorks Sequoia

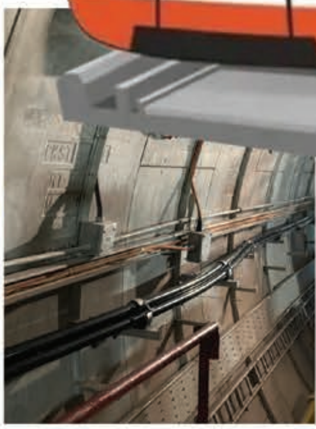
PROJECT Bangchark EURO V
OWNER Bangchark Refinery

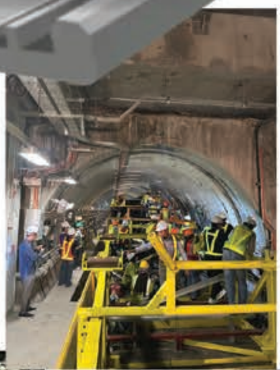
PROJECT Thaioil Clean Fuel
OWNER Thaioil Limited

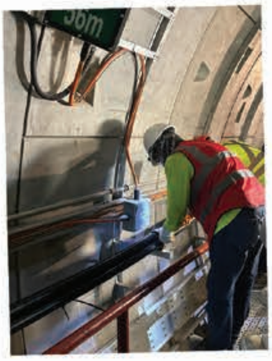
PROJECT REFERENCE

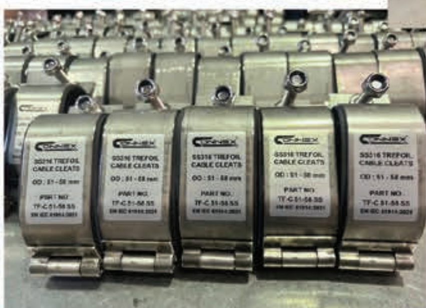
PROJECT MRT Orang Line

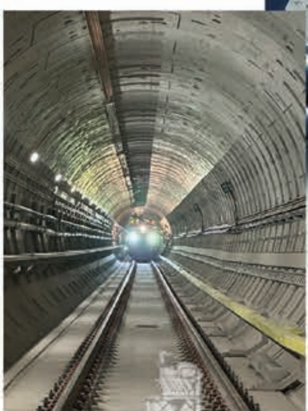
OWNER Bangkok Expressway and Metro Public Company (BEM)











CONNEX®

CONNECTING THE WORLD